

MSC-07765 (VOL. II)



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO/SOYUZ TEST PROJECT

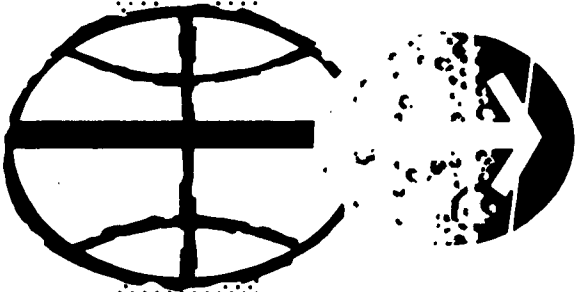
OPERATIONAL DATA BOOK

VOLUME II - MISSION MASS PROPERTIES



FEBRUARY 1973

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MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

APOLLO/SOYUZ TEST PROJECT OPERATIONAL DATA BOOK

VOLUME II

ASTP MASS PROPERTIES DATA BOOK

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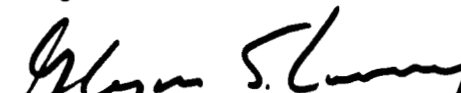
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REVISIONS

REV LTR	AMEND NO.	DESCRIPTION	DATE	APPROVED

VOLUME II
ASTP MASS PROPERTIES DATA BOOK

PREFACE

This document is the initial issue of the ASTP Mass Properties Data Book. Amendments released subsequent to publication of this Mass Properties Data Book will be numbered sequentially starting with number 1.

ASTP mass properties contained in this data book have been updated and supersede those previously published in Volume III, CSM/LM Spacecraft Operational Data Book, Revision 3.

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VOLUME II
ASTP MASS PROPERTIES DATA BOOK

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1.0 INTRODUCTION

1.1 SCOPE

The complete Operational Data Book for the ASTP mission will consist of two separate volumes. These are defined as follows:

Volume I - CSM/DM Data Book

- Part 1 - Constraints and Performance
- Part 2 - Launch Mission Rule Redlines

Volume II - Mass Properties Data Book

Volume I presents operational information on the capabilities and limitations of the spacecraft. A brief discussion of the purpose and scope of Volume II follows:

1.2 PURPOSE

The purpose of this document is to provide spacecraft mass properties data for use in the mission-planning activities, trajectory documentation, and mission simulations; and to provide all necessary information and documentation for consumable loading. The data contained herein represent the latest predictions for the launch configuration mass properties and consumable loadings. Updates to these data will be provided based on the actual weight and balance data for each spacecraft. Mass properties data will be maintained and updated through the actual consumable loading.

Section 2.0 presents relevant spacecraft configuration drawings and station locations which should be used for determining locations of various spacecraft components and the relationship to coordinate systems in the launch and docked configuration. Also included in this section are the mass property equations, definitions, and assumptions used in preparing the sequential mass properties presented in Section 3.0.

Section 3.0 presents mass properties and consumable loading data for the ASTP mission. Included in this section are the predicted mass properties by event from launch through normal entry, launch abort mass properties, tabularized mass properties for each main engine burn as a function of spacecraft weight, and a detailed listing of all equipment transferred between modules and/or rearranged during the mission.

Sections 4.0 and 5.0 contain consumables mass property data and mission independent consumable loading information for the CSM and DM, respectively.

Table 1-1 provides abbreviations and acronyms used within this volume.

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1.3 AMENDMENTS

Amendments to this document will be made by page additions, deletions, or replacements. Data changed by an amendment will be denoted by an amendment number and date in the upper right-hand corner of the page.

Any need for additional data or to depart from the use of data contained in the Operational Data Book volumes during operational planning and analysis activities should be brought to the attention of the Operational Data Branch, Integration Division, Program Operations Office, Manned Spacecraft Center.

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TABLE 1-1. SELECTED ABBREVIATIONS AND ACRONYMS

ACT	Activation
ACQ	Acquisition
ALIGN	Alignment
ANG	Angle
ASTP	Apollo/Soyuz Test Project
BIOINST	Bioinstrumentation
CAN	Canister
CAM	Camera
CK	Check
CSC	Close-Up Stereo Camera
COMPT	Compartment
CDR	Commander
CM	Command Module
CMP	Command Module Pilot
CSM	Command Service Module
COMM	Communication
CSI	Concentric Sequence Initiation
CWG	Constant Wear Garment
CONT	Container
DSEA	Data Storage Electronic Assembly
DECONTAM	Decontamination
DEPL	Depletion
DM	Docking Module
DOCK	Docking
EOI	Earth Orbit Insertion
ELECT	Electrical
ECU	Environmental Control Unit
EQUIP	Equipment
EXCL	Exclude
EXC	Excursion
EXP	Experiment
EV	Extravehicular
FWD	Forward

TABLE 1-1 (CONTINUED)

HASS	Hasselblad
INDIC	Indicator
INFLT	In-Flight
ICG	In-Flight Coverall Garment
IV	Intravehicular
JETT	Jettison
LES	Launch Escape System
LEV	Launch Escape Vehicle
LV	Launch Vehicle
LH	Left Hand
LEB	Left Hand Equipment Bay
LIQ	Liquid
MC	Main Chute
MECH	Mechanism
N/A	Not Available
NC1	Number of Orbit - Catch-Up (First Phasing Maneuver)
NC2	Number of Perigee - Catch-Up Maneuver (Second Phasing Maneuver)
NCC	Number of Orbit - Corrective Combination Maneuver
NPC	Number of Common Planar Node - Plane Change Maneuver (Related to Apogee Number as Other Maneuvers)
NSR	Number of Orbit - Slow Rate Catch-Up Initiation
OPS	Oxygen Purge System
PR	Pair
PGA	Pressure Garment Assembly
PROC	Procedure

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TABLE 1-1 (CONTINUED)

RAD	Radiation
RCS	Reaction Control System
RELOC	Relocation
RESTR	Restraint
RT	Right
RH	Right Hand
RHEB	Right Hand Equipment Bay
RSS	Root Sum Square
SCRS	Scissors
SEP	Separation
SM	Service Module
SLA	Service Module LM Adapter
SPS	Service Propulsion System
S/C	Spacecraft
STG	Stage
STOW	Stowage
SUBSYS	Subsystem
SUMP	Sump Tank
SURF	Surface
SYS	System
TEMP	Temporary
TBD	To Be Determined
TPI	Terminal Phase Initiation
TRANS	Transposition
TRANS/DOCK	Transposition and Docking
UMB	Umbilical
UPR	Upper
UEB	Upper Equipment Bay
UCTA	Urine Collection Transfer Assembly
WT	Waist Tether
W/	With
W/O	Without
XFR	Transfer

2.0 CONFIGURATION

This section provides relevant spacecraft configuration drawings, station locations, and location of various spacecraft components. Relationship of coordinate systems in the launch and docked configuration for the CSM, docking module, and Soyuz vehicles are also provided. Additionally, the mass property equations and assumptions utilized in preparing the mission sequential mass properties in Section 3 are specified. Data are presented in the following categories and order:

1. Mass Property Equations and Assumptions
2. Saturn-1B Outboard Profiles and Reference Dimensions
3. LES, CSM, DM, and SLA Outboard Profiles and Reference Dimensions at Earth Launch
4. Soyuz Outboard Profiles
5. Apollo Docked/Stacked Coordinate System Relationship
6. CSM, DM, and Soyuz Coordinate System Relationship at CSM/DM/Soyuz Docking
7. CSM Consumables Tank Locations and Engine Thrust Angles
8. DM Consumables Tank Locations

TABLE 2-1. MASS PROPERTIES EQUATIONS AND DEFINITIONS

Explanation of equations utilized for calculating mass properties presented in Section 3.

Define a right-handed three-dimensional coordinate system. Consider a composite rigid body consisting of N distinct parts with the following definitions for the j^{th} part, $j = 1, \dots, N$.

- w_j : Weight of j^{th} part
- x_j : x-Coordinate of the center of gravity of the j^{th} part
- y_j : y-Coordinate of the center of gravity of the j^{th} part
- z_j : z-Coordinate of the center of gravity of the j^{th} part
- I_{xx_j} : Moment of inertia of the j^{th} part with respect to the line passing through its center of gravity and parallel to the x-axis
- I_{yy_j} : Moment of inertia of the j^{th} part with respect to the line passing through its center of gravity and parallel to the y-axis
- I_{zz_j} : Moment of inertia of the j^{th} part with respect to the line passing through its center of gravity and parallel to the z-axis
- I_{xy_j} : Product of inertia of the j^{th} part with respect to the lines parallel to the x and y axes and passing through its center of gravity
- I_{yz_j} : Product of inertia of the j^{th} part with respect to the lines parallel to the y and z axes and passing through its center of gravity
- I_{xz_j} : Product of inertia of the j^{th} part with respect to the lines parallel to the x and z axes and passing through its center of gravity

For purposes of clarification; if the j^{th} body occupies the region V_j and $\rho_j(x, y, z)$ is its weight per unit volume at a point x, y, z in V_j , then the preceding moments of inertia are defined by the following integrals:

TABLE 2-1. (CONTINUED)

$$I_{xx_j} = \iiint_{V_j} [(y-y_j)^2 + (z-z_j)^2] \rho_j(x,y,z) dx dy dz$$

$$I_{yy_j} = \iiint_{V_j} [(x-x_j)^2 + (z-z_j)^2] \rho_j(x,y,z) dx dy dz$$

$$I_{zz_j} = \iiint_{V_j} [(x-x_j)^2 + (y-y_j)^2] \rho_j(x,y,z) dx dy dz$$

$$I_{xy_j} = \iiint_{V_j} (x-x_j) (y-y_j) \rho_j(x,y,z) dx dy dz$$

$$I_{yz_j} = \iiint_{V_j} (y-y_j) (z-z_j) \rho_j(x,y,z) dx dy dz$$

$$I_{xz_j} = \iiint_{V_j} (x-x_j) (z-z_j) \rho_j(x,y,z) dx dy dz$$

The mass characteristics of the composite body are therefore:

TOTAL WEIGHT OF COMPOSITE BODY

$$w = \sum_{j=1}^n w_j$$

CENTER OF GRAVITY OF COMPOSITE BODY

$$\bar{x} = \frac{1}{w} \sum_{j=1}^n w_j x_j, \quad \bar{y} = \frac{1}{w} \sum_{j=1}^n w_j y_j, \quad \bar{z} = \frac{1}{w} \sum_{j=1}^n w_j z_j$$

MOMENTS AND PRODUCTS OF INERTIA OF COMPOSITE BODY

These moments and products of inertia are with respect to the coordinate system obtained by a simple translation of the origin of the initial coordinate system to the center of gravity of the composite body.

$$I_{xx} = \sum_{j=1}^n I_{xx_j} + \sum_{j=1}^n (y_j^2 + z_j^2) w_j - (y^{-2} + z^{-2})w$$

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TABLE 2-1 (CONTINUED)

$$I_{yy} = \sum_{j=1}^n I_{yy_j} + \sum_{j=1}^n (x_j^2 + z_j^2) w_j - (x^{-2} + z^{-2}) w$$

$$I_{zz} = \sum_{j=1}^n I_{zz_j} + \sum_{j=1}^n (x_j^2 + y_j^2) w_j - (x^{-2} + y^{-2}) w$$

$$I_{xy} = \sum_{j=1}^n I_{xy_j} + \sum_{j=1}^n x_j y_j w_j - \bar{x} \bar{y} w$$

$$I_{yz} = \sum_{j=1}^n I_{yz_j} + \sum_{j=1}^n y_j z_j w_j - \bar{y} \bar{z} w$$

$$I_{xz} = \sum_{j=1}^n I_{xz_j} + \sum_{j=1}^n x_j z_j w_j - \bar{x} \bar{z} w$$

MOMENTS OF INERTIA WITH RESPECT TO THE PRINCIPAL AXES

By means of the preceding equations we can compute each entry in the inertia matrix A which is defined by

$$A \equiv \begin{pmatrix} I_{xx} & -I_{xy} & -I_{xz} \\ -I_{xy} & I_{yy} & -I_{yz} \\ -I_{xz} & -I_{yz} & I_{zz} \end{pmatrix}$$

The inertia matrix A can be shown to be positive semidefinite. In fact, A is a positive definite, except when the composite body is a one-dimensional spread or rod. Ruling out this possibility in practice, we can assume that A is positive definite. It therefore follows that the determinant of A is positive.

The characteristic equation for the eigenvalues λ of A is simply

$$\begin{vmatrix} I_{xx}-\lambda & -I_{xy} & -I_{xz} \\ -I_{xy} & I_{yy}-\lambda & -I_{yz} \\ -I_{xz} & -I_{yz} & I_{zz}-\lambda \end{vmatrix} = 0$$

TABLE 2-1 (CONTINUED)

which is equivalent to the cubic equation

$$\lambda^3 - \beta_1 \lambda^2 + \beta_2 \lambda + \beta_3 = 0$$

where

$$\beta_1 = I_{xx} + I_{yy} + I_{zz}$$

$$\beta_2 = \begin{vmatrix} I_{xx} & -I_{xy} \\ -I_{xy} & I_{yy} \end{vmatrix} + \begin{vmatrix} I_{xx} & -I_{xz} \\ -I_{xz} & I_{zz} \end{vmatrix} + \begin{vmatrix} I_{yy} & -I_{yz} \\ -I_{yz} & I_{zz} \end{vmatrix},$$

$$\beta_3 = \begin{vmatrix} I_{xx} & -I_{xy} & -I_{xz} \\ -I_{xy} & I_{yy} & -I_{yz} \\ -I_{xz} & -I_{yz} & I_{zz} \end{vmatrix}.$$

The roots of the cubic equation, $BI_{x'}$, $\underline{\ge}BI_{y'}$, $\underline{\ge}BI_{z'}$, are the moments of inertia of the composite body with respect to its principal axes x' , y' , z' . The directions of the axes are given by the orthonormal eigenvectors for their respective eigenvalues.

TABLE 2-2. COORDINATE SYSTEM NOTATION DEFINITIONS

a) Apollo Spacecraft Coordinate System (A6)

The Apollo spacecraft coordinate system origin is located 1000 inches below the CM heat shield outer mold line on the launch vehicle X-axis. The +X-axis is toward the CM nose, the +Z-axis in the direction of the crew's feet, and the +Y-axis forms a right-handed system. (Reference IED 50401, dated 15 July 1972, as amended.)

Note: The Apollo spacecraft coordinate system remains fixed relative to the CSM.

b) Soyuz Spacecraft Coordinate System (C6)

The Soyuz spacecraft coordinate system origin is 280.7 inches forward of the DM/Soyuz Docking Interface. The Soyuz spacecraft coordinate system -X-axis extends through the vehicle from the origin in the direction of the docking interface, and requires a 90° rotation about the X_{C6} -axis to align Y_{C6} and Z_{C6} with the Y_A and Z_A coordinate axes, respectively. (Reference IED 50401, dated 15 July 1972, as amended.)

c) Command Module Coordinate System (C)

The command module coordinate system origin is X_A (Apollo station) 1000.0. The +X-, +Y-, and +Z-axes are similarly directed to those of the Apollo coordinate system.

d) Service Module Coordinate System (S)

The service module coordinate system origin is X_A (Apollo station) 638.0. The +X-, +Y-, and +Z-axes are similarly directed to those of the Apollo coordinate system.

e) Launch Escape System Coordinate System (L)

The LES coordinate system origin is at the LES/CSM interface, X_A (Apollo station) 1083.5 and on the longitudinal vehicle axis. The +X-, +Y-, and +Z-axes are parallel to the +X-, +Y-, and +Z-axes of the launch vehicle, respectively.

f) Launch Vehicle Coordinate System (LV)

The launch vehicle coordinate system origin is 100 inches below the S-IB gimbal reference plane and on the longitudinal vehicle axis. The +X-axis is toward the payload, the +Z-axis is through position III and is opposite the direction of launch (target), and the +Y-axis forms a right-handed system.

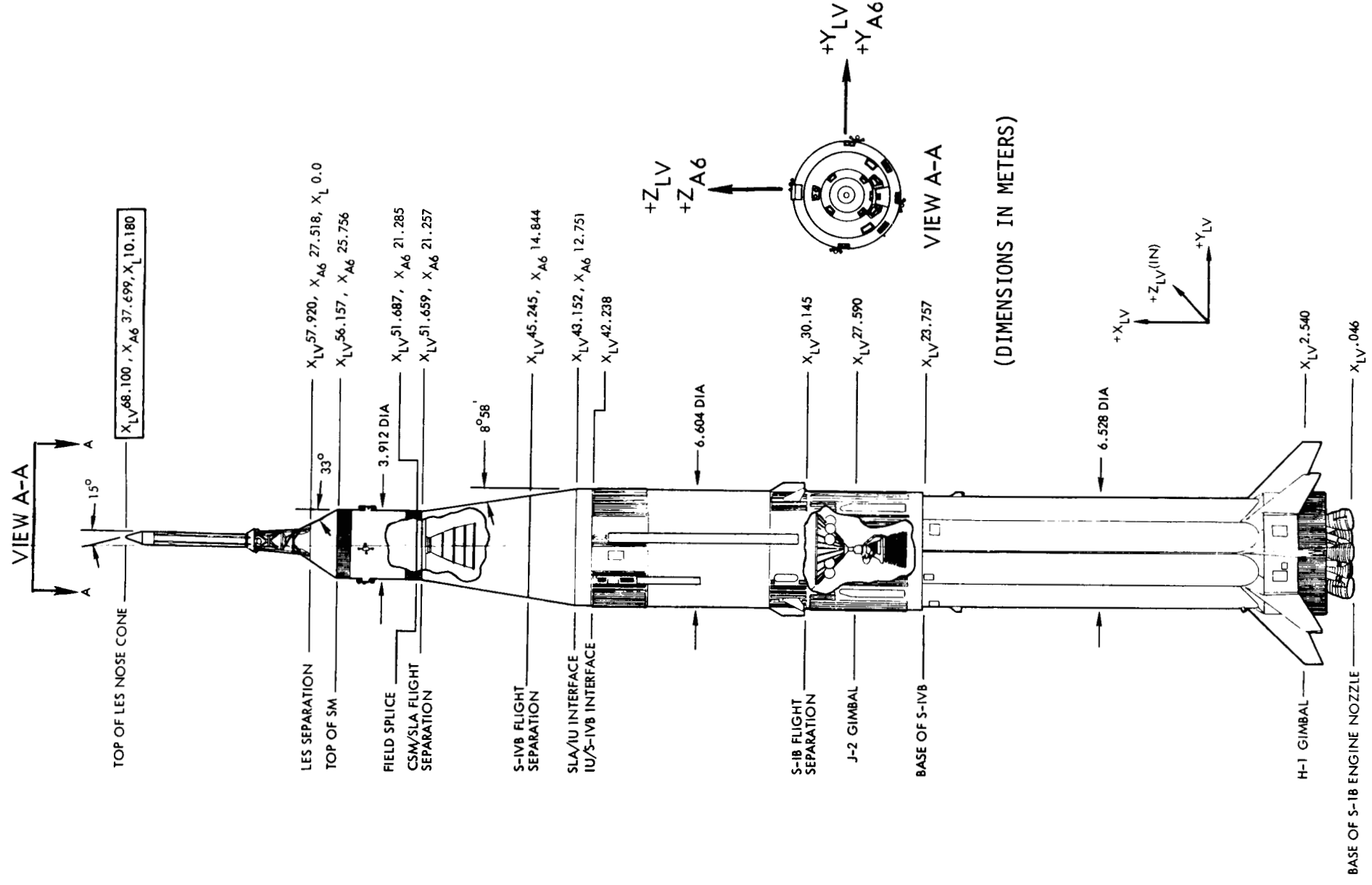
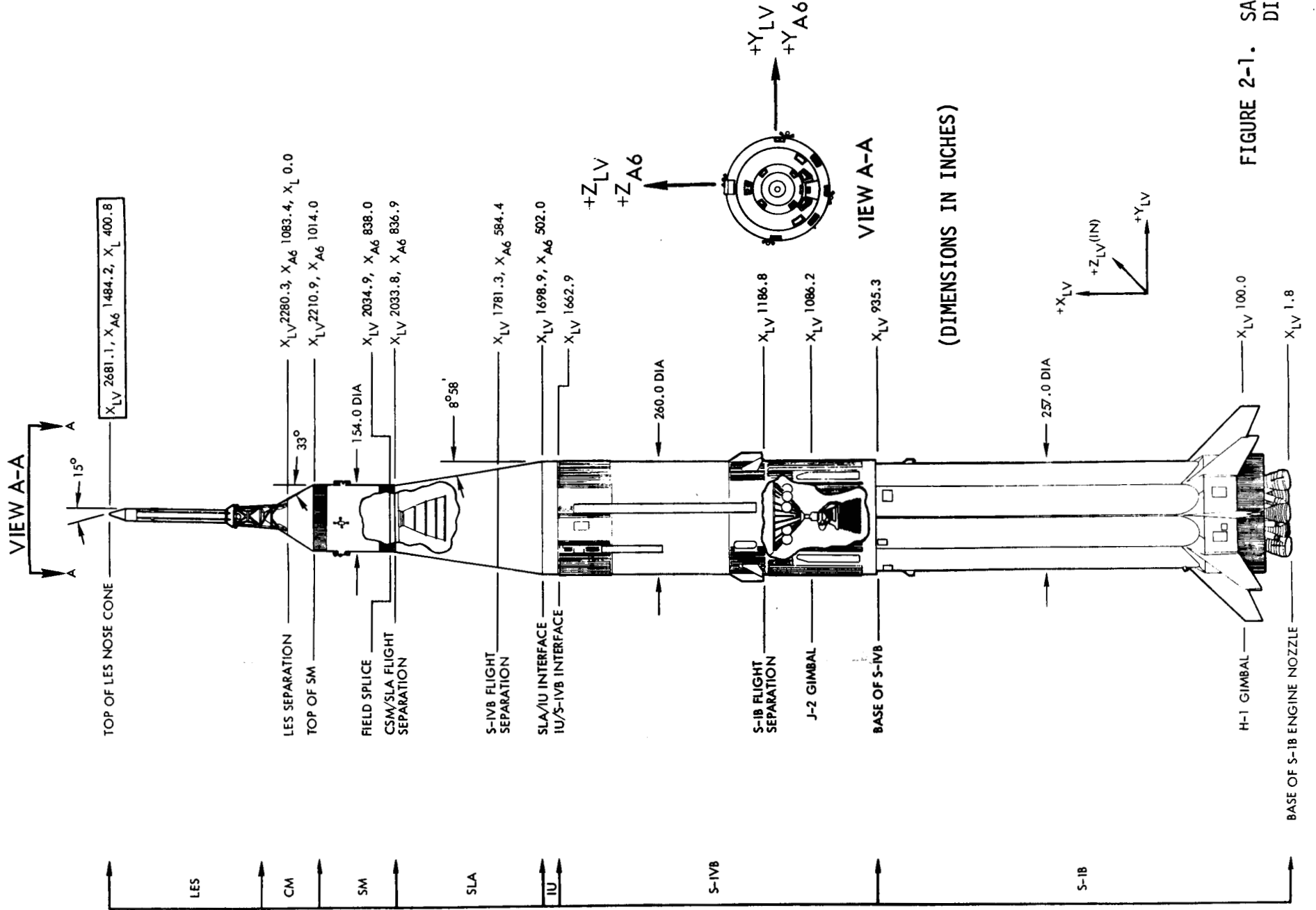
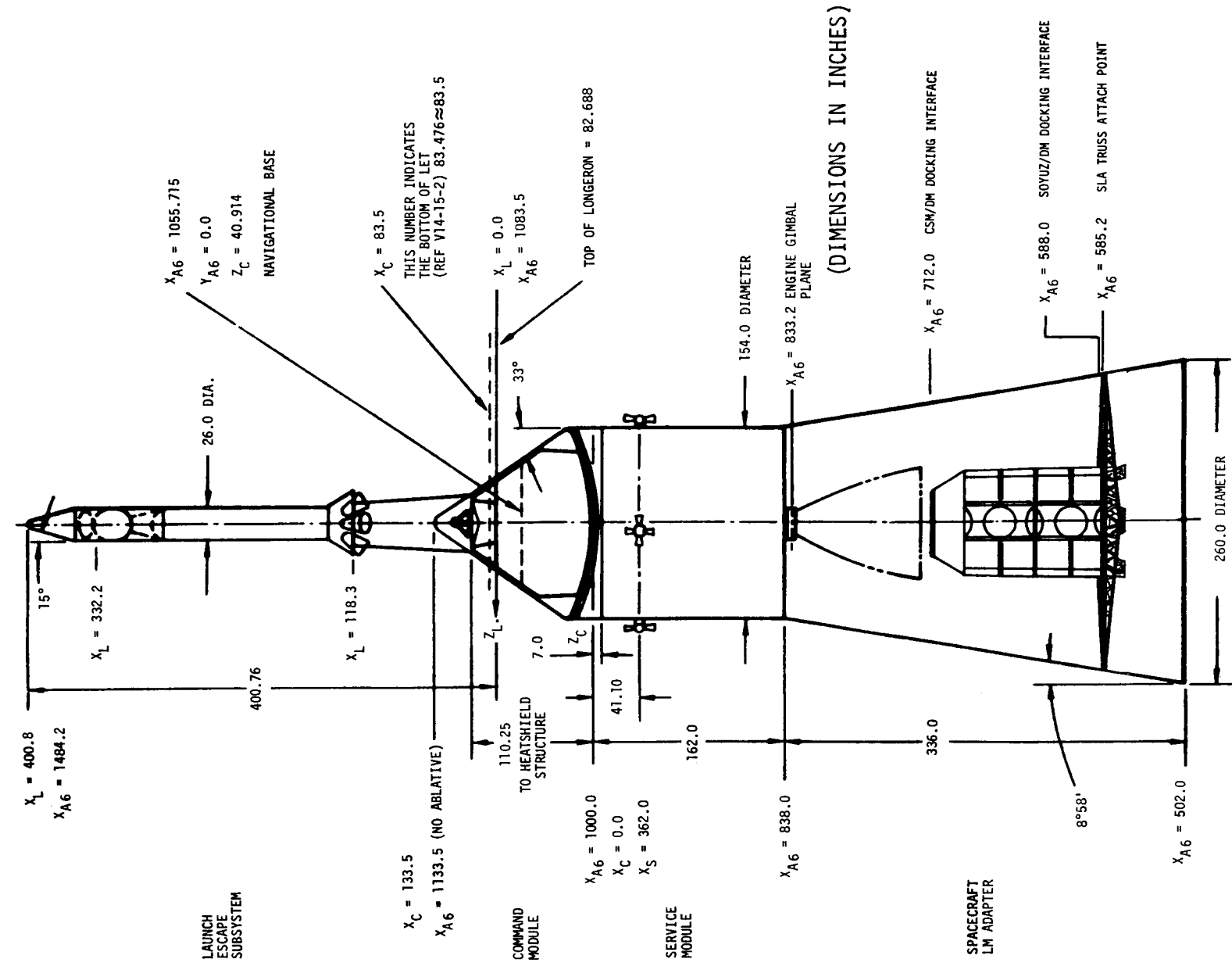
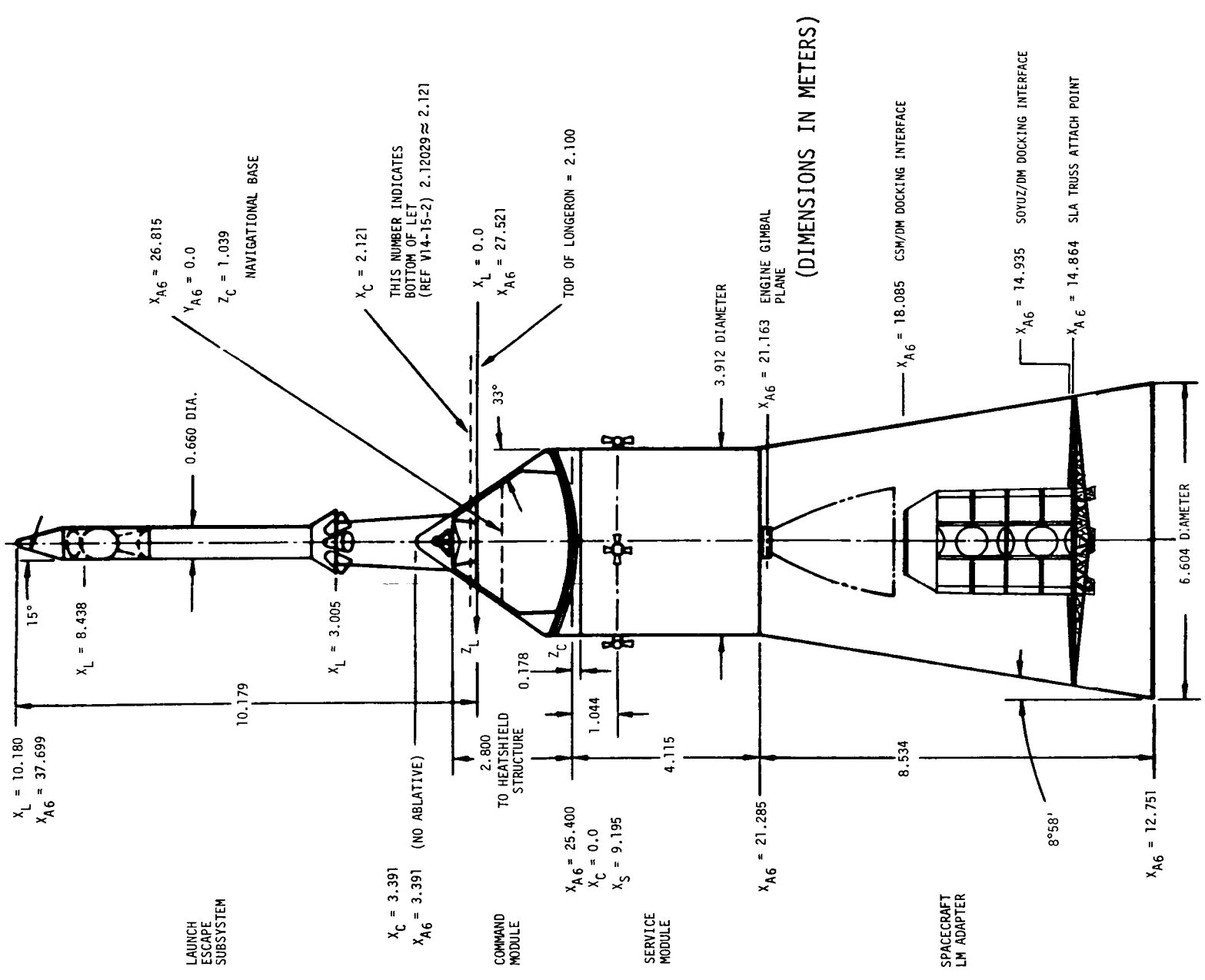


FIGURE 2-1. SATURN 1-B REFERENCE DIMENSIONS



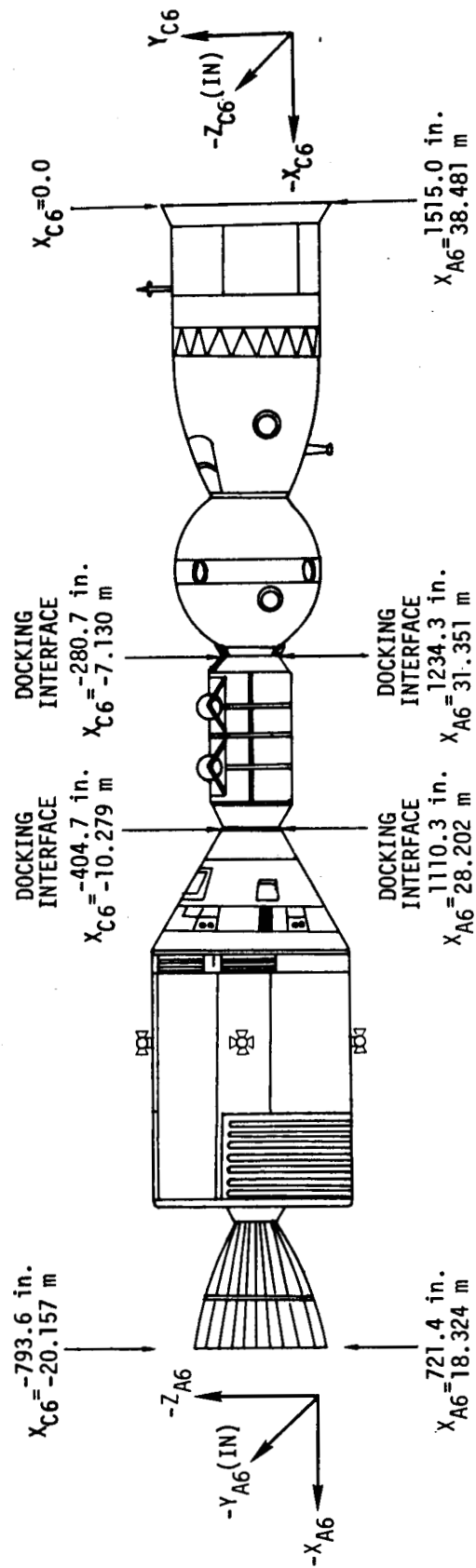
(DIMENSIONS IN INCHES)

FIGURE 2-2. LES/CSM/DM/SLA REFERENCE DIMENSIONS



(DIMENSIONS IN METERS)

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SOYUZ SPACECRAFT COORDINATE = X_{C6}
 APOLLO SPACECRAFT COORDINATE = X_{A6}

FIGURE 2-5. APOLLO/SOYUZ REFERENCE DIMENSIONS AND COORDINATE SYSTEMS

APOLLO SPACECRAFT
COORDINATES - STACKED
POSITION (X_{A6})

APOLLO SPACECRAFT
COORDINATES - DOCKED
POSITION (X_{A6})

TO TRANSFORM DM MASS PROPERTIES IN THE
APOLLO STACKED CONFIGURATION TO THE
APOLLO DOCKED CONFIGURATION USE THE
FOLLOWING EQUATIONS:

APOLLO DOCKED	APOLLO STACKED
X	= $\begin{cases} 1822.3 \text{ in.} \\ 46.287 \text{ m} \end{cases} -X$
Y	= Y
Z	= -Z
IXX	= IXX
IYY	= IYY
IZZ	= IZZ
IXY	= -IXY
IXZ	= IXZ
IYZ	= -IYZ

THE ABOVE EQUATIONS INDICATE A 180°
ROTATION ABOUT THE Y_{A6} - AXIS IN THE
APOLLO STACKED CONFIGURATION.

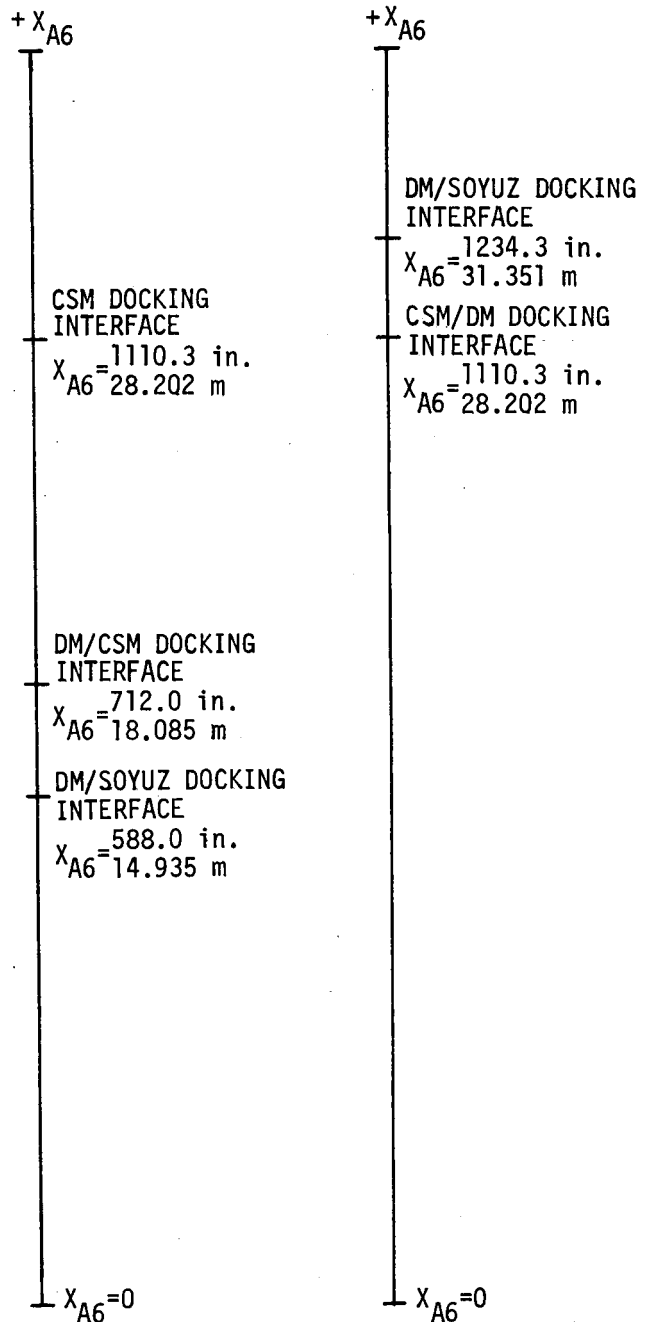


FIGURE 2-6. CSM/DM STACKED AND DOCKED COORDINATE SYSTEMS

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TO TRANSFORM THE MASS PROPERTIES IN THE SOYUZ COORDINATE SYSTEM TO THE APOLLO DOCKED COORDINATE SYSTEM USE THE FOLLOWING EQUATIONS:

APOLLO DOCKED	SOYUZ
X	= $\begin{Bmatrix} 1515.0 \text{ in.} \\ 34.481 \text{ m} \end{Bmatrix} +X$
Y	= Z
-Z	= Y
IXX	= IXX
IYY	= IZZ
IZZ	= IYY
IXY	= IXZ
IXZ	= -IXY
IYZ	= -IYZ

THE ABOVE EQUATIONS INDICATE A POSITIVE 90° ROTATION ABOUT THE X_{C6}-AXIS IN THE DOCKED CONFIGURATION.

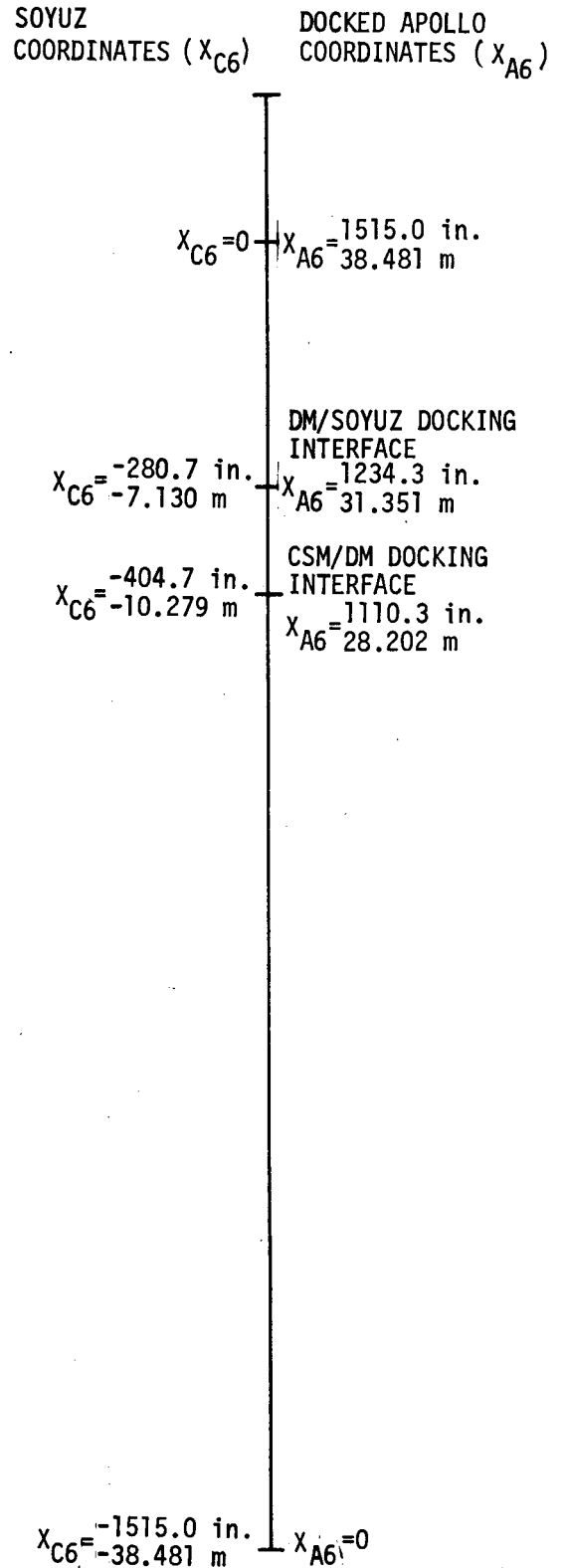
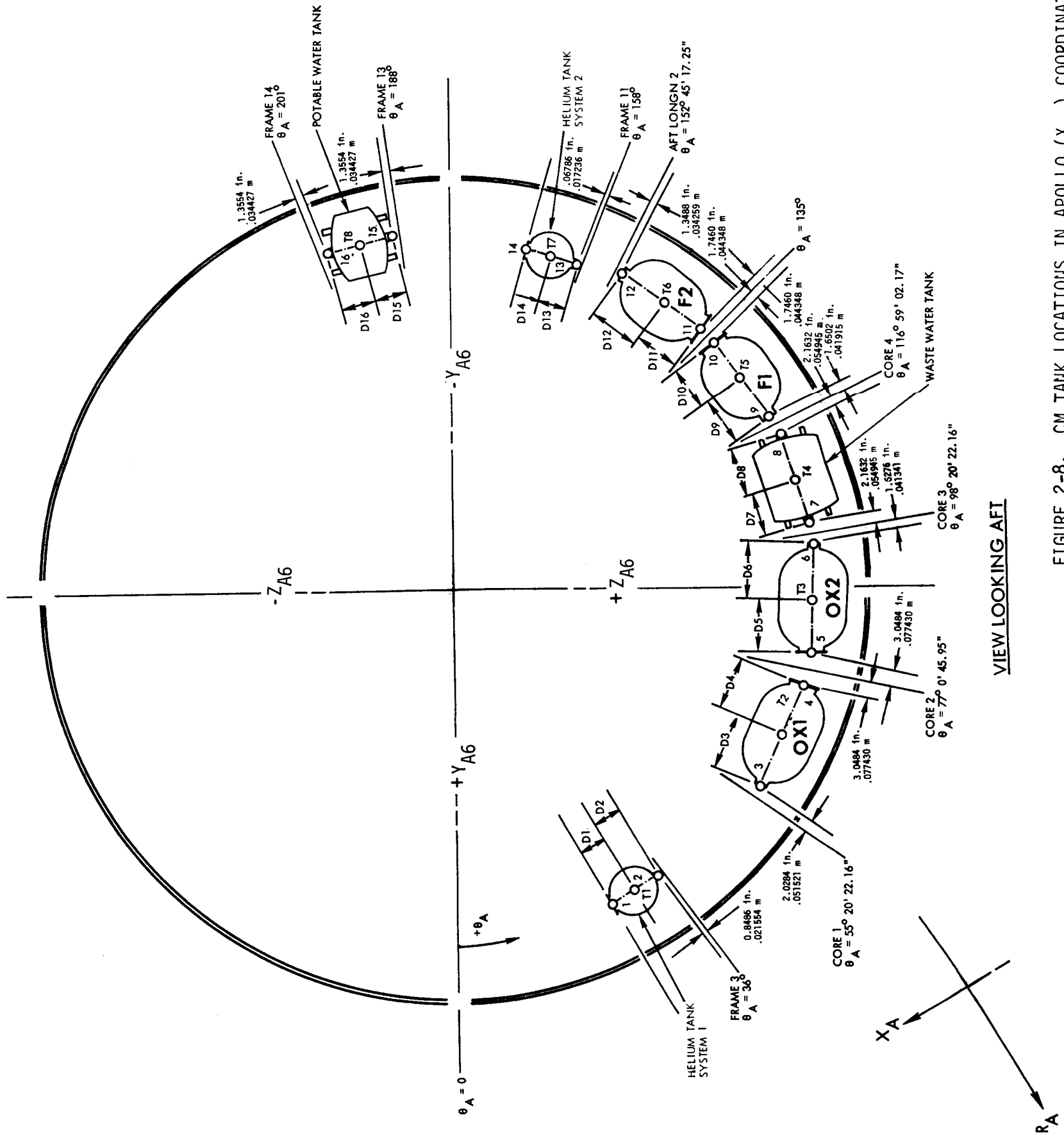


FIGURE 2-7. CSM/DM/SOYUZ DOCKED COORDINATE SYSTEMS



OX1 - SYSTEM 1 OXIDIZER TANK
 OX2 - SYSTEM 2 OXIDIZER TANK
 F1 - SYSTEM 1 FUEL TANK
 F2 - SYSTEM 2 FUEL TANK

*OXIDIZER AND FUEL TANKS HAVE
 DIAMETER OF 12.62 IN./3205 M

PT	YA6	YA6	ZA6	DISTANCE
1	1022.6000 in. 25.974092 m	57.3372 in. 1.456368 m	28.8372 in. .732466 m	4.81000 in. .122174 m
2		52.4137 in. 1.331311 m	37.0319 in. .940612 m	4.75000 in. .120650 m
3		36.0274 in. .914945 m	55.6649 in. 1.413891 m	10.2895 in. .261354 m
4		17.8326 in. .452949 m	63.7554 in. 1.619390 m	9.6175 in. .244285 m
5		11.8917 in. .302050 m	65.1255 in. 1.654191 m	9.6175 in. .244285 m
6		-8.0033 in. -.203284 m	65.8185 in. 1.671793 m	10.2895 in. .261354 m
7		-11.7159 in. -.297584 m	65.0097 in. 1.651250 m	8.56000 in. .217424 m
8		-28.0290 in. -.711938 m	59.8155 in. 1.519317 m	8.56000 in. .217424 m
9		-31.4605 in. -.799098 m	58.1506 in. 1.477028 m	9.0005 in. .228613 m
10		-45.4375 in. -1.154115 m	47.9067 in. 1.216833 m	8.3285 in. .211544 m
11		-47.9067 in. -1.216833 m	45.4375 in. 1.154115 m	8.3285 in. .211544 m
12		-58.1506 in. -1.477028 m	31.4605 in. .799098 m	9.0005 in. .228613 m
13		-59.7521 in. -1.517706 m	23.4095 in. .594602 m	4.75000 in. .120650 m
14		-62.5468 in. -1.588692 m	14.2672 in. .362387 m	4.81000 in. .122174 m
15		-65.0403 in. -1.652027 m	-10.5095 in. -.266943 m	6.11000 in. .155194 m
16	1022.6000 in. 25.974092 m	-61.9807 in. -1.574313 m	-22.3403 in. -.567445 m	6.11000 in. .155194 m

PT	YA6	YA6	ZA6	RA	θA
T1	1022.6000 in. 25.974092 m	54.8600 in. 1.393447 m	32.9603 in. .837193 m	64.0000 in. 1.625603 m	30°59'51.90"
T2		26.6200 in. .676149 m	59.8467 in. 1.520109 m	65.5000 in. 1.663703 m	66°09'13.25"
T3		2.2800 in. .057912 m	65.4603 in. 1.662695 m	65.5000 in. 1.663703 m	88°00'18.64"
T4		-19.8725 in. -.504763 m	62.4126 in. 1.585283 m	65.5000 in. 1.663703 m	107°39'42.17"
T5		-38.7200 in. -.983490 m	52.8300 in. 1.341885 m	65.5000 in. 1.663703 m	126°14'17.90"
T6		-52.8300 in. -1.341885 m	38.7200 in. .983490 m	65.5000 in. 1.663703 m	143°45'42.10"
T7		-61.1407 in. -1.552977 m	18.8670 in. .479223 m	63.9855 in. 1.625235 m	162°51'02.14"
T8	1022.6000 in. 25.974092 m	-63.5105 in. -1.613170 m	-16.4249 in. -.417193 m	65.6000 in. 1.666243 m	194°30'

FIGURE 2-8. CM TANK LOCATIONS IN APOLLO (XA6) COORDINATE SYSTEM

SM RCS QUAD A AND C

TABLE POINT NUMBER	Y A6			Z A6		
	QUAD A	QUAD C	QUAD A	QUAD C	QUAD A	QUAD C
3	1.708 in. .04338 m	-1.708 in. -.04338 m	-69.818 in. -1.77338 m	-69.818 in. -1.77338 m	69.818 in. 1.77338 m	69.818 in. 1.77338 m
4	7.346 in. .18659 m	-7.346 in. -.18659 m	-68.688 in. -1.74468 m	-68.688 in. -1.74468 m	68.688 in. 1.74468 m	68.688 in. 1.74468 m
5	7.346 in. .18659 m	-7.346 in. -.18659 m	-68.688 in. -1.74468 m	-68.688 in. -1.74468 m	68.688 in. 1.74468 m	68.688 in. 1.74468 m
6	7.346 in. .18659 m	-7.346 in. -.18659 m	-68.688 in. -1.74468 m	-68.688 in. -1.74468 m	68.688 in. 1.74468 m	68.688 in. 1.74468 m
7	-15.535 in. -.39459 m	15.535 in. .39459 m	-68.083 in. -1.72931 m	-68.083 in. -1.72931 m	68.083 in. 1.72931 m	68.083 in. 1.72931 m

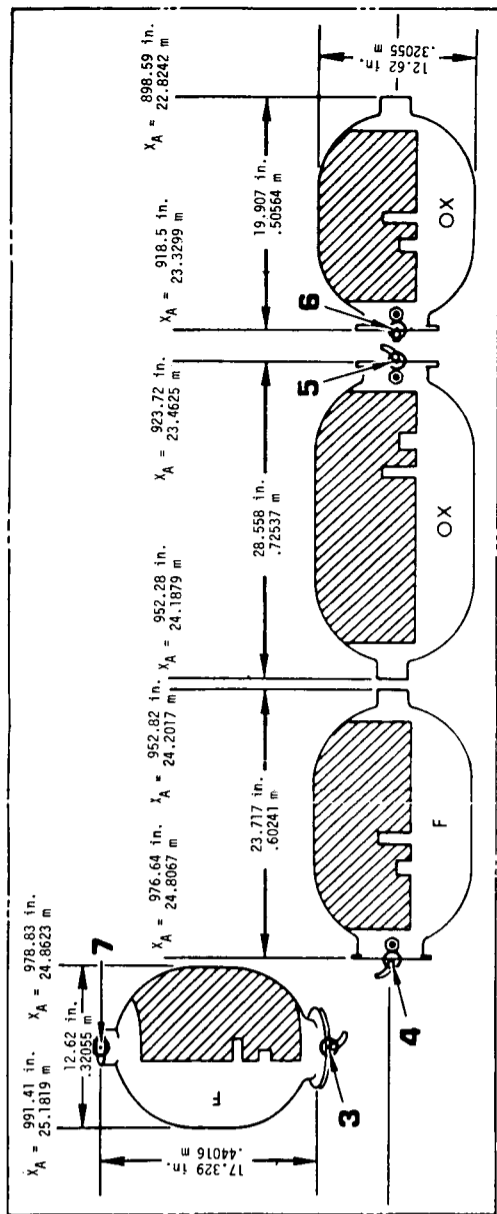


TABLE POINT NUMBER	Y A6			Z A6		
	QUAD B	QUAD D	QUAD B	QUAD D	QUAD B	QUAD D
3	67.171 in. 1.70615 m	-67.171 in. -1.70615 m	-19.123 in. -.48573 m	-19.123 in. -.48573 m	19.123 in. .48573 m	19.123 in. .48573 m
4	64.665 in. 1.64249 m	-64.665 in. -1.64249 m	-24.300 in. -.61722 m	-24.300 in. -.61722 m	24.300 in. .61722 m	24.300 in. .61722 m
5	64.665 in. 1.64249 m	-64.665 in. -1.64249 m	-24.300 in. -.61722 m	-24.300 in. -.61722 m	24.300 in. .61722 m	24.300 in. .61722 m
6	64.665 in. 1.64249 m	-64.665 in. -1.64249 m	-24.300 in. -.61722 m	-24.300 in. -.61722 m	24.300 in. .61722 m	24.300 in. .61722 m
7	69.805 in. 1.77305 m	-69.805 in. -1.77305 m	-1.995 in. -.05067 m	-1.995 in. -.05067 m	1.995 in. .05067 m	1.995 in. .05067 m

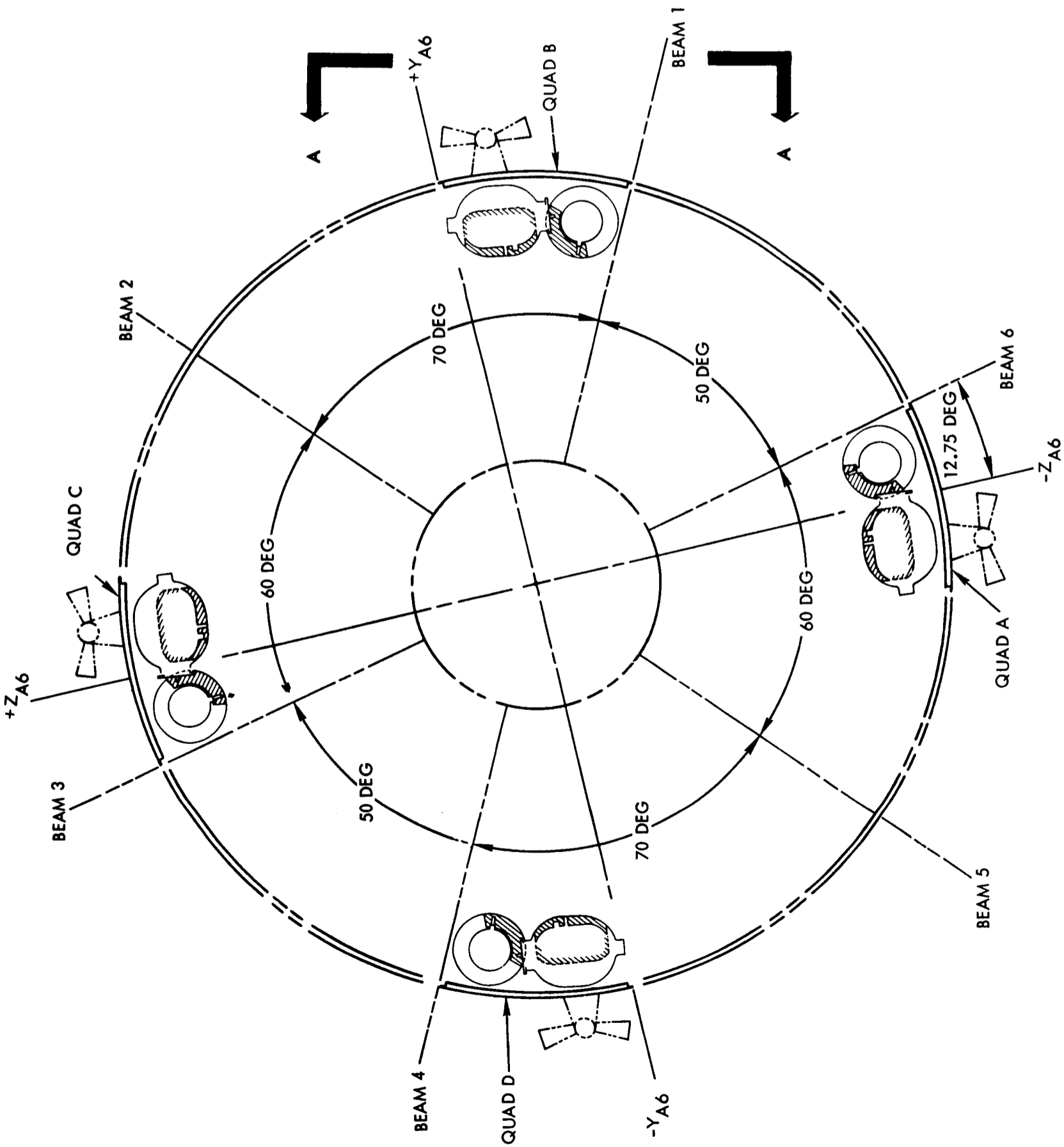


FIGURE 2-9. SM/RCS TANK LOCATIONS IN APOLLO (X_{A6}) COORDINATE SYSTEM

PSM	TANK CENTER OF GRAVITY		
	X_{A6}	Y_{A6}	Z_{A6}
Oxidizer 1	931.8 in. 23.668 m	20.7 in. .526 m	-21.8 in. -.554 m
Oxidizer 2	931.8 in. 23.668 m	17.1 in. .434 m	-34.5 in. -.876 m
Oxidizer 3	931.8 in. 23.668 m	32.4 in. .823 m	-27.8 in. -.706 m
Oxidizer 4	931.8 in. 23.668 m	19.8 in. .503 m	-47.5 in. -1.207 m
Oxidizer 5	931.8 in. 23.668 m	43.8 in. 1.112 m	-34.0 in. -.864 m
Fuel 1	931.8 in. 23.668 m	31.3 in. .795 m	-41.0 in. -1.041 m
Fuel 2	931.8 in. 23.668 m	23.2 in. .589 m	-61.5 in. -1.562 m
Fuel 3	931.8 in. 23.668 m	34.7 in. .881 m	-55.4 in. -1.407 m
Fuel 4	931.8 in. 23.668 m	46.2 in. 1.173 m	-48.6 in. -1.234 m

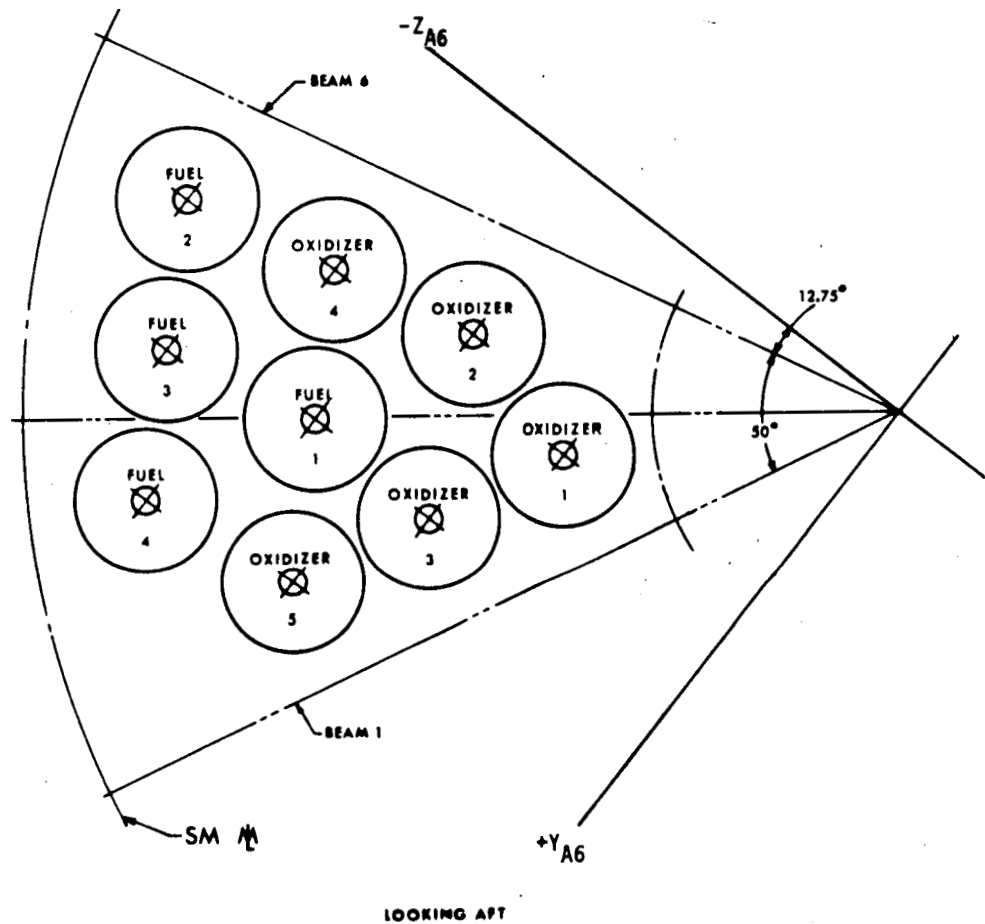
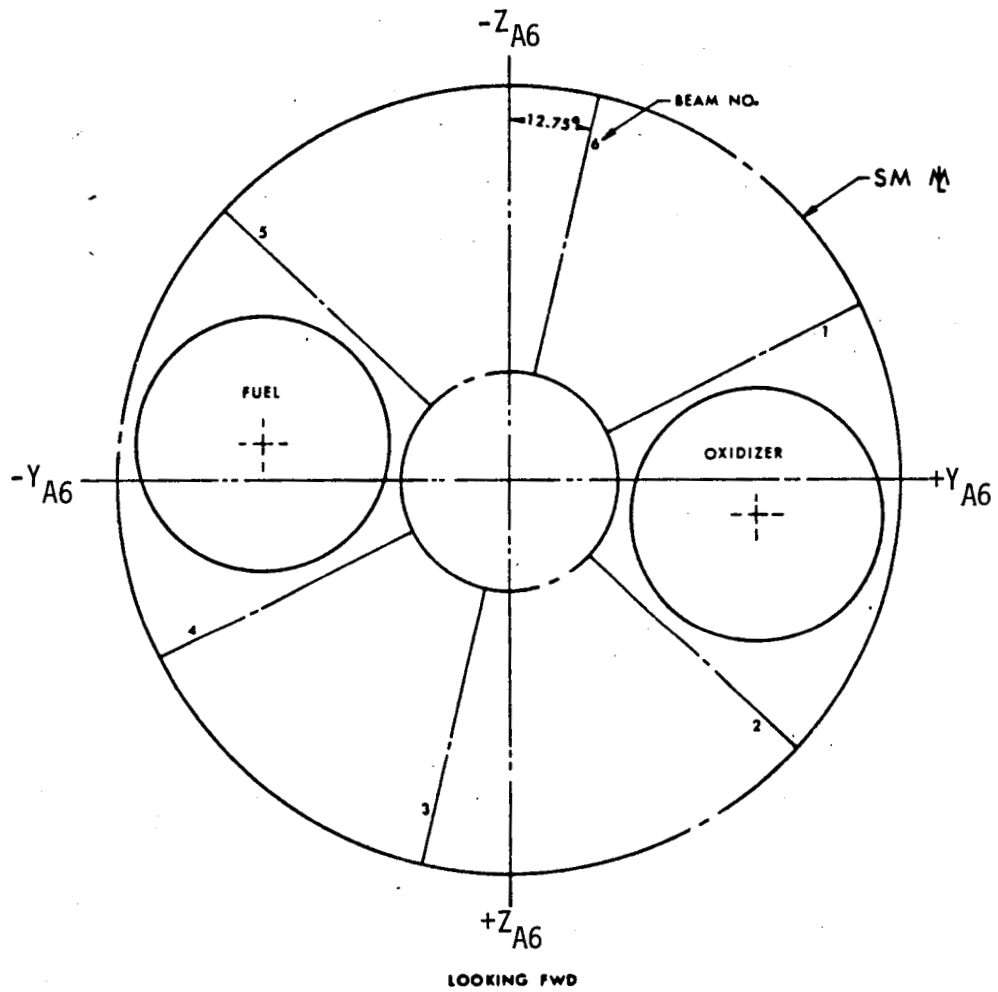


FIGURE 2-10. SM RCS PROPELLANT STORAGE MODULE (PSM) CONFIGURATION (APOLLO COORDINATES X_{A6})

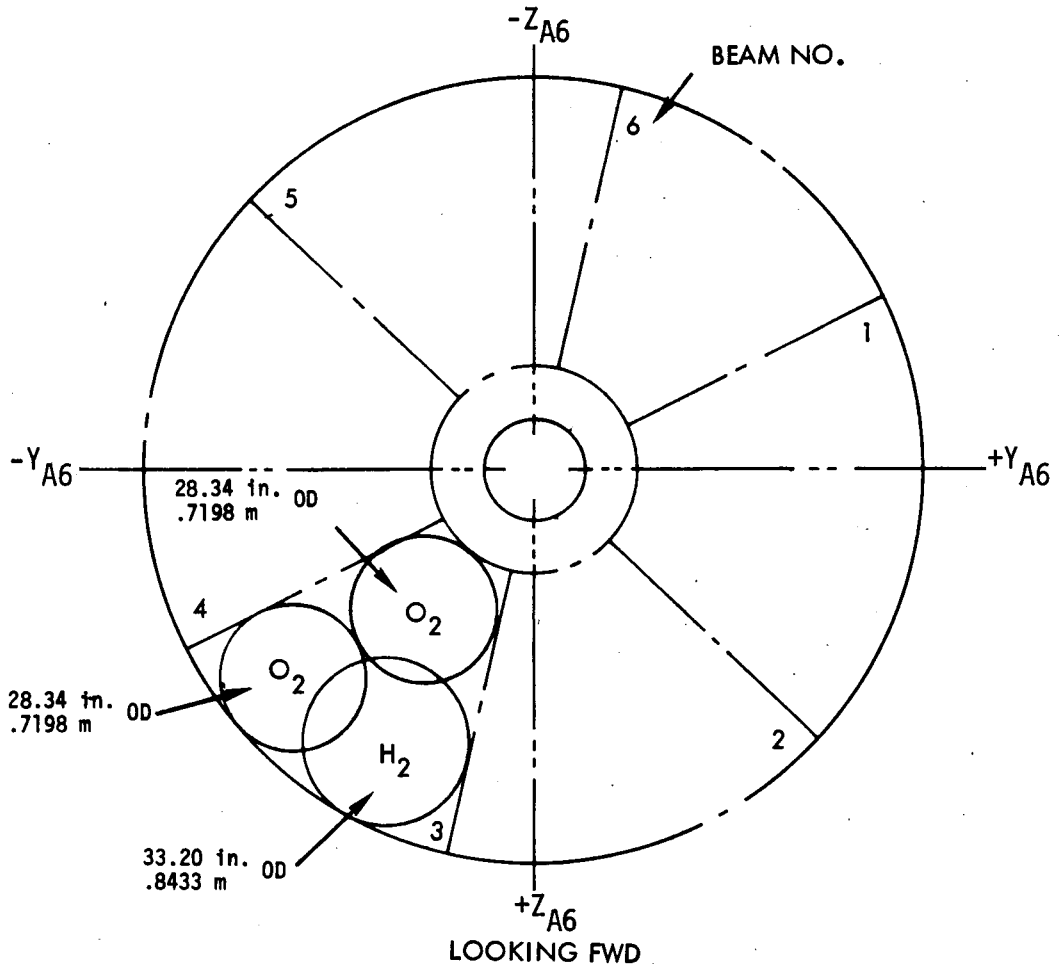
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TANKS	TANK CENTER OF GRAVITY		
	X_{A6}	Y_{A6}	Z_{A6}
SPS Oxidizer	909.0 in. 23.089 m	48.3 in. 1.227 m	6.6 in. .168 m
SPS Fuel	909.0 in. 23.089 m	-48.3 in. -1.227 m	-6.6 in. -.168 m

FIGURE 2-11. SM SPS TANK CONFIGURATION WITH C.G. LOCATIONS (APOLLO COORDINATES X_{A6})

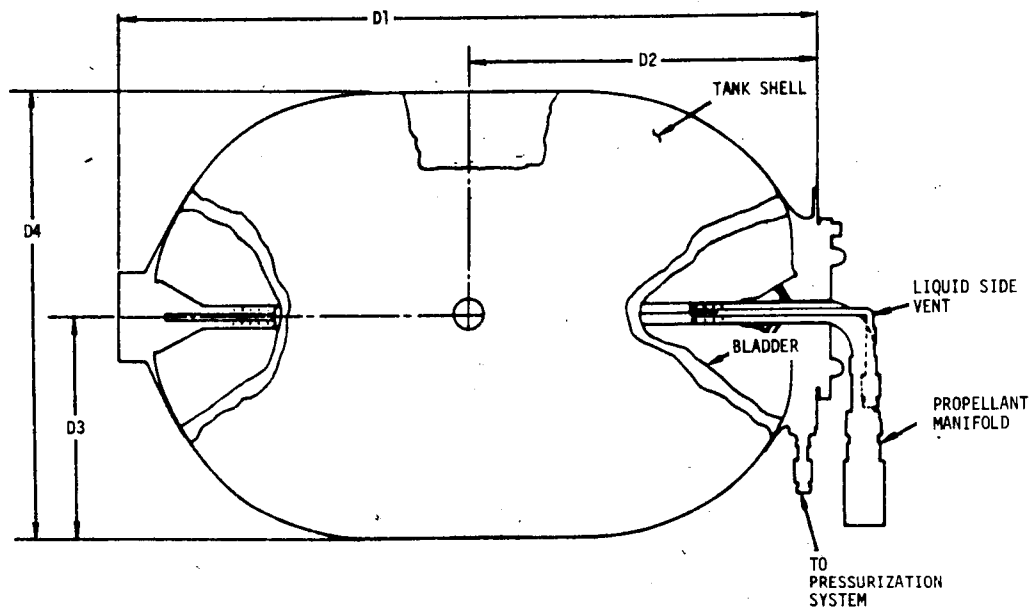
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TANKS	TANK CENTER OF GRAVITY		
	X _{A6}	Y _{A6}	Z _{A6}
LH ₂ No. 1 Tank	892.9 in. 22.680 m	-40.7 in. -1.034 m	41.2 in. 1.046 m
LH ₂ No. 2 Tank	859.4 in. 21.829 m	-40.7 in. -1.034 m	41.2 in. 1.046 m
LO ₂ No. 1 Tank	920.8 in. 23.388 m	-20.9 in. -.531 m	26.9 in. .674 m
LO ₂ No. 2 Tank	920.8 in. 23.388 m	-27.4 in. -.696 m	54.5 in. 1.384 m

FIGURE 2-12. SM CRYOGENIC TANK CONFIGURATION WITH C.G. LOCATIONS (APOLLO COORDINATES X_{A6})

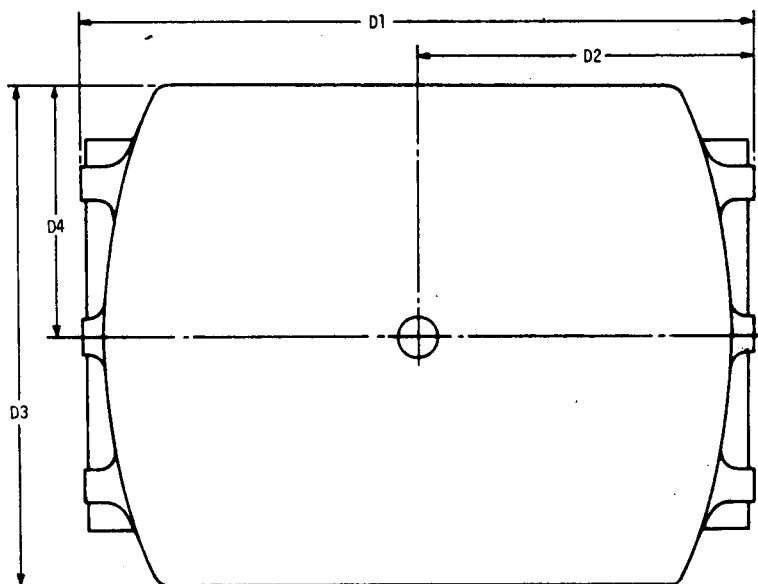
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TANKS	DIMENSIONS			
	D1	D2	D3	D4
CM Oxidizer	19.9 in. .505 m	9.6 in. .244 m	6.3 in. .160 m	12.6 in. .320 m
CM Fuel	17.3 in. .439 m	8.3 in. .211 m	6.3 in. .160 m	12.6 in. .320 m
PSM Oxidizer	37.8 in. .960 m	18.9 in. .480 m	6.3 in. .160 m	12.5 in. .318 m
PSM Fuel	37.8 in. .960 m	18.9 in. .480 m	6.3 in. .160 m	12.5 in. .318 m
SM Primary Oxidizer	28.6 in. .726 m	14.3 in. .363 m	6.3 in. .160 m	12.5 in. .318 m
SM Secondary Oxidizer	19.9 in. .505 m	9.6 in. .244 m	6.3 in. .160 m	12.6 in. .320 m
SM Primary Fuel	23.7 in. .602 m	11.9 in. .302 m	6.3 in. .160 m	12.6 in. .320 m
SM Secondary Fuel	17.3 in. .439 m	8.3 in. .211 m	6.3 in. .160 m	12.6 in. .320 m

FIGURE 2-13. CM AND SM RCS TANKS CUTAWAY VIEW AND DIMENSIONS

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TANKS	DIMENSIONS			
	D1	D2	D3	D4
CM Potable Water	12.2 in. .310 m	6.1 in. .155 m	12.3 in. .312 m	6.1 in. .155 m
CM Waste Water	17.1 in. .434 m	8.6 in. .218 m	12.3 in. .312 m	6.1 in. .155 m

FIGURE 2-14. CM WATER TANKS AND DIMENSIONS

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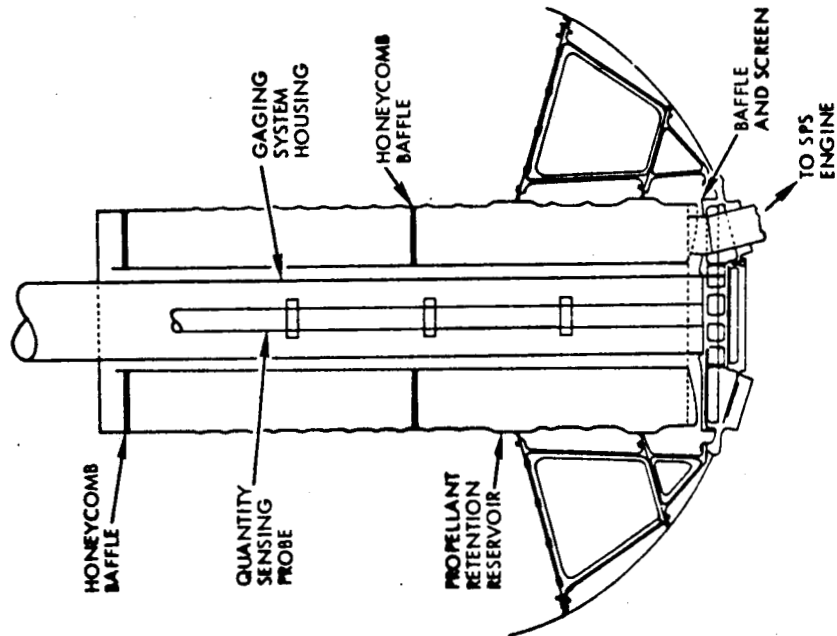
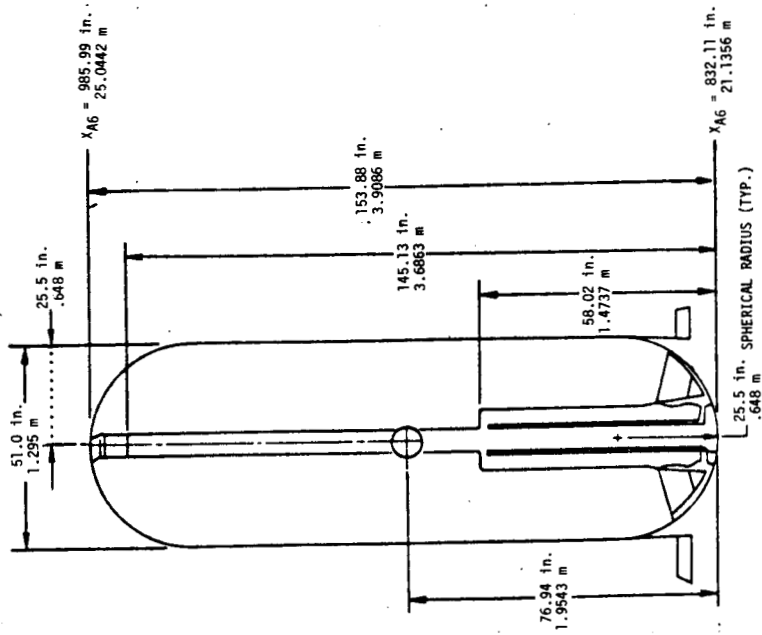


FIGURE 2-15. SPS TANK CUTAWAY VIEW AND DIMENSIONS

MSC-07765 (VOL. II)

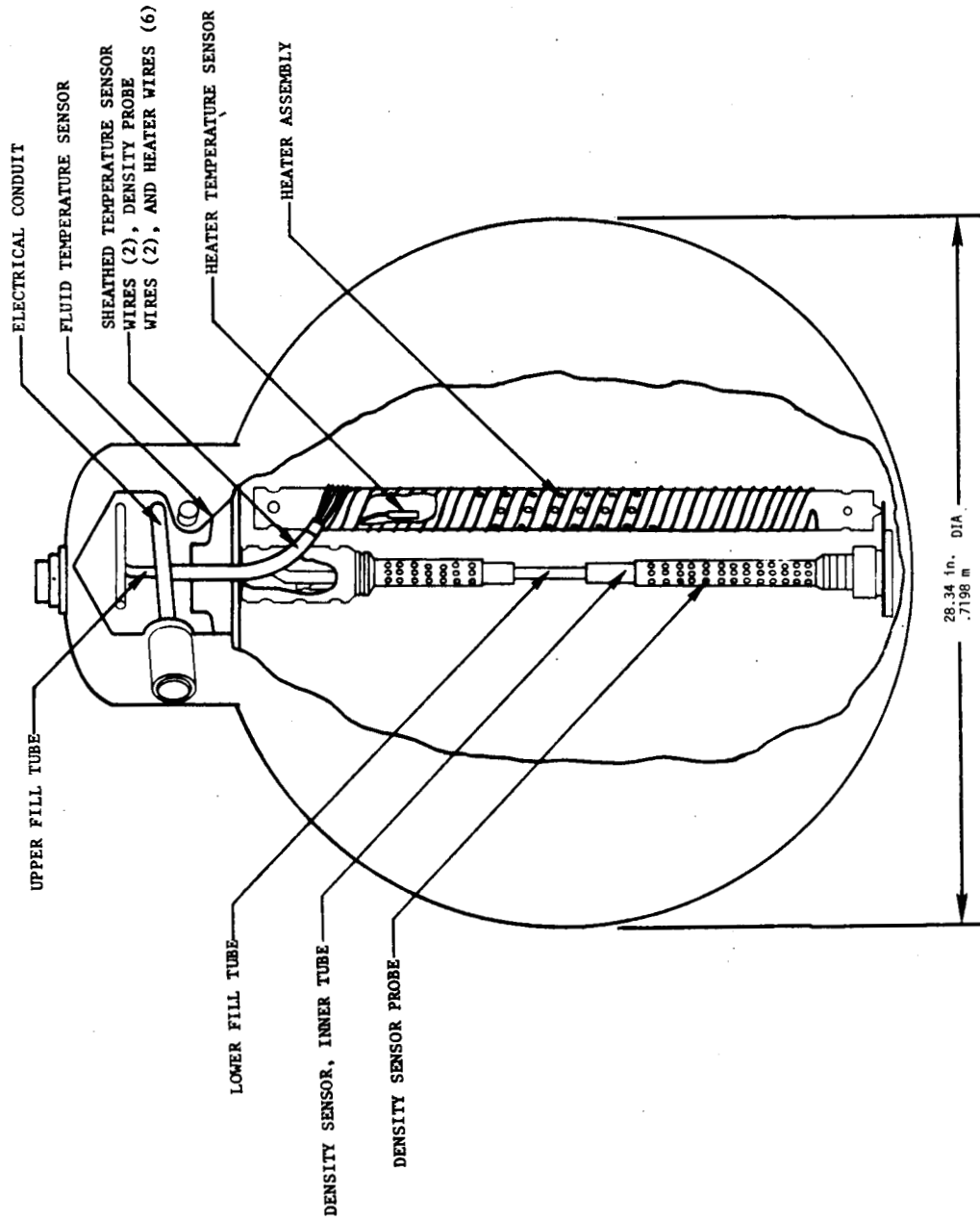


FIGURE 2-15. SM O₂ CRYOGENIC TANK CUTAWAY VIEW

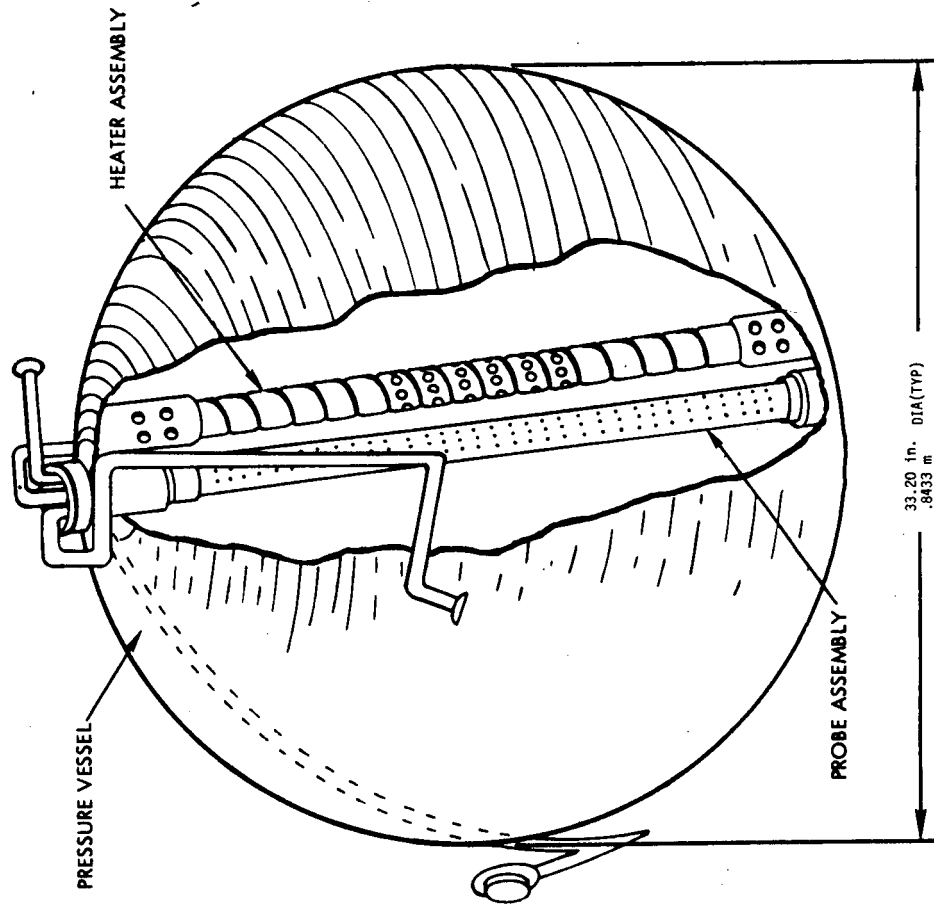


FIGURE 2-17. SM H₂ CRYOGENIC TANK CUTAWAY VIEW

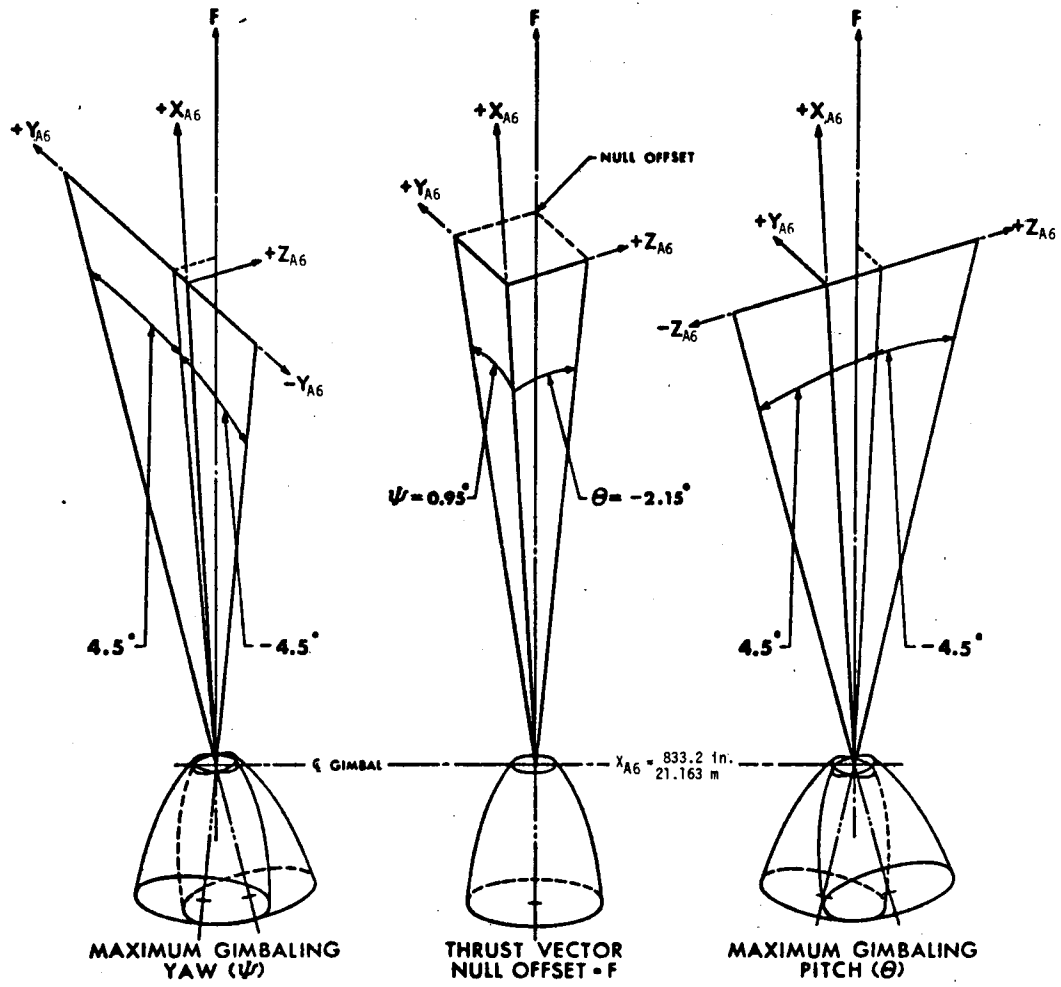


FIGURE 2-18. SPS ENGINE GIMBALING ORIENTATION

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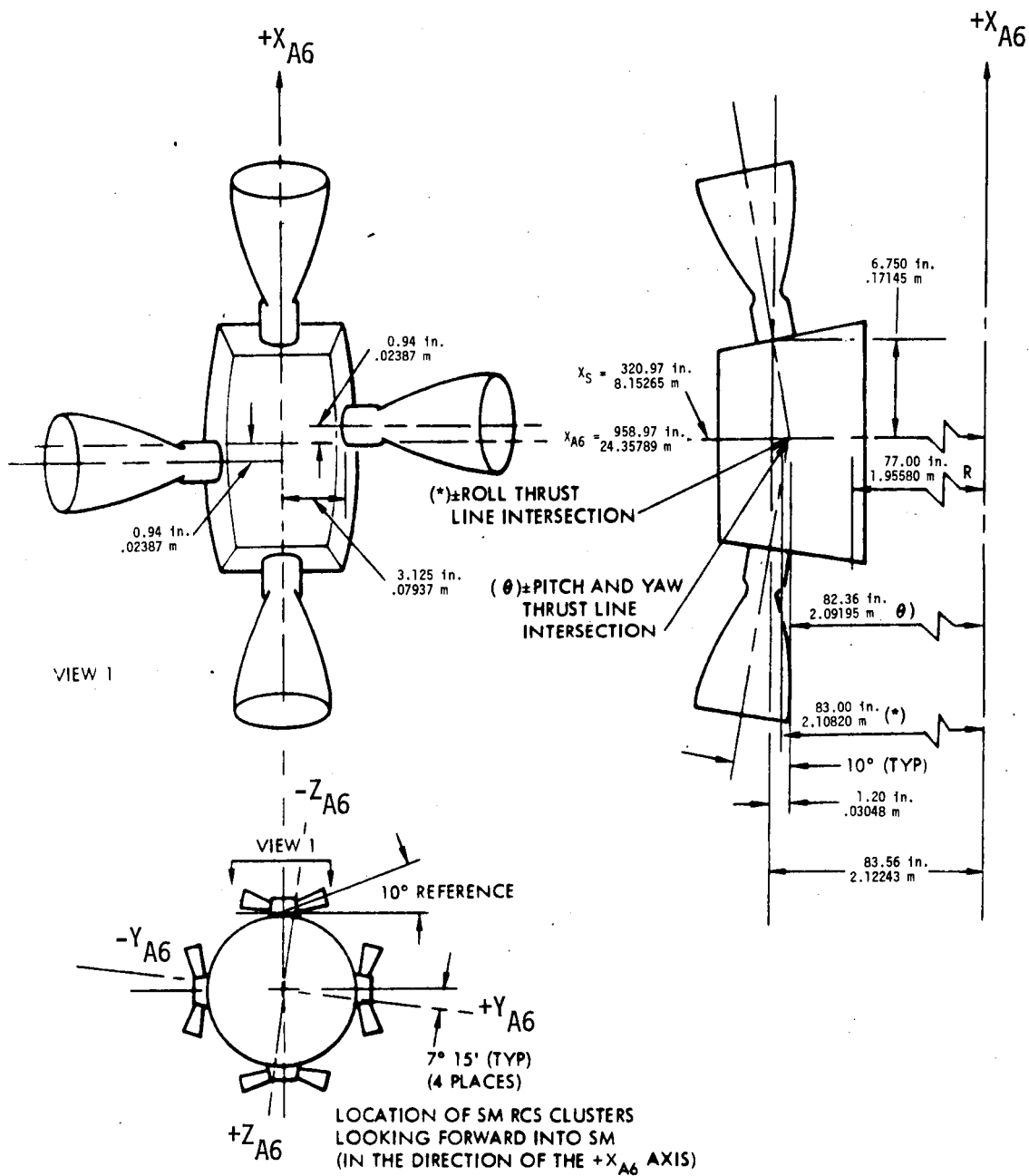


FIGURE 2-19. SERVICE MODULE RCS THRUST CHAMBER LOCATIONS

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TBS

FIGURE 2-20. DM O₂ TANK LOCATIONS

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3.0 SPACECRAFT MASS PROPERTIES AND LOADING DATA

The mass property data specified in this section represent the best prediction of launch configuration mass properties for each spacecraft. These data have been organized according to basic mission profile. In addition, data are presented by individual and composite spacecraft to reflect the variation of centers-of-gravity, moments of inertia, and products of inertia as a function of spacecraft weight to enable the user to reasonably predict spacecraft mass properties at any time in the mission profile. These data represent the composite results of detailed mass properties data supplied to NASA by the contractors and the USSR.

All mass property data are presented relative to the Apollo spacecraft coordinate system X_{A6} or Soyuz spacecraft coordinate system X_{C6} , as defined in Section 2 of this data book, and in IED 50401 dated 15 July 1972 as amended.

3.1 SUPPLEMENTARY DATA APPLICABLE TO SEQUENTIAL MASS PROPERTIES TABLES

General Comments to be applied to Tables 3.1-1 through 3.1-4;

The SPS propellant weights are total tanked.

The (+) or (-) sign following the name of an item indicates that the item is added to or subtracted from the preceding total.

Table 3.1-1

SM-SPS gimbal angles for SPS abort sequence are: Pitch = TBD
Yaw = TBD

Table 3.1-6

CSM consumable changes are presented in Table 3.1-6.

TABLE 3.1-1 (CONTINUED)
 CSM 111/SCYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 CSM+DM+SLA+LES AT LAUNCH

TANKED FLUIDS (LB)		TANKED FLUIDS (LB)		TANKED FLUIDS (LB)		TANKED FLUIDS (LB)	
SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT
CM-RCS A	134.4	SM RCS QD A	335.6	SM RCS QC B	335.6	CM-RCS B	134.4
SM RCS QD D	335.6	SPS	3560.0	PSM RCS	1427.6	OXYGEN	633.2
						SM RCS QD C	335.6
						HYDROGEN	55.2

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER OF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SF2)		
		X	Y	Z	IXX	IYY	IZZ	IXY	IXZ	IYZ
CM	12344.2	1041.40	-0.09	4.38	5629.2	5155.1	4776.1	54.4	-364.7	-12.6
SM	8532.6	517.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
DM	3835.0	657.10	.40	7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
SLA	4457.0	631.50	.60	-0.30	13095.0	17394.0	17429.0	1.0	1.0	1.0
LES	9100.0	1258.70	-0.10	.90	340.0	28408.0	28390.0	27.0	466.0	30.0
TOTAL	38312.8	588.31	-0.60	4.04	26163.6	483247.9	482646.9	-127.3	-1089.9	-427.8
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

MASS PROPERTIES (WITH TANKED FLUIDS)

CM	12613.0	1041.00	-0.21	5.50	5346.7	5337.2	4851.8	60.6	-420.8	-17.1
SM	15551.0	505.88	2.46	2.90	10208.1	15147.3	16085.1	-532.9	380.4	-1055.3
DM	3835.0	657.10	.40	7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
SLA	4457.0	631.50	.60	-0.30	13095.0	17394.0	17429.0	1.0	1.0	1.0
LES	9100.0	1258.70	-0.10	.90	340.0	28408.0	28390.0	27.0	466.0	30.0
TOTAL	45600.0	573.64	-0.85	3.23	30844.0	499054.5	500387.2	-1410.7	-415.7	-1045.6
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

PRINCIPAL MOMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

U AXIS			V AXIS			W AXIS		
DIR ANGLE(DEG)	ARM IJO	DIU	DIR ANGLE(DEG)	ARM IJO	DIU	DIR ANGLE(DEG)	ARM IJO	DIU
30835.4	30835.4	0.0	499104.6	499104.6	0.0	501241.9	501241.9	0.0
ALPHA .2	.000	.000	ALPHA 89.9	A(1) .000	.0017309	ALPHA 89.9	A(2) .000	.00258067
BETA -89.9	.000	.000	BETA 39.2	A(3) .000	.77481113	BETA 50.8	A(3) .000	.63218564
GAMMA -89.9	.000	.000	GAMMA -50.3	.63219023	.77481113	GAMMA 39.2	.63219023	.77481267

TABLE 3.1-1 (CONTINUED)
 CSM 111/SCYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 CSM/DW/SLA AT ECI

TANKED FLUIDS (LB)

SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT
CM-RCS A	134.4	SM RCS QD A	335.6	SM RCS QC B	335.6	CM-RCS B	134.4	SM RCS QD C	335.6	SM RCS QD C	335.6
SM RCS QD D	335.6	SPS	3560.0	PSM RCS	1427.6	OXYGEN	633.2	HYDROGEN	55.2		

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER OF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SF2)		
		X	Y	Z	IXX	IYY	IZZ	IXY	IYZ	IYZ
CM	12344.2	1041.40	-09	4.38	5629.2	5155.1	4776.1	54.4	-364.7	-12.6
SM	8522.6	917.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
DM	3835.0	657.10	.40	7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
SLA	4457.0	631.50	.60	-0.30	13095.0	17394.0	17429.0	1.0	1.0	1.0
TOTAL	29212.8	651.62	-0.75	5.01	25297.6	206639.5	206081.3	-552.7	952.8	-453.7
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

MASS PROPERTIES (WITH TANKED FLUIDS)

CM	12613.0	1041.00	-21	5.50	5846.7	5337.2	4851.8	60.6	-420.8	-17.1
SM	15551.0	905.88	2.46	2.80	10208.1	15147.3	16085.1	-532.9	380.4	-1055.3
DM	3835.0	657.10	.40	7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
SLA	4457.0	631.50	.60	-0.30	13095.0	17394.0	17429.0	1.0	1.0	1.0
TOTAL	36500.0	892.60	1.09	3.81	29988.4	212253.3	212715.2	-676.4	978.1	-1081.1
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

PRINCIPAL MOMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

U AXIS			V AXIS			W AXIS		
DIR ANGL(DEG)	DIR NC	DIR ANG(DEG)	DIR ANGL(DEG)	DIR NC	DIR ANG(DEG)	DIR ANGL(DEG)	DIR NC	DIR NO
2998.6	.0	211386.0	0	0	213590.3	0	0	0
ARM IJD	ARM IJC	ARM IJD	ARM IJC	ARM IJD	ARM IJC	ARM IJD	ARM IJC	DIR NO
A(1) .000	A(1) .000	ALPHA 89.6	A(1) .000	ALPHA 89.9	A(2) .000	ALPHA 89.9	A(2) .000	.001E3062
A(2) .000	A(2) .000	BETA 38.9	A(3) .000	BETA 51.1	A(3) .000	BETA 51.1	A(3) .000	.62E17894
GAMMA 90.7	GAMMA 51.1	GAMMA -51.1	GAMMA 38.9	GAMMA 38.9	GAMMA 38.9	GAMMA 38.9	GAMMA 38.9	.77E6673

TABLE 3.1-1 (CONTINUED)
 CSM 111/SOYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 CSM/DM CCKED

TANKED FLUIDS (LB)

SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT
CM-RCS A	134.4	SM-RCS QD A	318.1	SM-RCS QD B	318.1	SM-RCS QD C	318.1
SM RCS QD D	318.1	SPS	3560.0	PSM RCS	1427.6	HYDROGEN	55.2

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER OF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SF2)		
		X	Y	Z	IXX	IYY	IZZ	IXY	IXZ	IYZ
CM	12344.2	1041.40	-0.09	4.38	5629.2	5155.1	4776.1	54.4	-364.7	-12.6
SM	8532.6	917.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
DM	3825.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
TOTAL	24715.8	1017.75	-1.00	3.75	12284.1	54945.3	54266.4	438.9	-1874.9	-463.2
UNCERT	.C	.00	.00	.00	.0	.0	.0	.0	.0	.0

MASS PROPERTIES (WITH TANKED FLUIDS)

CM	12613.0	1041.00	-21	5.50	5846.7	5337.2	4851.8	60.6	-420.8	-17.1
SM	15481.0	905.73	2.48	2.81	10135.2	15083.7	16030.3	-531.7	381.8	-1038.4
DM	3825.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
TOTAL	31933.0	990.30	1.16	2.67	16885.8	78285.2	78655.2	-1141.0	-1114.7	-1058.2
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

PRINCIPAL MOMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

DIR ANG(DEG)	U AXIS			V AXIS			W AXIS			
	(SF2)	DIR NO	DIR ANG(DEG)	(SF2)	DIR NO	DIR ANG(DEG)	(SF2)	DIR NO	DIR ANG(DEG)	
IUU	16845.2	0	IUV	77396.3	0	IUW	79584.7	0	DIWH	.0
ALPHA	1.5	A(1)	ALPHA	89.9	A(1)	ALPHA	88.5	A(2)	.000	DIR NO
BETA	-99.0	A(2)	BETA	40.1	A(3)	BETA	49.9	A(3)	.000	.02531537
GAMMA	-89.0	A(3)	GAMMA	-49.9	GAMMA	40.2	GAMMA	40.2	.000	.64451321
										.76417395

TABLE 3.1-1 (CONTINUED)
 CSM III/SOYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 HCHWANN TRANSFER

TANKED FLUIDS (LB)

SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT
CM-RCS A	134.4	SM-RCS CC A	309.5	SM RCS QC B	309.5	CM-RCS B	134.4	SM RCS QD C	309.5
SM RCS QD D	309.5	SM SPS	3423.0	PSM RCS	1427.6	OXYGEN	628.4	SM HYDROGEN	54.8

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER OF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SF2)		
		X	Y	Z	IXX	IYY	IZZ	IXY	IXZ	IYZ
CM	12244.2	1041.06	-0.08	4.31	5618.2	5181.5	4785.3	54.9	-343.2	-13.2
SM	8532.6	517.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
DM	3639.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
TOTAL	24715.8	1017.62	-0.99	3.71	12273.0	54928.6	54232.7	439.3	-1857.7	-463.9
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

MASS PROPERTIES (WITH TANKED FLUIDS)

CM	12613.0	1040.66	-0.20	5.44	5836.1	5363.2	4860.3	61.0	-398.3	-17.7
SM	15304.4	506.06	2.41	2.82	10027.8	14994.3	15879.9	-515.7	380.7	-1037.4
DM	3839.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
TOTAL	31756.4	990.75	1.13	2.65	16766.2	77675.6	77967.5	-1098.8	-1104.8	-1057.6
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

PRINCIPAL MOMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

U AXIS				V AXIS				W AXIS				
DIR	ANGL(DEG)	ARML(IN)	DIR	ANGL(DEG)	ARML(IN)	DIR	ANGL(DEG)	ARML(IN)	DIR	ANGL(DEG)	ARML(IN)	
JUU	16727.2	0.00	IUV	76754.1	0.00	IWW	78928.0	0.00	DIR	78928.0	DIR	0.00
ALPHA	1.4	A(1)	ALPHA	89.9	A(1)	ALPHA	89.6	A(2)	ALPHA	89.6	BETA	0.00
BETA	-89.0	A(2)	BETA	41.1	A(3)	BETA	48.9	A(3)	BETA	48.9	GAMMA	0.00
GAMMA	-89.0	A(3)	GAMMA	-48.9		GAMMA	41.2		GAMMA	41.2		0.00

TABLE 3.1-1 (CONTINUED)
 CSM III/SOYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 CSM/DM AT CIRCULARIZATION

TANKED FLUIDS (L8)

SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT
CM-RCS A	134.4	SM-RCS QC A	298.9	SM-RCS QC B	298.9	CM-RCS B	134.4	SM-RCS QC C	298.9	SM RCS QD C	298.9
SM RCS QD D	258.5	SM SPS	3191.0	FSM RCS	1427.6	DXYGEN	623.8	SM HYDROGEN	54.6		

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER CF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SF2)		
		X	Y	Z	IXX	IYY	IZZ	IXY	IYZ	IXZ
CM	12344.2	1041.06	-0.08	4.31	5618.2	5181.5	4785.3	54.9	-343.2	-13.2
SM	8532.6	917.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
DM	3835.0	1164.7C	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
TOTAL	24715.8	1017.62	-0.99	3.71	12273.0	54928.6	54232.7	439.3	-1857.7	-463.9
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

MASS PREPERTIES (WITH TANKED FLUIDS)

CM	12613.0	1040.66	-0.20	5.44	5836.1	5363.2	4860.3	61.0	-398.3	-17.7
SM	15025.2	906.69	2.30	2.83	9864.6	14842.7	15622.3	-494.4	377.9	-1040.6
DM	3839.0	1164.7C	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
TOTAL	31477.2	991.84	1.06	2.65	16601.9	76736.4	76921.0	-1035.5	-1110.8	-1060.8
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

PRINCIPAL CMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

U AXIS	V AXIS			W AXIS			
	DIR ANG(DEG)	DIR NO	DIR ANG(DEG)	DIR ANG(DEG)	DIR NO	DIR NO	
16564.3(SF2)	ARMIJO	0.0	75763.9(SF2)	ARMIJC	0.0	77931.0(SF2)	DIWH
DIR ANG(DEG)	ARMIJO		DIR ANG(DEG)	ARMIJC		DIR ANG(DEG)	DIR NO
ALPHA 1.4	A(1)	.000	ALPHA 90.0	A(1)	.000	ALPHA 88.6	A(2)
BETA -89.0	A(2)	.000	BETA 42.5	A(3)	.000	BETA 47.5	A(3)
GAMMA -89.0	A(3)	.000	GAMMA -47.5			GAMMA 42.5	

TABLE 3.1-1 (CONTINUED)
 CSM 111/SOYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 CSM/DM NC 1

TANKED FLUIDS (LB)

SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT
CM-RCS A	134.4	SM-RCS QD A	288.8	SM RCS QC B	288.8	CM-RCS B	134.4	SM RCS QD C	288.8	SM HYDROGEN	52.9
SM RCS QD D	288.8	SM SPS	2654.0	PSM RCS	1427.6	DKY GEN	605.5				

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER OF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SF2)		
		X	Y	Z	IXX	IYY	IZZ	IXY	IXZ	IYZ
CM	12244.2	1041.06	-0.08	4.31	5618.2	5181.5	4785.3	54.9	-343.2	-13.2
SM	8522.6	517.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
DM	3835.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
TOTAL	24715.8	1017.62	-0.99	3.71	12273.0	54928.6	54232.7	439.3	-1857.7	-463.9
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

MASS PROPERTIES (WITH TANKED FLUIDS)

CM	12613.0	1040.66	-0.20	5.44	5836.1	5363.2	4860.3	61.0	-398.3	-17.7
SM	14427.8	508.56	2.01	2.84	9541.8	14457.8	14985.6	-438.5	368.7	-1059.7
DM	3835.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
TOTAL	30875.8	554.36	.91	2.65	16276.8	74394.7	74325.4	-893.3	-1118.1	-1080.1
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

PRINCIPAL MOMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

	U AXIS			V AXIS			W AXIS		
	DIR ANG(DEG)	ARM IJO	DIR NO	DIR ANG(DEG)	ARM IJC	DIR NO	DIR ANG(DEG)	ARM IJO	DIR NO
IUU	16242.5	.0	.0	75474.4	.0	.0	73280.1	.0	.0
ALPHA	1.4	.000	.000	88.6	.000	.000	89.8	.000	.00325863
BETA	-89.2	.000	.000	4.2	.000	.000	-45.8	.000	-.69719020
GAMMA	-88.9	.000	.000	45.8	.000	.000	44.2	.000	.71687879

TABLE 3.1-1 (CONTINUED)
 CSM 111/SCYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 CSP/DM NC 2

TANKED FLUIDS (LR)

SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT
CM-RCS A	134.4	SM-RCS QD A	275.3	SM-RCS GC B	275.3	CM-RCS B	134.4
SM RCS QD D	275.3	SM SPS	2552.0	PSM RCS	1427.6	SM HYDROGEN	587.2

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER OF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SP2)		
		X	Y	Z	IXX	IYY	IZZ	Ixy	Ixz	Iyz
CM	12344.2	1041.66	-0.08	4.31	5618.2	5181.5	4785.3	34.9	-343.2	-13.2
SM	8532.6	917.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
DM	38235.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
TOTAL	24715.8	1017.62	-0.99	3.71	12273.0	54928.6	54232.7	435.3	-1857.7	-463.9
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

MASS PROPERTIES (WITH TANKED FLUIDS)

CM	12613.0	1040.66	-0.20	5.44	5836.1	5363.2	4860.3	61.0	-398.3	-17.7
SM	14251.8	508.84	1.99	2.81	9423.8	14330.7	14819.3	-425.5	366.7	-1048.3
DM	3629.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
TOTAL	30793.8	554.58	.89	2.64	16158.6	73835.2	73726.6	-860.8	-1110.6	-1068.8
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

PRINCIPAL MOMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

U AXIS			V AXIS			W AXIS				
JUU	16125.0(SF2)	DIUU	.0	IUV	74884.0(SF2)	DIUV	.0	IUW	72711.5(SF2)	DIUW
DIR ANGLE(DEG)	ARMHJO	DIR NC	DIR ANG(DEG)	ARMHJC	DIR NC	DIR ANG(DEG)	ARMHJO	DIR NC	DIR NO	DIR NO
ALPHA	1.4	.000	ALPHA	88.6	A(1)	.000	ALPHA	89.8	A(2)	.000
BETA	-89.2	.000	BETA	43.7	A(3)	.000	BETA	-46.3	A(3)	.000
GAMMA	-88.9	.000	GAMMA	46.3	GAMMA	43.7	GAMMA	43.7	GAMMA	43.7

TABLE 3.1-1 (CONTINUED)
 CSM III/SOYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 CSM/DM AT TPI

TANKED FLUIDS (LB)

SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT
CM-RCS A	134.4	SM-RCS QD A	258.1	SM RCS QD B	258.1	CM-RCS B	134.4
SM RCS QD D	258.0	SM SPS	1814.0	PSM RCS	1427.6	SM HYDROGEN	536.6

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER OF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SF2)		
		X	Y	Z	IXX	IYY	IZZ	Ixy	Ixz	Iyz
CM	12344.2	1041.66	-0.08	4.31	5618.2	5181.5	4785.3	34.9	-343.2	-13.2
SM	8532.6	517.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
DM	3839.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
TOTAL	24715.8	1017.62	-0.99	3.71	12273.0	54928.6	54232.7	439.3	-1857.7	-463.9
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

MASS PROPERTIES (WITH TANKED FLUIDS)

CM	12613.0	1040.66	-0.20	5.44	5836.1	5363.2	4860.3	61.0	-358.3	-17.7
SM	13385.9	511.86	1.62	2.74	8951.1	13677.3	13825.7	-334.2	352.9	-1065.1
DM	3839.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
TOTAL	29841.9	558.83	.69	2.60	15683.4	70231.2	69779.9	-646.7	-1102.4	-1086.0
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

PRINCIPAL MOMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

IUV	U AXIS			V AXIS			W AXIS		
	DIR ANG(DEG)	ARM IJO	DIR AC	IUV	DIR ANG(DEG)	ARM IJO	IUV	DIR ANG(DEG)	ARM IJO
15652.8(SF2)	1.3	A(1)	-.59573182	71140.6(SF2)	89.5	A(2)	68900.1(SF2)	DIR NO	DIR NO
13385.9	89.3	A(2)	-.01144637	88.8	A(1)	77280324	89.5	A(2)	COB29784
3839.0	-98.8	A(3)	-.020213191	39.4	A(3)	63427729	-50.6	A(3)	-63454245
				50.6	GAMMA	39.4			-77284346

TABLE 3.1-1 (CONTINUED)
 CSM 111/SOYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 CSM/DW AT DOCKING TO SCYUZ

TANKED FLUIDS (LB)

SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT
CM-RCS A	134.4	SM-RCS QD A	166.1	SP RCS QC B	166.1	CM-RCS B	134.4	SM RCS QD C	166.1		
SM RCS QD D	166.0	SM SPS	1814.0	PSM PCS	1427.6	OKY GEN	536.6	SM HYDROGEN	466.8		

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER OF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SF2)		
		X	Y	Z	IXX	IYY	IZZ	IXY	IXZ	IYZ
CM	12344.2	1041.66	-0.08	4.31	5618.2	5181.5	4785.3	54.9	-343.2	-13.2
SM	8532.6	917.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
DM	3839.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
TOTAL	24715.8	1017.62	-0.99	3.71	12273.0	54928.6	54232.7	439.3	-1857.7	-463.9
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

MASS PROPERTIES (WITH TANKED FLUIDS)

CM	12613.0	1040.66	-0.20	5.44	5836.1	5363.2	4860.3	61.0	-398.3	-17.7
SM	13021.9	911.14	1.66	2.81	8568.3	13368.5	13563.7	-330.9	358.5	-975.8
DM	3839.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
TOTAL	29473.9	995.60	.70	2.63	15300.9	69668.1	69263.8	-650.2	-1115.3	-996.5
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

PRINCIPAL MOMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

U AXIS	V AXIS	W AXIS	U AXIS			V AXIS			W AXIS		
			DIR ANG(DEG)	DIR ANG(DEG)	DIR ANG(DEG)	DIR ANG(DEG)	DIR ANG(DEG)	DIR ANG(DEG)	DIR ANG(DEG)	DIR ANG(DEG)	DIR ANG(DEG)
15276.5(SF2)	70509.3(SF2)	69453.0(SF2)	DIR NO	DIR NO	DIR NO	DIR NO	DIR NO	DIR NO	DIR NO	DIR NO	
1.3	89.7	89.5	ARM IJO	ARM IJC	ARM IJD	ARM IJO	ARM IJC	ARM IJD	ARM IJO	ARM IJC	
A(1)	A(1)	A(1)	A(1)	A(1)	A(1)	A(1)	A(1)	A(1)	A(1)	A(1)	
-89.3	39.6	-50.4	BETA	BETA	BETA	BETA	BETA	BETA	BETA	BETA	
A(2)	A(2)	A(2)	A(2)	A(2)	A(2)	A(2)	A(2)	A(2)	A(2)	A(2)	
-88.8	50.5	39.6	GAMMA	GAMMA	GAMMA	GAMMA	GAMMA	GAMMA	GAMMA	GAMMA	

TABLE 3.1-1 (CONTINUED)
 CSM 111/SCYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 CSM/DM/SCYUZ AT DCKING

TANKED FLUIDS (LB)

SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT
CM-RCS A	134.4	SM-RCS QD A	166.1	SM RCS QC B	166.1	CM-RCS B	134.4	SM RCS QD C	166.1	SM RCS QD C	166.1
SM RCS QD D	166.0	SM SPS	1814.0	PSM RCS	1427.6	OKYGEN	536.6	SM HYDROGEN	46.8	SM HYDROGEN	46.8

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER OF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SF2)		
		X	Y	Z	IXX	IYY	IZZ	IXY	IYZ	IZZ
CM	12344.2	1041.66	-0.08	4.31	5618.2	5181.5	4785.3	54.9	-343.2	-13.2
SM	8532.6	517.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
DM	3839.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
SOYUZ	14575.0	1406.70	-.40	-.40	3507.0	17789.0	18223.0	16.0	433.0	14.0
TOTAL	39656.8	1164.42	-.77	2.16	15814.8	377440.0	377144.7	920.0	-4646.9	-454.8
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

MASS PROPERTIES (WITH TANKED FLUIDS)

CM	12613.0	1040.66	-0.20	5.44	5836.1	5363.2	4860.3	61.0	-398.3	-17.7
SM	13021.9	511.14	1.66	2.81	8568.3	13368.5	13563.7	-330.9	358.5	-975.8
DM	3835.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
SOYUZ	14575.0	1406.70	-.40	-.40	3507.0	17789.0	18223.0	16.0	433.0	14.0
TOTAL	44448.9	1136.75	.33	1.61	18830.2	442686.9	442699.4	-1595.2	-3327.2	-575.3
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

PRINCIPAL MOMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

U AXIS	V AXIS			W AXIS		
	DIR ANGLE(DEG)	DIR ANGLE(DEG)	DIR ANGLE(DEG)	DIR ANGLE(DEG)	DIR ANGLE(DEG)	DIR ANGLE(DEG)
18758.1(SF2)	441721.2(SF2)	441721.2(SF2)	443657.1(SF2)	443657.1(SF2)	443657.1(SF2)	443657.1(SF2)
ARM1JO	ARM1JC	ARM1JC	ARM1JC	ARM1JO	ARM1JO	ARM1JO
A(1)	A(1)	A(1)	A(1)	A(2)	A(2)	A(2)
A(2)	A(2)	A(2)	A(3)	A(3)	A(3)	A(3)
A(3)	A(3)	A(3)	GAMMA	GAMMA	GAMMA	GAMMA
DIR ANGLE(DEG)	DIR ANGLE(DEG)	DIR ANGLE(DEG)	DIR ANGLE(DEG)	DIR ANGLE(DEG)	DIR ANGLE(DEG)	DIR ANGLE(DEG)
ALPHA	ALPHA	BETA	BETA	ALPHA	BETA	ALPHA
BETA	BETA	GAMMA	GAMMA	BETA	GAMMA	BETA
GAMMA	GAMMA			GAMMA		GAMMA

TABLE 3.1-1 (CONTINUED)
 CSM 111/SCYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 CSM/DM/SCYUZ CHECKED

TANKED FLUIDS (LB)		TANKED FLUIDS (LB)		TANKED FLUIDS (LB)	
SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT
CM-RCS A SM RCS QD D	134.4 166.0	SM RCS QD A SM SPS	166.1 1814.0	CM-RCS B OXYGEN	134.4 536.6
		SM RCS QD B PSP RCS	166.1 1427.6		
				SM RCS QD C SM HYDROGEN	166.1 46.8

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER OF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SF2)		
		X	Y	Z	IXX	IYY	IZZ	IXY	IXZ	IYZ
CM	1210.4	1041.66	-0.07	4.32	5612.1	5165.7	4768.6	54.8	-343.4	-13.3
SM	8532.6	917.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
DM	3825.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
SOYUZ	15008.8	1406.70	-.40	-.40	3507.0	17789.1	18223.1	16.0	433.0	14.0
TOTAL	39696.8	1164.74	-.77	2.16	15808.8	377723.0	377426.7	919.9	-4651.9	-454.8
UNCERT	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00

MASS PROPERTIES (WITH TANKED FLUIDS)

CM	12575.2	1040.69	-0.19	5.45	5829.9	5347.4	4843.7	60.9	-398.6	-17.8
SM	13021.9	911.14	1.66	2.81	8568.3	13368.5	13563.7	-330.9	358.5	-975.8
DM	3835.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
SOYUZ	15008.8	1406.70	-.40	-.40	3507.0	17789.1	18223.1	16.0	433.0	14.0
TOTAL	44440.9	1137.04	.33	1.61	18824.1	443121.0	443132.5	-1597.8	-3330.9	-575.3
UNCERT	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00

PRINCIPAL MOMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

U AXIS			V AXIS			W AXIS		
DIR ANGLE(DEG)	ARM IJO	DIR AC	DIR ANGLE(DEG)	ARM IJC	DIR AC	DIR ANGLE(DEG)	ARM IJO	DIR AC
18792.0	.000	442154.9	0	.000	444130.7	0	.000	444130.7
.5	.000	55556224	-89.8	.000	00292874	89.5	.000	00821692
-99.8	.000	-00274737	BETA 44.5	.000	71275005	BETA 45.5	.000	70140810
-89.6	.000	-00164071	GAMMA -45.5	.000	-70141240	GAMMA 44.5	.000	-71271254

TABLE 3.1-1 (CONTINUED)
 CSM 111/SOYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 CSM/DW/SCYUZ PRE SEP

TANKED FLUIDS (LB)

SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT
CM-RCS A	134.4	SM-RCS QC A	144.8	SM-RCS QC B	144.8	CM-RCS B	134.4	SM-RCS QD C	144.9
SM RCS QD D	144.8	SM SPS	1814.0	PSM RCS	1427.6	OXYGEN	435.6	SM HYDROGEN	34.8

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER OF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SF2)		
		X	Y	Z	IXX	IYY	IZZ	IXY	IXZ	IYZ
CM	12344.2	1041.06	-0.08	4.31	5618.2	5181.5	4785.3	54.9	-343.2	-13.2
SM	8532.6	517.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
DM	3835.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
SOYUZ	14975.0	1406.70	-.40	-.40	3507.0	17789.1	18223.1	16.0	433.0	14.0
TOTAL	39650.8	1164.42	-.77	2.16	15814.8	377440.4	377145.0	920.0	-4646.9	-454.8
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

MASS PROPERTIES (WITH TANKED FLUIDS)

CM	12613.0	1040.66	-.20	5.44	5836.1	5363.2	4860.3	61.0	-398.3	-17.7
SM	12823.9	510.93	1.92	2.50	8420.8	13251.1	13477.3	-328.4	355.2	-928.5
DM	3835.0	1164.70	.40	-7.20	790.0	1666.0	1666.0	1.0	1.0	1.0
SOYUZ	14975.0	1406.70	-.40	-.40	3507.0	17789.1	18223.1	16.0	433.0	14.0
TOTAL	44250.9	1137.70	.40	1.51	18682.6	440652.7	440700.0	-1735.9	-3121.5	-928.5
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

PRINCIPAL MOMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

U AXIS			V AXIS			W AXIS					
IUV	18652.4(SF2)	DIUV	.0	IUV	439749.6(SF2)	DIUV	.0	IUV	441633.4(SF2)	DIUV	.0
DIR ANG(DEG)	ARM IJO	DIR AC	DIR ANG(DEG)	ARM IJC	DIR ANG(DEG)	ARM IJO	DIR NO	DIR ANG(DEG)	ARM IJO	DIR NO	
ALPHA	-5	.55556429	ALPHA	-89.9	A(1)	-.00218280	ALPHA	89.5	A(2)	.000	
BETA	-89.8	-.00410668	BETA	44.0	A(3)	.000	BETA	46.0	A(3)	.000	
GAMMA	-89.6	-.00138683	GAMMA	-46.0	GAMMA	44.0	GAMMA	44.0	GAMMA	.71883480	

TABLE 3.1-1 (CONTINUED)
 CSM 111/SCYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 CSM/DM AT SEP FROM SCYUZ

TANKED FLUIDS (LB)			TANKED FLUIDS (LB)		
SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT
CM-RCS A	134.4	SM-RCS QD A	144.8	CM-RCS B	134.4
SM RCS QD D	144.8	SM SPS	1814.0	PSM RCS	435.6
				SM RCS QD C	144.9
				SM HYDROGEN	34.8

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER OF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SF2)		
		X	Y	Z	IXX	IYY	IZZ	IXY	IXZ	IYZ
CM	12145.9	1035.93	-0.08	4.39	5617.4	4972.8	4578.4	55.0	-328.9	-13.2
SM	8522.6	517.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
DM	4027.3	1164.70	.38	-6.85	792.1	1668.2	1666.0	1.0	1.0	.9
TOTAL	24715.8	1018.00	-0.99	3.72	12273.0	55487.3	54792.4	442.0	-1866.1	-463.9
UNCERT	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00

MASS PROPERTIES (WITH TANKED FLUIDS)

CM	12414.7	1035.56	-0.20	5.52	5834.7	5151.7	4651.2	60.7	-381.6	-17.7
SM	12823.9	510.93	1.92	2.50	8420.9	13251.1	13477.3	-328.4	355.2	-528.5
DM	4027.3	1164.70	.38	-6.85	792.1	1668.2	1666.0	1.0	1.0	.9
TOTAL	29275.9	1000.47	-0.81	2.49	15154.5	69961.2	69590.5	-706.7	-1045.5	-950.0
UNCERT	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00

PRINCIPAL MOMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

U AXIS				V AXIS				W AXIS					
DIR ANGLE(DEG)	ARM IJO	DIR NC	DIR ANG(DEG)	IYY	7070.2 (SF2)	DIWV	ARM IJO	DIR NC	DIR ANG(DEG)	IWW	68810.3 (SF2)	DIR NC	DIR NO
15125.8	.000	.000	7070.2	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1.3	.000	.000	88.8	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
-89.3	.000	.000	39.7	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
-88.9	.000	.000	50.3	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

TABLE 3.1-1 (CONTINUED)
 CSM 111/SCYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 CSM AT SEP FROM DM

SYSTEM		WEIGHT		SYSTEM		WEIGHT		SYSTEM		WEIGHT	
CM-RCS A	SM RCS QD D	134.4	133.5	SM-PCS QC A	SM SPS	133.4	1733.0	SM RCS QC B	PSM RCS	133.4	1427.6
SM RCS QD C	SM HYDROGEN	133.5	3.3					CM-PCS B	OXYGEN	134.4	106.1

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER OF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SF2)		
		X	Y	Z	IXX	IYY	IZZ	IXY	IXZ	IYZ
CM	12145.9	1039.93	-0.08	4.39	5617.4	4972.8	4578.4	55.0	-325.9	-13.2
SM	8532.6	917.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
TOTAL	20678.5	989.43	-1.26	5.78	11362.7	31307.1	30728.6	231.3	-254.0	-449.7
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

MASS PROPERTIES (WITH TANKED FLUIDS)

CM	12414.7	1039.56	-0.20	5.52	5834.7	5151.7	4651.2	60.7	-381.6	-17.7
SM	12336.4	911.07	2.67	1.39	8138.9	12994.5	13255.1	-310.0	337.5	-835.1
TOTAL	24751.1	975.52	1.23	3.47	14007.4	40218.3	39966.6	-742.0	664.7	-868.7
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

PRINCIPAL MOMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

U AXIS			V AXIS			W AXIS		
DIR	ANG(DEG)	ARM IJO	DIR	ANG(DEG)	ARM IJC	DIR	ANG(DEG)	ARM IJO
13968.2	21.52	1011.0	40970.8	1.00	1011.0	39253.4	1.00	1011.0
ALPHA	2.3	A(1)	ALPHA	89.7	A(1)	ALPHA	-87.8	A(2)
BETA	-98.3	A(2)	BETA	40.7	A(3)	BETA	-49.3	A(3)
GAMMA	98.5	A(3)	GAMMA	49.3	GAMMA	GAMMA	40.8	GAMMA

TABLE 3.1-1 (CONTINUED)
 CSM 111/SCYUZ EXPECTED SEQUENTIAL MASS PROPERTIES
 CSM AT DEORBIT

TANKED FLUIDS (LR)

SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT	SYSTEM	WEIGHT
CM-PCS A	134.4	SM-RCS QD A	123.4	SM RCS QD B	123.4	CM-RCS B	134.4	SM RCS QD C	123.5
SM RCS QD D	123.5	SM SPS	1020.0	PSM RCS	1427.6	OXY GEN	106.1	SM HYDROGEN	3.3

MASS PROPERTIES (WITHOUT TANKED FLUIDS)

MODULE	WT (LB)	CENTER OF GRAVITY (IN)			MOMENTS OF INERTIA (SF2)			PRODUCTS OF INERTIA (SF2)		
		X	Y	Z	IXX	IYY	IZZ	IXY	IXZ	IYZ
CM	12145.9	1035.57	-0.08	4.41	5614.3	4975.0	4575.6	55.2	-333.3	-13.0
SM	8532.6	917.55	-2.95	7.76	5724.1	10118.4	9937.7	-203.7	522.1	-426.0
TOTAL	20678.5	585.46	-1.26	5.79	11359.5	31311.6	30736.2	231.5	-254.3	-449.4
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

MASS PROPERTIES (WITH TANKED FLUIDS)

CM	12414.7	1035.60	-0.20	5.55	5831.6	5145.9	4648.5	60.9	-385.1	-17.5
SM	11583.4	515.14	2.16	1.39	7739.4	12209.3	12128.7	-217.0	339.1	-874.0
TOTAL	23998.1	579.52	.94	3.54	13600.5	37412.2	36818.9	-536.6	623.1	-904.2
UNCERT	.0	.00	.00	.00	.0	.0	.0	.0	.0	.0

PRINCIPAL MOMENTS AND PRINCIPAL AXES (WITH TANKED FLUIDS)

U AXIS			V AXIS			W AXIS		
DIR_ANGLE(DEC)	ARM_IJO	DIR_NO	IUV	38067.4(SF2)	DIWV	IWW	36193.7(SF2)	DIWW
13570.6	.000	.0	.0	.0	.0	.0	.0	.0
DIR_ANGLE(DEC)	ARM_IJO	DIR_NO	DIR_ANGLE(DEC)	ARM_IJO	DIR_NO	DIR_ANGLE(DEC)	ARM_IJO	DIR_NO
2.1	A(1)	.000	89.8	A(1)	.000	ALPHA	-87.9	A(2)
-88.7	A(2)	.000	35.8	A(3)	.000	BETA	-54.2	A(3)
98.4	GAMMA	.0276596	54.2	GAMMA	.5856373	GAMMA	35.9	

XA COORDINATES TABLE 3.1-1 (CONTINUED)
CM 111 REENTRY SEQUENTIAL MASS PROPERTIES

DESCRIPTION	S	WEIGHT POUNDS	C. G. INCHES			INERTIAS SLUG-FT ²			PRODUCTS SLUG-FT ²		
			X	Y	Z	IXX	IYY	IZZ	IXY	IXZ	IYZ
CM AT SEPARATION		12414.7	1039.6	-0.2	5.6	5831	5146	4648	60	-384	-18
CM RCS	-	12.0	1022.6	5.2	57.5	0	0	0	0	0	0
CM AT ENTRY		12402.7	1039.6	-0.2	5.5	5824	5138	4647	61	-382	-18
CM/RCS	-	19.4	1022.6	5.2	57.5	0	0	0	0	0	0
ABLATOR BURN-OFF	-	80.0	1008.5	0.0	0.0	54	43	41	0	0	0
ENTRY COOLING	-	2.0	1022.6	-19.7	62.5	0	0	0	0	0	0
FORWARD HEAT SHLD.	-	310.0	1094.3	-0.5	0.8	64	26	23	0	0	0
DROGUE+DISCONNECTS	-	80.0	1089.0	0.0	-23.9	1	1	0	0	0	0
CM AT MAIN CHUTE DEPLOY		11911.3	1038.1	-0.2	5.8	5675	4772	4316	62	-338	-19
PILOT CHUTE+RISER	-	45.5	1089.0	5.9	-5.8	2	2	1	0	0	0
MAIN CHUTE	-	401.4	1089.1	-0.4	8.5	62	22	43	0	0	0
CM AT IMPACT		11464.4	1036.1	-0.2	5.7	5609	4485	4011	60	-344	-18

TABLE 3.1-2
CSM 111 PAD ABORT MASS PROPERTIES

TBS

TABLE 3.1-3
CSM 111 HIGH ALTITUDE ABORT MASS PROPERTIES

TBS

TABLE 3.1-4
S-IVB SEQUENTIAL MASS PROPERTIES

TBS

TABLE 3.1-5
ASTP FLUID BUDGET

EVENT	COMMAND MODULE			SERVICE MODULE					DM		SOYUZ
	RCS	POTABLE WATER	WASTE WATER	RCS	SPS	H2	O2	O2	O2	O2&N2	
PRELAUNCH CHECKOUT	268.8	30.0	35.0	2770.0	3560.0	55.2	633.2	48.0	48.0	48.0	-
PAYLOAD READY FOR LAUNCH ⁽²⁾ PERFORM NOMINAL LAUNCH- JETTISON LES	268.8	30.0	35.0	2770.0 -70.0	3560.0 -137.0	55.2 -0.4	633.2 -4.8	48.0	48.0	48.0	-
INITIAL ORBIT ACHIEVED TRANSPOSITION & DOCKING				-34.4	-232.0	-0.2	-4.6				
CSM/DM HOHMANN TRANSFER				-42.4	-537.0	-1.7	-18.3				
CSM/DM CIRCULARIZATION				-40.4	-102.0	-1.7	-18.3				
CSM/DM NC 1				-54.0	-578.0	-2.2	-22.8				
CSM/DM NC 2				-22.4	-91.0	-1.1	-13.9				
CSM/DM NCC				-22.4	-69.0	-1.1	-13.9				
CSM/DM NSR				-24.1							
CSM/DM TPI				-368.0							
CSM/DM READY FOR DOCKING											
CSM/DM/SOYUZ DOCKING	268.8	30.0	35.0	2091.9	1814.0	46.8	536.6	48.0	48.0	48.0	-
CSM/DM/SOYUZ DOCKED				-85.0		12.0	101.0				
CSM/DM/SOYUZ READY FOR SEPARATION											
CSM/DM AT SOYUZ SEPARATION											
CSM/DM AT SHAPING	268.8	30.0	35.0	2006.9	1814.0	34.8	435.6	48.0	48.0	48.0	-
CSM AT DM SEPARATION				-27.1	-81.0	-3.3	-34.7				
CSM AT DEORBIT				-18.4	-713.0	-28.2	-294.8				
CM/SM SEPARATION	268.8	30.0	35.0	1921.4	1020.0	3.3	106.1				
CM AT ENTRY	-12.0										
CM AT MC DEPLOY	-19.4										
CM AT IMPACT	237.4	30.0	35.0								

(1) ALL WEIGHTS EXPRESSED IN POUNDS.

(2) PAYLOAD READY FOR LAUNCH TOTALS REFLECT TOTAL LOADED EXCEPT FOR THE SPS PROPELLANT. THERE IS AN ADDITIONAL 151.2 POUNDS OF SPS PROPELLANT TRAPPED OUTSIDE THE TANKS.

TABLE 3.1-6
COMMAND MODULE 111 STOWAGE VOLUME CENTROIDS

The following stowage locations have unique volume centroids not associated with stowage volumes.

<u>NOMENCLATURE</u>	<u>LOCATION</u>	<u>X</u>	<u>Y</u>	<u>Z</u>
G&N Signal Cond. Panel	LEB	1069.0	25.0	29.0
Display Keyboard	LEB	1060.0	26.0	32.0
Sleep Restraint Assy-RH & Ctr.	Aft UEB	1018.0	23.0	-51.0
Sleep Restraint Assy-LH	Aft UEB	1018.0	-23.0	-50.0
Food Container	B1	1050.0	-27.0	39.0
Food Container	L3	1048.0	-47.0	12.0
Fecal Stowage Container	RHEB	1039.0	47.0	12.0
PGA Container	On Aft Bulkhead Under Ctr. Couch	1015.0	0.0	-19.9
CO ₂ Absorbers (2)	In ECU	1031.0	-48.3	19.9
CO ₂ Absorbers (4)	A3	1016.0	-24.0	28.0
CO ₂ Absorbers (4)	A4	1015.0	-7.0	28.0
CO ₂ Absorbers (4)	A5	1015.0	9.0	28.0
CO ₂ Absorbers (4)	B5	1031.0	-8.0	39.0
CO ₂ Absorbers (4)	B6	1031.0	13.0	39.0
CO ₂ Absorbers (4)	A6	1017.0	26.0	28.0
Order of Locations Used in Sequential Mass Properties Tables for CO ₂ Absorbed				
First 8.0 lb CO ₂ Absorbed	B5	1031.0	-8.0	39.0
Second 8.0 lb CO ₂ Absorbed	B6	1031.0	13.0	39.0
Remainder CO ₂ Absorbed	Composite Location	1017.6	-4.4	27.1

TABLE 3.1-6 (CONTINUED)
 APOLLO/SOYUZ TEST PROJECT COMMAND MODULE STOWAGE VOLUME CENTROIDS

<u>AREA</u>	<u>X</u>	<u>Y</u>	<u>Z</u>
A-1	1011.0	-21.0	-22.0
A-3	1016.0	-24.0	28.0
On A-3	1019.0	-31.0	29.0
Under A-3	1013.0	-17.0	27.0
A-4	1015.0	-7.0	28.0
A-5	1015.0	9.0	28.0
A-6	1017.0	26.0	28.0
A-7	1011.0	22.0	8.0
A-8	1011.0	21.0	-23.0
Side of A-8	1012.0	35.0	-23.0
B-1	1050.0	-27.0	39.0
B-2	1039.0	-38.0	37.0
B-3	1031.0	-28.0	40.0
B-4	1031.0	-20.0	40.0
B-5	1031.0	-8.0	39.0
B-6	1031.0	13.0	39.0
B-8	1024.0	-38.0	37.0
L-2	1059.0	-44.0	14.0
L-3	1048.0	-47.0	12.0
U-1	1033.0	23.0	-50.0
U-2	1033.0	-23.0	-50.0
U-3	1033.0	-36.0	-44.0
U-4	1038.0	39.0	-43.0
R-1	1072.0	26.0	21.0
R-2	1072.0	26.0	14.0
R-3	1072.0	26.0	9.0
R-4	1075.0	28.0	3.0
R-5	1059.0	44.0	15.0
R-6	1048.0	46.0	26.0
R-8	1052.0	46.0	12.0
R-11	1038.0	47.0	26.0
R-12	1072.0	26.0	9.0
R-13	1024.0	45.0	-26.0
RHLEB	1050.0	15.0	33.0
LHLEB	1050.0	-15.0	33.0

TABLE 3.1-6 (CONTINUED)
 APOLLO/SOYUZ TEST PROJECT DOCKING MODULE STOWAGE VOLUME CENTROIDS

CSM/DM DOCKED LOCATIONS

<u>AREA</u>	<u>X</u>	<u>Y</u>	<u>Z</u>
LOCKER D1	1205.3	0.0	-20.0
LOCKER D2	1166.3	2.8	-20.0
LOCKER D3	1157.1	-13.0	17.0
TV MOUNT (SOYUZ END)	1209.3	-4.5	21.0
TV MOUNT (CM END)	1133.6	-17.3	-8.8
FIRE EXTINGUISHER	1208.8	-14.2	20.2
SPEAKER BOX	1207.5	-22.6	-9.4
O2 MASK CONTAINER	1171.8	22.5	-11.5
O2 MASK CONTAINER	1195.3	-22.5	-11.5

TABLE 3.1-7
ASTP EQUIPMENT TRANSFER SUMMARIES

EVENT	WEIGHT (POUNDS)	CENTER OF GRAVITY (INCHES)			MOMENTS OF INERTIA (SLUG. FT ²)			PRODUCTS OF INERTIA (SLUG. FT ²)		
		X	Y	Z	IXX	IYY	IZZ	IXY	IXZ	IYZ
PAYLOAD READY FOR LAUNCH	910.8	1046.61	0.26	0.26	246.0	409.0	400.0	2.0	11.0	-18.0
EQUIPMENT TO BE RELOCATED IN CM AT HOHMANN TRANSFER	-173.7	1041.80	-1.46	-14.95	19.0	4.0	16.0	0.0	0.0	0.0
EQUIPMENT RELOCATED IN CM AT HOHMANN TRANSFER	173.7	1017.40	-0.58	-19.33	1.0	2.0	4.0	0.0	0.0	0.0
EQUIPMENT TO BE TRANSFERRED FROM CM TO SOYUZ AT DOCKED	- 33.8	1031.04	-2.25	0.96	6.0	15.0	16.0	0.0	0.0	0.0
EQUIPMENT TRANSFERRED FROM CM TO SOYUZ AT DOCKED	33.8	1406.70	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0
EQUIPMENT TO BE TRANSFERRED FROM SOYUZ TO CM PRIOR TO SEPARATION	- 33.8	1406.70	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0
EQUIPMENT TRANSFERRED FROM SOYUZ TO CM PRIOR TO SEPARATION	33.8	1031.04	-2.25	0.96	6.0	15.0	16.0	0.0	0.0	0.0
EQUIPMENT TO BE TRANSFERRED FROM CM TO DM PRIOR TO DM JETTISON	-198.3	1109.85	-0.10	-0.10	0.0	2.0	1.0	0.0	0.0	0.0
EQUIPMENT TRANSFERRED FROM CM TO DM PRIOR TO DM JETTISON	198.3	1164.70	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0
EQUIPMENT TO BE RELOCATED IN CM PRIOR TO CM/SM SEPARATION	- 23.6	1016.42	1.60	-25.83	1.0	0.0	1.0	0.0	0.0	0.0
EQUIPMENT RELOCATED IN CM PRIOR TO CM/SM SEPARATION	23.6	1036.86	1.07	-13.56	1.0	0.0	1.0	0.0	0.0	0.0

NOTE: MASS PROPERTIES ARE PRESENTED IN APOLLO COORDINATES.

TABLE 3.1-7 (CONTINUED)

APOLLO/SOYUZ TRANSFERRED CREW AND EQUIPMENT STORAGE LIST							APOLLO COORDINATES		
ITEMS REARRANGED IN CM PRIOR TO HOHMANN TRANSFER							X-C-G.	Y-C-G.	Z-C-G.
DESCRIPTION	STOW. ITEM	QTY	STORAGE LOCATION	WEIGHT	X-C-G.	Y-C-G.	Z-C-G.		
BAG, MDTION SICKNESS	A0208.	1	ON LH CREWMAN	.1	1043.0	-24.5	-11.9		
BAG, MDTION SICKNESS	A0208.	1	ON CTR CREWMAN	.1	1043.0	.0	-11.9		
BAG, MDTION SICKNESS	A0208.	1	ON RH CREWMAN	.1	1043.0	24.5	-11.9		
JACKET ASSY, ICG	B0124.	1	LOCKER U2	1.8	1033.0	-23.0	-50.0		
JACKET ASSY, ICG	B0124.	1	LOCKER U2	1.8	1033.0	-23.0	-50.0		
JACKET ASSY, ICG	B0124.	1	LOCKER U2	1.8	1033.0	-23.0	-50.0		
TROUSER ASSY, ICG	B0125.	1	LOCKER U2	1.8	1033.0	-23.0	-50.0		
TROUSER ASSY, ICG	B0125.	1	LOCKER U2	1.8	1033.0	-23.0	-50.0		
TROUSER ASSY, ICG	B0125.	1	LOCKER U2	1.8	1033.0	-23.0	-50.0		
BOOT, LEFT, ICG	B0126.	1	LOCKER U2	.4	1033.0	-23.0	-50.0		
BOOT, LEFT, ICG	B0126.	1	LOCKER U2	.4	1033.0	-23.0	-50.0		
BOOT, LEFT, ICG	B0126.	1	LOCKER U2	.4	1033.0	-23.0	-50.0		
BOOT, RIGHT, ICG	B0127.	1	LOCKER U2	.4	1033.0	-23.0	-50.0		
BOOT, RIGHT, ICG	B0127.	1	LOCKER U2	.4	1033.0	-23.0	-50.0		
BOOT, RIGHT, ICG	B0127.	1	LOCKER U2	.4	1033.0	-23.0	-50.0		
SUIT (ITLSA)	B0200.	1	ON LH CREWMAN	43.1	1043.0	-24.5	-11.9		
SUIT (ITLSA)	B0200.	1	ON CTR CREWMAN	43.1	1043.0	.0	-11.9		
SUIT (ITLSA)	B0200.	1	ON RH CREWMAN	43.1	1043.0	24.5	-11.9		
GLOVES, IV (PAIR)	B0201.	1	ON LH CREWMAN	2.0	1043.0	-24.5	-11.9		
GLOVES, IV (PAIR)	B0201.	1	ON CTR CREWMAN	2.0	1043.0	.0	-11.9		
GLOVES, IV (PAIR)	B0201.	1	ON RH CREWMAN	2.0	1043.0	24.5	-11.9		
HELMET ASSY, PRESSURE	B0202.	1	ON LH CREWMAN	3.1	1043.0	-24.5	-11.9		
HELMET ASSY, PRESSURE	B0202.	1	ON CTR CREWMAN	3.1	1043.0	.0	-11.9		
HELMET ASSY, PRESSURE	B0202.	1	ON RH CREWMAN	3.1	1043.0	24.5	-11.9		
COMMUNICATION CARRIER	B0203.	1	ON LH CREWMAN	1.6	1043.0	-24.5	-11.9		
COMMUNICATION CARRIER	B0203.	1	ON CTR CREWMAN	1.6	1043.0	.0	-11.9		
COMMUNICATION CARRIER	B0203.	1	ON RH CREWMAN	1.6	1043.0	24.5	-11.9		
VEST, DUAL LIFE	B0206.	1	ON LH CREWMAN	2.4	1043.0	-24.5	-11.9		
VEST, DUAL LIFE	B0206.	1	ON CTR CREWMAN	2.4	1043.0	.0	-11.9		
VEST, DUAL LIFE	B0206.	1	ON RH CREWMAN	2.4	1043.0	24.5	-11.9		
HARNES, CWG, ELECTRICAL	C0105.	1	LOCKER A8	.4	1043.0	24.5	-11.9		
HARNES, CWG, ELECTRICAL	C0105.	1	LOCKER A8	.4	1011.0	21.0	-23.0		
HARNES, CWG, ELECTRICAL	C0105.	1	LOCKER A8	.4	1011.0	21.0	-23.0		

TABLE 3.1-7 (CONTINUED)

APOLLO/SOYUZ TRANSFERRED CREW AND EQUIPMENT STORAGE LIST							APOLLO COORDINATES			
DESCRIPTION	STOW. ITEM	QTY	STORAGE LOCATION	WEIGHT	X-C.G.	Y-C.G.	Z-C.G.			
HARNES, CMG, ELECTRICAL	C0105.	1	LOCKER A8	.4	1011.0	21.0	-23.0			
HARNES, ELECTRICAL, SUIT	C0202.	1	ON LH CREWMAN	.4	1043.0	-24.5	-11.9			
HARNES, ELECTRICAL, SUIT	C0202.	1	ON CTR CREWMAN	.4	1043.0	.0	-11.9			
HARNES, ELECTRICAL, SUIT	C0202.	1	ON RH CREWMAN	.4	1043.0	24.5	-11.9			
HEADSET, LIGHTWEIGHT	F0101.	1	LOCKER A8	.4	1011.0	21.0	-23.0			
HEADSET, LIGHTWEIGHT	F0102.	1	LOCKER A8	.4	1011.0	21.0	-23.0			
HEADSET, LIGHTWEIGHT	F0103.	1	LOCKER A8	.4	1011.0	21.0	-23.0			
CM EQUIP. RELOC. 1				173.70	1041.80	-1.46	-14.95			
MOMENTS AND PRODUCTS, SLUG-FT SQ. ALPHABETICAL		19	4	16	0	1	2			

TABLE 3.1-7 (CONTINUED)

APOLLO/SOWUZ TRANSFERRED CREW AND EQUIPMENT STORAGE LIST							APOLLO COORDINATES		
DESCRIPTION	STOW. ITEM	QTY	STORAGE LOCATION	WEIGHT	X-C.G.	Y-C.G.	Z-C.G.		
BAG, MOTION SICKNESS	A0208.	1	AFT BLKD	.1	1015.0	.0	-20.0		
BAG, MOTION SICKNESS	A0208.	1	AFT BLKD	.1	1015.0	.0	-20.0		
BAG, MOTION SICKNESS	A0208.	1	AFT BLKD	.1	1015.0	.0	-20.0		
JACKET ASSY, ICG	B0124.	1	ON LH CREWMAN	1.8	1043.0	-24.5	-11.9		
JACKET ASSY, ICG	B0124.	1	ON CTR CREWMAN	1.8	1043.0	.0	-11.9		
JACKET ASSY, ICG	B0124.	1	ON RH CREWMAN	1.8	1043.0	24.5	-11.9		
TROUSER ASSY, ICG	B0125.	1	ON LH CREWMAN	1.8	1043.0	-24.5	-11.9		
TROUSER ASSY, ICG	B0125.	1	ON CTR CREWMAN	1.8	1043.0	.0	-11.9		
TROUSER ASSY, ICG	B0125.	1	ON RH CREWMAN	1.8	1043.0	24.5	-11.9		
BOOT, LEFT, ICG	B0126.	1	ON LH CREWMAN	.4	1043.0	-24.5	-11.9		
BOOT, LEFT, ICG	B0126.	1	ON CTR CREWMAN	.4	1043.0	.0	-11.9		
BOOT, LEFT, ICG	B0126.	1	ON RH CREWMAN	.4	1043.0	24.5	-11.9		
BOOT, RIGHT, ICG	B0127.	1	ON LH CREWMAN	.4	1043.0	-24.5	-11.9		
BOOT, RIGHT, ICG	B0127.	1	ON CTR CREWMAN	.4	1043.0	.0	-11.9		
BOOT, RIGHT, ICG	B0127.	1	ON RH CREWMAN	.4	1043.0	24.5	-11.9		
SUIT (ITLSA)	B0200.	1	AFT BLKD	43.1	1015.0	.0	-20.0		
SUIT (ITLSA)	B0200.	1	AFT BLKD	43.1	1015.0	.0	-20.0		
SUIT (ITLSA)	B0200.	1	AFT BLKD	43.1	1015.0	.0	-20.0		
GLOVES, IV (PAIR)	B0201.	1	AFT BLKD	2.0	1015.0	.0	-20.0		
GLOVES, IV (PAIR)	B0201.	1	AFT BLKD	2.0	1015.0	.0	-20.0		
GLOVES, IV (PAIR)	B0201.	1	AFT BLKD	2.0	1015.0	.0	-20.0		
HELMET ASSY, PRESSURE	B0202.	1	AFT BLKD	3.1	1015.0	.0	-20.0		
HELMET ASSY, PRESSURE	B0202.	1	AFT BLKD	3.1	1015.0	.0	-20.0		
HELMET ASSY, PRESSURE	B0202.	1	AFT BLKD	3.1	1015.0	.0	-20.0		
COMMUNICATION CARRIER	B0203.	1	LOCKER A1	1.6	1011.0	-21.0	-22.0		
COMMUNICATION CARRIER	B0203.	1	LOCKER A1	1.6	1011.0	-21.0	-22.0		
COMMUNICATION CARRIER	B0203.	1	LOCKER A1	1.6	1011.0	-21.0	-22.0		
VEST, DUAL LIFE	B0206.	1	AFT BLKD	2.4	1015.0	.0	-20.0		
VEST, DUAL LIFE	B0206.	1	AFT BLKD	2.4	1015.0	.0	-20.0		
VEST, DUAL LIFE	B0206.	1	AFT BLKD	2.4	1015.0	.0	-20.0		
HARNES, CWG, ELECTRICAL	C0105.	1	ON LH CREWMAN	.4	1043.0	-24.5	-11.9		
HARNES, CWG, ELECTRICAL	C0105.	1	ON CTR CREWMAN	.4	1043.0	.0	-11.9		

TABLE 3.1-7 (CONTINUED)

APOLLO/SOYUZ TRANSFERRED CREW AND EQUIPMENT STOWAGE LIST		APOLLO COORDINATES					
DESCRIPTION	STOR. ITEM	QTY	STOWAGE LOCATION	WEIGHT	X-C.G.	Y-C.G.	Z-C.G.
HARNES, CMG, ELECTRICAL	C0105.	1	ON RH CREWMAN	.4	1043.0	24.5	-11.9
HARNES, ELECTRICAL, SUIT	C0202.	1	AFT BLKD	.4	1015.0	.0	-20.0
HARNES, ELECTRICAL, SUIT	C0202.	1	AFT BLKD	.4	1015.0	.0	-20.0
HARNES, ELECTRICAL, SUIT	C0202.	1	AFT BLKD	.4	1015.0	.0	-20.0
HEADSET, LIGHTWEIGHT	E0101.	1	CN LH CREWMAN	.4	1043.0	-24.5	-11.9
HEADSET, LIGHTWEIGHT	E0102.	1	ON CTR CREWMAN	.4	1043.0	.0	-11.9
HEADSET, LIGHTWEIGHT	E0103.	1	CN RH CREWMAN	.4	1043.0	24.5	-11.9
CM EQUIP -RELOC. 1				173.70	1017.40	-5.58	-19.33
MOMENTS AND PRODUCTS, SLUG-FT SQ, ALPHABETICAL				4	0	0	0

TABLE 3.1-7 (CONTINUED)

APOLLO/SOYUZ TRANSFERRED CREW AND EQUIPMENT STOWAGE LIST							APOLLO COORDINATES		
ITEMS TRANSFERRED FROM CM TO SOYUZ POST CW/DW/SOYUZ DOCKING							X-C-G.	Y-C-G.	Z-C-G.
DESCRIPTION	STOW. ITEM	QTY	STOWAGE LOCATION	WEIGHT	X-C-G.	Y-C-G.	Z-C-G.		
CAMERA, 16MM DATA ACQUISITION	A0100.	1	LOCKER A1	1.8	1011.0	-21.0	-22.0		
MAGAZINE, 16MM DAC (DM)	A0101.1	7	LOCKER A1	7.0	1011.0	-21.0	-22.0		
CABLE, POWER (DAC)	A0104.	1	LOCKER A1	.2	1011.0	-21.0	-22.0		
LENS, 5MM (WITH COVER)	A0109.	1	LOCKER A1	.7	1011.0	-21.0	-22.0		
CAMERA, 35MM NIKON	A0121.	1	LOCKER B2	1.8	1039.0	-38.0	37.0		
LENS, 55MM F/1.2	A0122.	1	LOCKER B2	1.0	1039.0	-38.0	37.0		
CASSETTE, 35MM FILM	A0123.	4	LOCKER B2	.8	1039.0	-38.0	37.0		
CANISTER, 35MM FILM	A0124.	3	LOCKER B2	NEGL	1039.0	-38.0	37.0		
CAMERA, COLOR TV	E0110.	1	LOCKER A7	12.2	1011.0	22.0	8.0		
MONITOR, TV	E0111.	1	LOCKER A11	2.9	1140.6	.0	.0		
CABLE, TV MONITOR	E0112.	1	LOCKER A11	.6	1140.6	.0	.0		
LENS, ZOOM, WITH COVER	E0113.	1	LOCKER A7	1.5	1011.0	22.0	8.0		
CABLE, 12 FT TV	E0114.	1	LOCKER A7	.7	1140.6	.0	.0		
BAG, 35MM CAMERA SYSTEM	06360.	1	LOCKER B2	1.0	1039.0	-38.0	37.0		
CONTAINER, 16MM MAGAZINE	06374.	1	LOCKER A1	NEGL	1011.0	-21.0	-22.0		
CONTAINER, 16MM MAGAZINE	06374.	1	LOCKER R13	NEGL	1024.0	45.0	-26.0		
CONTAINER, 16MM EQUIP. TRANSFER	06375.	1	LOCKER A1	.3	1011.0	-21.0	-22.0		
KIT, ASTRONAUT PREFERENCE	A0142.	3	LOCKER A8	.3	1011.0	21.0	-23.0		
CONTAINER, SOYUZ TRANSFER	06369.	1	AFT BLKD	.9	1015.0	.0	-20.0		
TOTAL TRANSFERRED -							33.80	1031.04	.96
MOMENTS AND PRODUCTS, SLUG-FT SQ, ALPHABETICAL							16	-2.25	0

TABLE 3.1-7 (CONTINUED)

APOLLO/SOYUZ TRANSFERRED CREW AND EQUIPMENT STOWAGE LIST		SOYUZ COORDINATES					
DESCRIPTION	STOW. ITEM	QTY	STOWAGE LOCATION	WEIGHT	X-C.G.	Y-C.G.	Z-C.G.
CAMERA, 16MM DATA ACQUISITION	A0100.	1	SOYUZ VOL. CENTRIOD	1.8	1406.7	-0	-0
MAGAZINE, 16MM DAC (DM)	A0101.1	7	SOYUZ VOL. CENTRIOD	7.0	1406.7	-0	-0
CABLE, POWER (DAC)	A0104.	1	SOYUZ VOL. CENTRIOD	.2	1406.7	-0	-0
LENS, 5MM (WITH COVER)	A0109.	1	SOYUZ VOL. CENTRIOD	.7	1406.7	-0	-0
CAMERA, 35MM NIKON	A0121.	1	SOYUZ VOL. CENTRIOD	1.8	1406.7	-0	-0
LENS, 55MM F/1.2	A0122.	1	SOYUZ VOL. CENTRIOD	1.0	1406.7	-0	-0
CASSETTE, 35MM FILM	A0123.	4	SOYUZ VOL. CENTRIOD	.8	1406.7	-0	-0
CANISTER, 35MM FILM	A0124.	3	SOYUZ VOL. CENTRIOD	NEGL	1406.7	-0	-0
CAMERA, COLOR TV	E0110.	1	SOYUZ VOL. CENTRIOD	12.2	1406.7	-0	-0
MONITOR, TV	E0111.	1	SOYUZ VOL. CENTRIOD	2.9	1406.7	-0	-0
CABLE, TV MONITOR	E0112.	1	SOYUZ VOL. CENTRIOD	.6	1406.7	-0	-0
LENS, ZOOM, WITH COVER	E0113.	1	SOYUZ VOL. CENTRIOD	1.5	1406.7	-0	-0
CABLE, 12 FT TV	E0114.	1	SOYUZ VOL. CENTRIOD	.7	1406.7	-0	-0
BAG, 35MM CAMERA SYSTEM	O6360.	1	SOYUZ VOL. CENTRIOD	1.0	1406.7	-0	-0
CONTAINER, 16MM MAGAZINE	O6374.	1	SOYUZ VOL. CENTRIOD	NEGL	1406.7	-0	-0
CONTAINER, 16MM MAGAZINE	O6374.	1	SOYUZ VOL. CENTRIOD	NEGL	1406.7	-0	-0
CONTAINER, 16MM EQUIP. TRANSFER	O6375.	1	SOYUZ VOL. CENTRIOD	.3	1406.7	-0	-0
KIT, ASTRONAUT PREFERENCE	A0142.	3	SOYUZ VOL. CENTRIOD	.3	1406.7	-0	-0
CONTAINER, SOYUZ TRANSFER	O6369.	1	SOYUZ VOL. CENTRIOD	.9	1406.7	-0	-0
TOTAL TRANSFERRED				33.80	1406.70	-00	-00
MOMENTS AND PRODUCTS, SLUG-FT SQ, ALPHABETICAL				0	0	0	0

TABLE 3.1-7 (CONTINUED)

APCLLC/SOYUZ TRANSFERRED CREW AND EQUIPMENT STOWAGE LIST		SOYUZ COORDINATES						
ITEMS TRANSFERRED FROM SOYUZ TO CM PRIOR TO CM/DM/SOYUZ UNDOCKING								
DESCRIPTION	STCW. ITEM	REF	QTY	STOWAGE LOCATION	WEIGHT	X-C.G.	Y-C.G.	Z-C.G.
CAMERA, 16MM DATA ACQUISITION	A0100.		1	SOYUZ VCL-CENTRIOD	1.2	1406.7	.C	.0
MAGAZINE, 16MM DAC (DM)	A0101.1		7	SOYUZ VCL-CENTRIOD	7.0	1406.7	.C	.0
CABLE, POWER (DAC)	A0104.		1	SOYUZ VCL-CENTRIOD	.2	1406.7	.C	.0
LENS, 5MM (WITH COVER)	A0109.		1	SOYUZ VCL-CENTRIOD	.7	1406.7	.C	.0
CAMERA, 35MM NIKON	A0121.		1	SOYUZ VCL-CENTRIOD	1.8	1406.7	.C	.0
LENS, 55MM F/1.2	A0122.		1	SOYUZ VCL-CENTRIOD	1.0	1406.7	.C	.0
CASSETTE, 35MM FILM	A0123.		4	SOYUZ VCL-CENTRIOD	.8	1406.7	.C	.0
CANISTER, 35MM FILM	A0124.		3	SOYUZ VCL-CENTRIOD	NEGL	1406.7	.C	.0
CAMERA, COLOR TV	F0110.		1	SOYUZ VCL-CENTRIOD	12.2	1406.7	.C	.0
MONITOR, TV	F0111.		1	SOYUZ VCL-CENTRIOD	2.9	1406.7	.C	.0
CABLE, TV MONITOR	F0112.		1	SOYUZ VCL-CENTRIOD	.6	1406.7	.C	.0
LENS, ZOOM, WITH COVER	F0113.		1	SOYUZ VCL-CENTRIOD	1.5	1406.7	.C	.0
CABLE, 12 FT TV	F0114.		1	SOYUZ VCL-CENTRIOD	.7	1406.7	.C	.0
BAG, 35MM CAMERA SYSTEM	C6360.		1	SOYUZ VCL-CENTRIOD	1.0	1406.7	.C	.0
CONTAINER, 16MM MAGAZINE	C6374.		1	SOYUZ VCL-CENTRIOD	NEGL	1406.7	.C	.0
CONTAINER, 16MM MAGAZINE	C6374.		1	SOYUZ VCL-CENTRIOD	NEGL	1406.7	.C	.0
CONTAINER, 16MM EQUIP. TRANSFER	C6375.		1	SOYUZ VCL-CENTRIOD	.3	1406.7	.C	.0
KIT, ASTRONAUT PREFERENCE	A0142.		3	SOYUZ VCL-CENTRIOD	.3	1406.7	.C	.0
CONTAINER, SOYUZ TRANSFER	C6369.		1	SOYUZ VCL-CENTRIOD	.9	1406.7	.C	.0
TOTAL TRANSFERRED					33.80	1406.7C	.0C	.00
MOMENTS AND PRODUCTS, SLUG-FT SS, ALPHABETICAL					0	0	0	0

TABLE 3.1-7 (CONTINUED)

APOLLO/SOYUZ TRANSFERRED CREW AND EQUIPMENT STORAGE LIST							APOLLO COORDINATES			
DESCRIPTION	STOW. ITEM	QTY	STORAGE LOCATION	WEIGHT	X-C.G.	Y-C.G.	Z-C.G.			
CAMERA, 16MM DATA ACQUISITION	A0100.	1	LOCKER A1	1.9	1011.0	-21.0	-22.0			
MAGAZINE, 16MM DAC (DM)	A0101.1	7	LOCKER A1	7.0	1011.0	-21.0	-22.0			
CABLE, POWER (DAC)	A0104.	1	LOCKER A1	.2	1011.0	-21.0	-22.0			
LENS, 5MM (WITH COVER)	A0109.	1	LOCKER A1	.7	1011.0	-21.0	-22.0			
CAMERA, 35MM NIKON	A0121.	1	LOCKER B2	1.8	1039.0	-38.0	37.0			
LENS, 55MM F/1.2	A0122.	1	LOCKER B2	1.0	1039.0	-38.0	37.0			
CASSETTE, 35MM FILM	A0123.	4	LOCKER B2	.8	1039.0	-38.0	37.0			
CANISTER, 35MM FILM	A0124.	3	LOCKER B2	NEGL	1039.0	-38.0	37.0			
CAMERA, COLOR TV	E0110.	1	LOCKER A7	12.2	1011.0	22.0	8.0			
MONITOR, TV	E0111.	1	LOCKER A11	2.9	1140.6	.0	.0			
CABLE, TV MONITOR	E0112.	1	LOCKER A11	.6	1140.6	.0	.0			
LENS, ZOOM, WITH COVER	E0113.	1	LOCKER A7	1.5	1011.0	22.0	8.0			
CABLE, 12 FT TV	E0114.	1	LOCKER A11	.7	1140.6	.0	.0			
BAG, 35MM CAMERA SYSTEM	06360.	1	LOCKER B2	1.0	1039.0	-38.0	37.0			
CONTAINER, 16MM MAGAZINE	06374.	1	LOCKER A1	NEGL	1011.0	-21.0	-22.0			
CONTAINER, 16MM MAGAZINE	06374.	1	LOCKER R13	NEGL	1024.0	45.0	-26.0			
CONTAINER, 16MM EQUIP. TRANSFER	06375.	1	LOCKER A1	.3	1011.0	-21.0	-22.0			
KIT, ASTRONAUT PREFERENCE	A0142.	3	LOCKER A8	.3	1011.0	21.0	-23.0			
CONTAINER, SOYUZ TRANSFER	06369.	1	AFT BLKD	.9	1015.0	.0	-20.0			
TOTAL TRANSFERRED				33.80	1031.04	-2.25	.96			
MOMENTS AND PRODUCTS, SLUG-FT SQ, ALPHABETICAL				16	0	0	0			

TABLE 3.1-7 (CONTINUED)

APOLLO/SOYUZ TRANSFERRED CREW AND EQUIPMENT STOWAGE LIST		APOLLO COORDINATES				
ITEMS TRANSFERRED FROM CM TO DM PRIOR TO CS/M/DM UNDOCKING		WEIGHT	X-C.G.	Y-C.G.	Z-C.G.	
DESCRIPTION	STOW. ITEM	QTY	STOWAGE LOCATION			
BAG, JETTISON STOWAGE PROBE, DOCKING DOCKING STRUCTURE	B0108. 06337. TBD	1 1 1	LOCKER A1 INSTALLED IN TUNNEL INSTALLED IN TUNNEL	1011.0 1110.3 1110.3	-21.0 .0 .0	-22.0 .0 .0
TOTAL TRANSFERRED - MOMENTS AND PRODUCTS, SLUG-FT SQ. ALPHABETICAL				198.30 1109.85	-21.0 0	-22.0 0

TABLE 3.1-7 (CONTINUED)

APOLLO/SOYUZ TRANSFERRED CREW AND EQUIPMENT STOWAGE LIST							
ITEMS TRANSFERRED FROM CM TO DM PRIOR TO CSM/DM UNDOCKING							
DM COORDINATES							
DESCRIPTION	STOW. ITEM	QTY	STOWAGE LOCATION	WEIGHT	X-C.G.	Y-C.G.	Z-C.G.
BAG, JETTISON STOWAGE PROBE, DOCKING DOCKING STRUCTURE	80108. 06337. T8D	1 1 1	DM VOLUME CENTROID DM VOLUME CENTROID DM VOLUME CENTROID	.9 85.7 111.7	1164.7 1164.7 1164.7	.0 .0 .0	.0 .0 .0
TOTAL TRANSFERRED MOMENTS AND PRODUCTS, SLUG-FT SQ, ALPHABETICAL				198.30	1164.70	.00	.00

TABLE 3.1-7 (CONTINUED)

APOLLO/SOYUZ TRANSFERRED CREW AND EQUIPMENT STORAGE LIST		APOLLO COORDINATES				
ITEMS REARRANGED IN CM PRIOR TO CM/SM SEPARATION		STOWAGE LOCATION	WEIGHT	X-C.G.	Y-C.G.	Z-C.G.
DESCRIPTION	STOW. ITEM	QTY				
PAD, HEADREST	B0112.	3	LOCKER A8	1011.0	21.0	-23.0
HEEL RESTRAINT, LH AND RH	B0113.	3	LOCKER A8	1011.0	21.0	-23.0
COMMUNICATION CARRIER	B0203.	1	LOCKER A1	1011.0	-21.0	-22.0
COMMUNICATION CARRIER	B0203.	1	LOCKER A1	1011.0	-21.0	-22.0
COMMUNICATION CARRIER	B0203.	1	LOCKER A1	1011.0	-21.0	-22.0
VEST, DUAL LIFE	B0206.	1	AFT BLKD	1015.0	.0	-20.0
VEST, DUAL LIFE	B0206.	1	AFT BLKD	1015.0	.0	-20.0
VEST, DUAL LIFE	B0206.	1	AFT BLKD	1015.0	.0	-20.0
HEADSET, LIGHTWEIGHT	E0101.	1	CN LH CREWMAN	1043.0	-24.5	-11.9
HEADSET, LIGHTWEIGHT	E0102.	1	CN CTR CREWMAN	1043.0	.0	-11.9
HEADSET, LIGHTWEIGHT	E0103.	1	CN RH CREWMAN	1043.0	24.5	-11.9
SLEEP RESTRAINT ASSY(RIGHT)	00392.	1	UPPER EQUIP. STORAGE	1027.0	.0	-51.0
CM EQUIP. RELOC. 2	-					
MOMENTS AND PRODUCTS, SLUG-FT SQ, ALPHABETICAL						
				23.60	1016.42	1.60
				0	0	0
				1	0	-25.83
				0	0	0

TABLE 3.1-7 (CONTINUED)

APOLLO/SOYUZ TRANSFERRED CREW AND EQUIPMENT STORAGE LIST							APOLLO COORDINATES		
ITEMS REARRANGED IN CM PRIOR TO CM/SM SEPARATION							X-C.G.	Y-C.G.	Z-C.G.
DESCRIPTION	STOW. ITEM	QTY	STOWAGE LOCATION	WEIGHT	X-C.G.	Y-C.G.	Z-C.G.		
PAD, HEADREST	B0112.	3	CN CENTER COUCH	3.3	1043.0	.0	-10.4		
HEEL RESTRAINT, LH AND RH	B0113.	3	CN CTR CREWMAN	3.3	1043.0	.0	-11.9		
COMMUNICATION CARRIER	B0203.	1	CN LH CREWMAN	1.6	1043.0	-24.5	-11.9		
COMMUNICATION CARRIER	B0203.	1	CN CTR CREWMAN	1.6	1043.0	.0	-11.9		
COMMUNICATION CARRIER	B0203.	1	CN RH CREWMAN	1.6	1043.0	24.5	-11.9		
VEST, DUAL LIFE	B0206.	1	CN LH CREWMAN	2.4	1043.0	-24.5	-11.9		
VEST, DUAL LIFE	B0206.	1	CN CTR CREWMAN	2.4	1043.0	.0	-11.9		
VEST, DUAL LIFE	B0206.	1	CN RH CREWMAN	2.4	1043.0	24.5	-11.9		
HEADSET, LIGHTWEIGHT	E0101.	1	LOCKER A8	.4	1011.0	21.0	-23.0		
HEADSET, LIGHTWEIGHT	E0102.	1	LOCKER A8	.4	1011.0	21.0	-23.0		
HEADSET, LIGHTWEIGHT	E0103.	1	LOCKER A8	.4	1011.0	21.0	-23.0		
SLEEP RESTRAINT ASSY(RIGHT)	O0392.	1	AFT BLKD	3.8	1015.0	.0	-20.0		
CM EQUIP. RELOC. 2 MOMENTS AND PRODUCTS, SLUG-FT SQ, ALPHABETICAL				23.60	1036.86	1.07	-13.56		
				1	0	0	0		

TABLE 3.1-8
 CONSUMABLES LOADING REQUIREMENTS AND TOLERANCES FORM
 APOLLO/SOYUZ MISSION

SPS Propellant

Pressure (psia)		Temperature (°F)		Quantity Readout (%)	
Fuel	Oxidizer	Fuel	Oxidizer	Fuel	Oxidizer
25 \pm 5	25 \pm 5	70 \pm 5	70 \pm 5	TBS	TBS

SPS Propellant Load (lb)	Load. Requirement		Total	Actual	
	Fuel	Oxidizer		Fuel	Oxidizer
Load ⁽¹⁾ Trapped Outside Tanks ⁽²⁾ Tanked Trapped Inside Tanks ⁽²⁾ Nominal Deliverable ⁽³⁾	TBS	TBS	TBS	TBS	TBS

Service Module RCS Propellant⁽⁴⁾

- Secondary Fuel - Quads A, B, C, D - See Loading Window - Figure 4.3-1.
- Primary Fuel - Quads A, B, C, D - See Loading Window - Figure 4.3-2.
- Primary and Secondary Oxidizer - Quads A, B, C, D - See Loading Window - Figure 4.3-3.
- PSM Fuel - See Loading Window - Figure 4.3-4.
- PSM Oxidizer - See Loading Window - Figure 4.3-5.

Command Module RCS Propellant⁽⁴⁾

- Fuel - Systems A and B - See Loading Window - Figure 4.3-6.
- Oxidizer - Systems A and B - See Loading Window - Figure 4.3-7.

Helium and Nitrogen⁽⁷⁾

Consumable	Loading Requirement			Actual		
	Pressure (psia)	Temp. (°F)	Weight (lb)	Earth Launch Weight (lb)	Pressure (psia)	Temp. (°F)
Helium - SPS Bottles	3600	70	43.8			
Helium - Fuel Tanks	178	70	} 2.7			
Helium - N ₂ O ₄ Tanks	178	70				
Helium - SM/RCS						
Quads A	4150	70	} 5.44			
Quads B	4150	70				
Quads C	4150	70				
Quads D	4150	70				
- PSM	TBS	70	4.06			
Helium - CM/RCS						
System A	4150	70	} 1.06			
System B	4150	70				
Nitrogen - SM						
Primary	2500	85	} 1.3			
Secondary	2500	85				

TABLE 3.1-8 (CONTINUED)
 CONSUMABLES LOADING REQUIREMENTS AND TOLERANCES FORM
 APOLLO/SOYUZ MISSION

Command Module Water and GOX

	Pressure (psia)	Loading Requirement Weight (lb)	Earth Launch Weight (lb)	Actual
Waste Water ⁽⁵⁾ Potable Water ⁽⁵⁾ CM/GOX	900±50	3.7	35.0 30.0 6.7 (entry)	

Service Module Hydrogen and Oxygen⁽⁶⁾

	Loading Req. Per Tank (pounds)	Earth Launch Weight Per Tank (lb)	Actual Per Tank (lb)
Hydrogen Tank 1	29.3	27.6	
Tank 2	29.3	27.6	
Oxygen Tank 1	330.1	316.6	
Tank 2	330.1	316.6	

Docking Module Oxygen and Oxygen/Nitrogen

	Loading Req. Per Tank (pounds)	Earth Launch Weight Per Tank (lb)	Actual Per Tank (lb)
Oxygen	48.0	48.0	
Oxygen/Nitrogen	48.0	48.0	

NOTES:

- (1) Indicated propellant load is based on nominal pressure and temperature prior to actual loading. This number will be updated after loading is accomplished.
- (2) See Section 4.1 for explanation of trapped SPS propellant.
- (3) See Table 3.1-11 for loading uncertainties.
- (4) See Section 4.2 for SM/RCS loads and uncertainties to be used in mission planning. Actual SM/RCS loads and uncertainties will be published in Table 3.1-12.
- (5) Launch Rule Redlines determine lift-off values.
- (6) Launch Mission Rules will determine offload and minimum/maximum lift-off quantities for H₂ and O₂.
- (7) CSM helium and nitrogen should be loaded in accordance with loading windows contained in Apollo/Soyuz Test Project Operational Data Book, Volume I, Part 2.

TABLE 3.1-9
SPS PROPELLANT LOAD CALCULATION FORM
APOLLO/SOYUZ MISSION

SPS Propellant Load Calculation

	Fuel	Oxidizer
1. Enter SPS quantity readout at flight load (25 psia)		
2. Use table below to obtain propellant load for above quantity readout.		
3. Nominal propellant density at loading temperature (use temperature - density graph below) (lb/ft ³)		
4. Cubic feet of propellant (item 2 divided by item 3)		
5. Calculated density from Table 3.1-10, item F (lb/ft ³)		
6. Resulting actual propellant load (item 4 times item 5)		

Propellant Load

<u>PUGS READOUT (%)</u>	<u>FUEL LOAD (lb)</u>	<u>OXIDIZER LOAD (lb)</u>
TBS	TBS	TBS

SPS Oxidizer SPS Fuel SPS Propellant Temperature/Density Graph at 25 ±5 psia

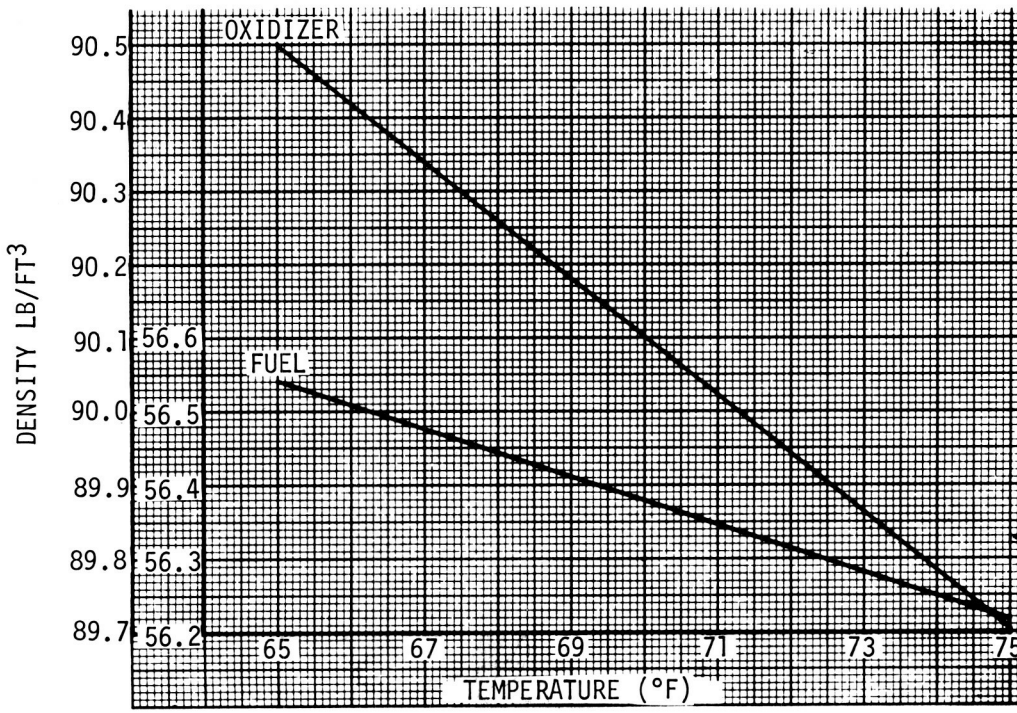


TABLE 3.1-10 (CONTINUED)

SPS PROPELLANT LOAD CALCULATION FORM
 APOLLO/SOYUZ MISSION SPS PROPELLANT LOAD PARAMETERS
 (To be provided by KSC following loading)

Enter the following information at zero adjust	
<u>Fuel</u>	<u>Oxidizer</u>
Adjusted quantity fuel readout - percent _____	Adjusted quantity oxidizer readout - percent _____
Fuel sump voltage reading taken from _____	Oxidizer sump voltage reading taken from _____
ACE to three significant digits - volts _____	ACE to three significant digits - volts _____

Enter the following information at sump tank full adjust
 (Propellant at top of standpipe)

Enter the following information at sump tank full adjust (Propellant at top of standpipe)	
<u>Fuel</u>	<u>Oxidizer</u>
Fuel sump tank pressure - psia _____	Oxidizer sump tank pressure - psia _____
Fuel temperature - °F _____	Oxidizer temperature - °F _____
Adjusted quantity fuel readout - percent _____	Adjusted quantity oxidizer readout - percent _____
Fuel sump voltage reading taken from _____	Oxidizer sump voltage reading taken from _____
ACE to three significant digits - volts _____	ACE to three significant digits - volts _____

Enter the following information at flight load

Enter the following information at flight load	
<u>Fuel</u>	<u>Oxidizer</u>
a. Fuel quantity readout - percent _____	a. Oxidizer quantity readout - percent _____
b. Fuel sump tank pressure - psia _____	b. Oxidizer sump tank pressure - psia _____
c. Fuel temperature - °F _____	c. Oxidizer temperature - °F _____
d. Fuel sump voltage reading taken from ACE to three significant digits - volts _____	d. Oxidizer sump voltage reading taken from ACE to three significant digits - volts _____
e. Fuel measured specific gravity @ 25°C - 14.7 psia _____	e. Oxidizer measured specific gravity @ _____ - 14.7 psia _____
f. Fuel measured density 25°C 14.7 psia (Item b times 62.428) - lb/ft ³ _____	f. Oxidizer measured density @ 14.7 psia (Item b times 62.428) - lb/ft ³ _____
g. Calculated density - lb/ft ³ - at system pressure and temperature, Items b and c above. Use density equation outlined in Section 4.1 _____	g. Calculated density - lb/ft ³ at system pressure and temperature, Items b and c above. Use density equation outlined in Section 4.1. _____

Enter the following information at leak check pressure

Enter the following information at leak check pressure	
<u>Fuel</u>	<u>Oxidizer</u>
System pressure - psia _____	System pressure - psia _____
Quantity fuel readout - percent _____	Quantity oxidizer readout - percent _____
Fuel sump voltage reading from ACE _____	Oxidizer sump voltage reading from ACE _____

TABLE 3.1-11
SPS PROPELLANT UNCERTAINTIES
APOLLO/SOYUZ MISSION

ITEM	FUEL	OXIDIZER
<u>LOADING UNCERTAINTIES</u>	(1b)	(1b)
Tank Volume	TBS	TBS
Temperature Gage (+2.0°F)		
Standpipe Height		
Propellant Gage (+0.35% of Gageable)		
Density Measurement ⁽¹⁾		
Batch Density ⁽¹⁾		
Loading Pressure ⁽¹⁾		
RSS	TBS	TBS
TOTAL RSS	TBS	
Loading Specification ^{(1) (2)}		
Tolerance on Propellant Temperature of Flight Load		
TOTAL LOADING UNCERTAINTY	TBS	

- NOTES: (1) Data will be known after loading is accomplished.
 (2) Loading specification is an allowable tolerance about nominal; this number is added to the loading uncertainty variable.

TABLE 3.1-12
 COMMAND AND SERVICE MODULE RCS LOADING SUMMATION FORM
 APOLLO/SOYUZ MISSION

This table will be completed when loading is accomplished. For Mission Planning, reference should be made to Section 4.1 for nominal load, loading tolerances, and nominal deliverable propellants.

COMMAND MODULE

	<u>Fuel</u>		<u>Oxidizer</u>	
	<u>Tank A</u>	<u>Tank B</u>	<u>Tank A</u>	<u>Tank B</u>
Propellant Load	_____	_____	_____	_____
Total	_____	_____	_____	_____
Maximum Trapped	_____	_____	_____	_____
Nominal Deliverable	_____	_____	_____	_____

SERVICE MODULE

<u>Quad A (1b)</u>		<u>Quad B (1b)</u>	
Secondary Fuel	_____	Secondary Fuel	_____
Primary Fuel	_____	Primary Fuel	_____
Total Fuel	_____	Total Fuel	_____
Maximum Trapped	_____	Maximum Trapped	_____
Nominal Deliverable	_____	Nominal Deliverable	_____
Total Oxidizer	_____	Total Oxidizer	_____
Maximum Trapped	_____	Maximum Trapped	_____
Nominal Deliverable	_____	Nominal Deliverable	_____

<u>Quad C (1b)</u>		<u>Quad D (1b)</u>	
Secondary Fuel	_____	Secondary Fuel	_____
Primary Fuel	_____	Primary Fuel	_____
Total Fuel	_____	Total Fuel	_____
Maximum Trapped	_____	Maximum Trapped	_____
Nominal Deliverable	_____	Nominal Deliverable	_____
Total Oxidizer	_____	Total Oxidizer	_____
Maximum Trapped	_____	Maximum Trapped	_____
Nominal Deliverable	_____	Nominal Deliverable	_____

<u>PSM</u>	
Total Fuel	_____
Maximum Trapped	_____
Nominal Deliverable	_____
Total Oxidizer	_____
Maximum Trapped	_____
Nominal Deliverable	_____

TOTAL SM/RCS PROPELLANT LOAD (1b)

Total Fuel	_____	Total Oxidizer	_____
Maximum Trapped	_____	Maximum Trapped	_____
Nominal Deliverable	_____	Nominal Deliverable	_____

4.0 CSM REFERENCE CONSUMABLE MASS PROPERTIES DATA

The data presented in this section will enable the user to obtain the separate centers-of-gravity and moments-of-inertia for those spacecraft consumables onboard that significantly affect overall CSM and CM performance. CSM consumables mass property data must be compared to the current onboard consumable loading data for each mission provided in Section 3.0. The mass property data are presented in the following sections:

- 4.1 SPS Tank Consumables Mass Properties, Trapped Propellants, SPS Density Equations and Graphs
- 4.2 RCS/ECS/EPS Consumables Mass Properties, and SM RCS Quad Mass Properties
- 4.3 CSM RCS Load Calculation Tables and Loading Windows

TABLE 4.1-1

Table 4.1-1 presents the mass characteristics for the SM/SPS propellant tanks.

The following units apply to the indicated headings:

Height of Propellant - Inches	Mass of Propellant - Pounds
Tank Volume Unstretched - Ft ³	Center of Mass - X _A Coordinates - Inches
Tank Volume Stretched - Ft ³	Moment of Inertia (I _{YY}) - Slug-ft ²

Further, Moment of Inertia I_{ZZ} = Moment of Inertia I_{YY}; Moment of Inertia I_{XX} = 0.0 for all propellant weights; tank pressure used in calculating this table was 175 ±5 psia, propellant temperature was 70°F, density for fuel was 56.43 lb/ft³, and oxidizer density was 90.21 lb/ft³.

The Y_A and Z_A Center of Mass components for the individual tanks are constant and are as follows:

	Y _A (inches)	Z _A (inches)
Fuel Sump	-48.3	-6.6
Oxidizer Sump	48.3	6.6

TABLE 4.1-1 (CONTINUED)
FUEL SUMP TANK

HEIGHT OF PROPELLANT	TANK VOLUME UNSTRETCHED	TANK VOLUME STRETCHED	MASS OF PROPELLANT	CENTER OF MASS	MOMENT OF INERTIA(IYY)
4.00	5.02	5.02	283.7	860.5	12.0
5.00	5.31	5.31	300.3	859.1	12.0
6.00	5.67	5.68	321.2	857.7	12.0
7.00	6.11	6.12	346.1	856.3	12.0
8.00	6.61	6.63	374.9	855.0	12.0
9.00	7.18	7.21	407.3	853.9	12.0
10.00	7.81	7.84	443.1	852.9	12.0
11.00	8.49	8.53	482.1	852.0	12.0
12.00	9.23	9.27	524.1	851.3	12.1
13.00	10.01	10.07	568.9	850.8	12.2
14.00	10.85	10.91	616.3	850.4	12.3
15.00	11.72	11.79	666.1	850.1	12.4
16.00	12.63	12.71	718.1	849.9	12.5
17.00	13.57	13.66	772.0	849.8	12.7
18.00	14.55	14.65	827.7	849.8	12.8
19.00	15.56	15.66	885.0	849.8	13.0
20.00	16.58	16.70	943.6	849.9	13.3
21.00	17.63	17.75	1003.3	850.1	13.5
22.00	18.69	18.83	1064.0	850.2	13.8
23.00	19.77	19.91	1125.4	850.5	14.0
24.00	20.86	21.01	1187.3	850.7	14.3
25.00	21.95	22.11	1249.5	851.0	14.6
26.00	22.49	22.66	1280.7	851.2	14.9
27.00	23.04	23.21	1311.8	851.3	15.2
28.00	24.13	24.31	1374.0	851.6	15.4
29.00	25.22	25.41	1436.2	852.0	15.7
30.00	26.31	26.51	1498.4	852.3	16.0
31.00	27.41	27.61	1560.7	852.7	16.7
32.00	28.50	28.71	1622.9	853.1	17.1
33.00	29.59	29.82	1685.1	853.5	17.6
34.00	30.68	30.92	1747.3	853.8	18.2
35.00	31.77	32.02	1809.5	854.2	18.7
36.00	32.86	33.12	1871.8	854.7	19.2
37.00	33.96	34.22	1934.0	855.1	20.0
38.00	35.05	35.32	1996.2	855.5	20.6
39.00	36.14	36.42	2058.4	855.9	21.2
39.00	37.23	37.52	2120.6	856.3	22.1

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TABLE 4.1-1 (CONTINUED)
FUEL SUMP TANK

HEIGHT OF PROPELLANT	TANK VOLUME UNSTRECHED	TANK VOLUME STRECHED	MASS OF PROPELLANT	CENTER OF MASS	MOMENT OF INERTIA(IYY)
40.00	38.32	38.62	2182.9	856.8	23.0
41.00	39.41	39.72	2245.1	857.2	24.3
42.00	40.51	40.82	2307.3	857.6	25.8
43.00	41.60	41.92	2369.5	858.1	27.7
44.00	42.69	43.03	2431.7	858.5	29.9
45.00	43.78	44.13	2494.0	859.0	32.3
46.00	44.87	45.23	2556.2	859.4	35.1
47.00	45.96	46.33	2618.4	859.9	38.1
48.00	47.06	47.43	2680.6	860.3	41.5
49.00	48.15	48.53	2742.8	860.8	45.1
50.00	49.24	49.63	2805.1	861.2	49.0
51.00	50.33	50.73	2867.3	861.7	53.2
52.00	51.42	51.83	2929.5	862.2	57.7
53.00	52.51	52.93	2991.7	862.6	62.5
54.00	53.61	54.03	3053.9	863.1	67.6
55.00	54.70	55.13	3116.2	863.6	73.1
56.00	55.79	56.24	3178.4	864.0	78.8
57.00	56.88	57.34	3240.6	864.5	84.9
58.00	57.97	58.44	3302.8	865.0	91.4
58.02	57.99	58.46	3304.1	865.0	91.5
59.00	59.15	59.62	3369.8	865.5	100.8
60.00	60.33	60.81	3436.9	866.0	108.2
61.00	61.50	62.00	3504.1	866.5	115.9
62.00	62.68	63.18	3571.2	867.0	123.9
63.00	63.86	64.37	3638.3	867.5	132.4
64.00	65.04	65.56	3705.4	868.0	141.2
65.00	66.21	66.75	3772.5	868.5	150.5
66.00	67.39	67.93	3839.6	869.0	160.1
67.00	68.57	69.12	3906.7	869.5	170.2
68.00	69.75	70.31	3973.8	870.0	180.7
69.00	70.92	71.50	4040.9	870.5	191.6
70.00	72.10	72.68	4108.0	871.0	203.0
71.00	73.28	73.87	4175.1	871.5	214.8
72.00	74.46	75.06	4242.3	872.0	227.1
73.00	75.63	76.25	4309.4	872.6	239.8
74.00	76.81	77.43	4376.5	873.1	253.0
75.00	77.99	78.62	4443.6	873.6	266.7

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TABLE 4.1-1 (CONTINUED)

FUEL SUMP TANK

HEIGHT OF PROPELLANT	TANK VOLUME UNSTRECHED	TANK VOLUME STRECHED	PROPELLANT MASS	CENTER OF MASS	MOMENT OF INERTIA(IYY)
75.00	79.16	79.81	4510.7	874.1	280.8
77.00	80.34	81.00	4577.8	874.6	295.5
78.00	81.52	82.18	4644.9	875.1	310.7
79.00	82.70	83.37	4712.0	875.6	326.4
80.00	83.87	84.56	4779.1	876.1	342.6
81.00	85.05	85.74	4846.2	876.6	359.3
82.00	86.23	86.93	4913.3	877.1	376.5
83.00	87.41	88.12	4980.4	877.6	394.3
84.00	88.58	89.31	5047.6	878.1	412.7
85.00	89.76	90.49	5114.7	878.6	431.6
86.00	90.94	91.68	5181.8	879.1	451.1
87.00	92.12	92.87	5248.9	879.6	471.1
88.00	93.29	94.06	5316.0	880.1	491.7
89.00	94.47	95.24	5383.1	880.6	512.9
90.00	95.65	96.43	5450.2	881.1	534.7
91.00	96.83	97.62	5517.3	881.6	557.2
92.00	98.00	98.81	5584.4	882.1	580.2
93.00	99.18	99.99	5651.5	882.6	603.8
94.00	100.36	101.18	5718.6	883.1	628.1
95.00	101.54	102.37	5785.8	883.6	653.0
96.00	102.71	103.55	5852.9	884.1	678.5
97.00	103.89	104.74	5920.0	884.6	704.7
98.00	105.07	105.93	5987.1	885.1	731.5
99.00	106.25	107.12	6054.2	885.6	759.0
100.00	107.42	108.30	6121.3	886.1	787.2
101.00	108.60	109.49	6188.4	886.6	816.1
102.00	109.78	110.68	6255.5	887.1	845.6
103.00	110.96	111.87	6322.6	887.6	875.9
104.00	112.13	113.05	6389.7	888.1	906.8
105.00	113.31	114.24	6456.8	888.7	938.4
106.00	114.49	115.43	6523.9	889.2	970.8
107.00	115.67	116.62	6591.1	889.7	1003.9
108.00	116.84	117.80	6658.2	890.2	1037.7
109.00	118.02	118.99	6725.3	890.7	1072.2
110.00	119.20	120.18	6792.4	891.2	1107.5
111.00	120.38	121.36	6859.5	891.7	1143.6
112.00	121.55	122.55	6926.6	892.2	1180.4

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TABLE 4.1-1 (CONTINUED)
FUEL SUMP TANK

HEIGHT OF PROPELLANT	TANK VOLUME UNSTRECHED	TANK VOLUME STRECHED	MASS OF PROPELLANT	CENTER OF MASS	MOMENT OF INERTIA(IYY)
113.00	122.73	123.74	6993.7	892.7	1218.0
114.00	123.91	124.93	7060.8	893.2	1256.4
115.00	125.09	126.11	7127.9	893.7	1295.5
116.00	126.26	127.30	7195.0	894.2	1335.4
117.00	127.44	128.49	7262.1	894.7	1376.2
118.00	128.62	129.68	7329.2	895.2	1417.7
119.00	129.79	130.86	7396.4	895.7	1460.0
120.00	130.97	132.05	7463.5	896.2	1503.2
121.00	132.15	133.24	7530.6	896.7	1547.2
122.00	133.33	134.43	7597.7	897.2	1592.0
123.00	134.50	135.61	7664.8	897.7	1637.7
124.00	135.68	136.80	7731.9	898.2	1684.2
125.00	136.86	137.99	7799.0	898.7	1731.6
126.00	138.04	139.17	7866.1	899.2	1779.8
127.00	139.21	140.36	7933.2	899.7	1829.0
128.00	140.39	141.55	8000.3	900.2	1879.0
128.30	140.75	141.91	8020.5	900.3	1894.1
129.00	141.57	142.74	8067.4	900.7	1929.8
130.00	142.74	143.92	8134.4	901.2	1981.5
131.00	143.91	145.10	8201.0	901.7	2033.8
132.00	145.07	146.27	8267.0	902.2	2086.5
133.00	146.10	147.31	8325.8	902.6	2134.1
134.00	147.35	148.56	8396.8	903.2	2192.7
135.00	148.46	149.69	8460.2	903.6	2245.8
136.00	149.55	150.78	8522.2	904.1	2298.5
137.00	150.61	151.85	8582.5	904.6	2350.7
138.00	151.63	152.89	8641.1	905.0	2402.0
139.00	152.63	153.89	8697.6	905.4	2452.3
140.00	153.58	154.85	8752.0	905.8	2501.2
141.00	154.49	155.77	8803.9	906.2	2548.6
142.00	155.36	156.64	8853.2	906.6	2594.0
143.00	156.17	157.46	8899.6	907.0	2637.4
144.00	156.93	158.23	8943.0	907.3	2678.3
145.00	157.64	158.94	8983.1	907.6	2716.6
146.00	158.28	159.59	9019.8	907.9	2751.8
147.00	158.86	160.17	9052.8	908.1	2783.8

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TABLE 4.1-1 (CONTINUED)

FUEL SUMP TANK		CENTER OF MASS		MOMENT OF INERTIA(IYY)	
HEIGHT OF PROPELLANT	TANK VOLUME UNSTRECHED	TANK VOLUME STRECHED	MASS OF PROPELLANT	MASS	
148.00	159.37	160.69	9082.0	908.4	2812.2
149.00	159.81	161.13	9107.0	908.6	2836.8
150.00	160.17	161.50	9127.8	908.7	2857.3
151.00	160.46	161.78	9144.0	908.9	2873.4
152.00	160.66	161.99	9155.6	909.0	2884.9
153.00	160.78	162.11	9162.2	909.0	2891.5
153.80	160.81	162.14	9163.9	909.0	2893.1

TABLE 4.1-1 (CONTINUED)
OXIDIZER SUMP TANK

HEIGHT OF PROPELLANT	TANK VOLUME UNSTRETCHED	TANK VOLUME STRETCHED	MASS OF PROPELLANT	CENTER OF MASS	MOMENT OF INERTIA (IYY)
4.00	5.02	5.02	452.5	860.5	19.3
5.00	5.31	5.31	479.0	859.1	20.1
6.00	5.67	5.68	512.3	857.7	20.5
7.00	6.11	6.12	552.1	856.3	20.8
8.00	6.61	6.63	598.0	855.0	21.0
9.00	7.18	7.21	649.6	853.9	21.4
10.00	7.81	7.84	706.7	852.9	21.8
11.00	8.49	8.53	768.9	852.0	22.1
12.00	9.23	9.27	836.0	851.3	22.4
13.00	10.01	10.07	907.4	850.8	23.0
14.00	10.85	10.91	983.1	850.4	23.5
15.00	11.72	11.79	1062.5	850.1	24.0
16.00	12.63	12.71	1145.4	849.9	24.4
17.00	13.57	13.66	1231.4	849.8	25.1
18.00	14.55	14.65	1320.2	849.8	25.6
19.00	15.56	15.66	1411.6	849.8	25.9
20.00	16.58	16.70	1505.0	849.9	26.1
21.00	17.63	17.75	1600.3	850.1	26.4
22.00	18.69	18.83	1697.1	850.2	26.8
23.00	19.77	19.91	1795.0	850.5	27.1
24.00	20.86	21.01	1893.8	850.7	27.5
25.00	21.95	22.11	1993.7	851.0	27.9
25.50	22.49	22.66	2042.7	851.2	28.2
26.00	23.04	23.21	2092.3	851.3	28.4
27.00	24.13	24.31	2191.6	851.6	28.6
28.00	25.22	25.41	2290.8	852.0	28.8
29.00	26.31	26.51	2390.1	852.3	29.0
30.00	27.41	27.61	2489.3	852.7	29.3
31.00	28.50	28.71	2588.5	853.1	29.8
32.00	29.59	29.82	2687.8	853.5	30.3
33.00	30.68	30.92	2787.0	853.8	31.9
34.00	31.77	32.02	2886.3	854.2	31.6
35.00	32.86	33.12	2985.5	854.7	32.1
36.00	33.96	34.22	3084.8	855.1	32.9
37.00	35.05	35.32	3184.0	855.5	33.9
38.00	36.14	36.42	3283.2	855.9	34.3
39.00	37.23	37.52	3382.5	856.3	35.2

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TABLE 4.1-1 (CONTINUED)
OXIDIZER SUMP TANK

HEIGHT OF PROPELLANT	TANK VOLUME UNSTRECHED	TANK VOLUME STRECHED	MASS OF PROPELLANT	CENTER OF MASS	MUMENT OF INERTIA(IYY)
40.00	38.32	38.62	3481.7	856.8	36.7
41.00	39.41	39.72	3581.0	857.2	38.7
42.00	40.51	40.82	3680.2	857.6	41.2
43.00	41.60	41.92	3779.4	858.1	44.2
44.00	42.69	43.03	3878.7	858.5	47.7
45.00	43.78	44.13	3977.9	859.0	51.6
46.00	44.87	45.23	4077.2	859.4	56.0
47.00	45.96	46.33	4176.4	859.9	60.8
48.00	47.06	47.43	4275.7	860.3	66.1
49.00	48.15	48.53	4374.9	860.8	71.9
50.00	49.24	49.63	4474.1	861.2	78.1
51.00	50.33	50.73	4573.4	861.7	84.9
52.00	51.42	51.83	4672.6	862.2	92.0
53.00	52.51	52.93	4771.9	862.6	99.7
54.00	53.61	54.03	4871.1	863.1	107.9
55.00	54.70	55.13	4970.3	863.6	116.6
56.00	55.79	56.24	5069.6	864.0	125.8
57.00	56.88	57.34	5168.8	864.5	135.5
58.00	57.97	58.44	5268.1	865.0	145.7
58.02	57.99	58.46	5270.1	865.0	146.0
59.00	59.15	59.62	5375.0	865.5	160.9
60.00	60.33	60.81	5482.0	866.0	172.5
61.00	61.50	62.00	5589.0	866.5	184.8
62.00	62.68	63.18	5696.1	867.0	197.7
63.00	63.86	64.37	5803.1	867.5	211.2
64.00	65.04	65.56	5910.1	868.0	225.3
65.00	66.21	66.75	6017.2	868.5	240.0
66.00	67.39	67.93	6124.2	869.0	255.4
67.00	68.57	69.12	6231.3	869.5	271.5
68.00	69.75	70.31	6338.3	870.0	288.2
69.00	70.92	71.50	6445.3	870.5	305.6
70.00	72.10	72.68	6552.4	871.0	323.8
71.00	73.28	73.87	6659.4	871.5	342.6
72.00	74.46	75.06	6766.5	872.0	362.2
73.00	75.63	76.25	6873.5	872.6	382.5
74.00	76.81	77.43	6980.5	873.1	403.5
75.00	77.99	78.62	7087.6	873.6	425.4

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TABLE 4.1-1 (CONTINUED)
OXIDIZER SUMP TANK

HEIGHT OF PROPELLANT	TANK VOLUME UNSTRECHED	TANK VOLUME STRECHED	MASS OF PROPELLANT	CENTER OF MASS	MOMENT OF INERTIA(IYY)
76.00	79.16	79.81	7194.6	874.1	448.0
77.00	80.34	81.00	7301.7	874.6	471.4
78.00	81.52	82.18	7408.7	875.1	495.6
79.00	82.70	83.37	7515.7	875.6	520.6
80.00	83.87	84.56	7622.8	876.1	546.4
81.00	85.05	85.74	7729.8	876.6	573.1
82.00	86.23	86.93	7836.9	877.1	600.6
83.00	87.41	88.12	7943.9	877.6	629.0
84.00	88.58	89.31	8050.9	878.1	658.3
85.00	89.76	90.49	8158.0	878.6	688.4
86.00	90.94	91.68	8265.0	879.1	719.5
87.00	92.12	92.87	8372.0	879.6	751.4
88.00	93.29	94.06	8479.1	880.1	784.3
89.00	94.47	95.24	8586.1	880.6	818.2
90.00	95.65	96.43	8693.2	881.1	853.0
91.00	96.83	97.62	8800.2	881.6	888.7
92.00	98.00	98.81	8907.2	882.1	925.4
93.00	99.18	99.99	9014.3	882.6	963.1
94.00	100.36	101.19	9121.3	883.1	1001.8
95.00	101.54	102.37	9228.4	883.6	1041.5
96.00	102.71	103.55	9335.4	884.1	1082.3
97.00	103.89	104.74	9442.4	884.6	1124.0
98.00	105.07	105.93	9549.5	885.1	1166.8
99.00	106.25	107.12	9656.5	885.6	1210.7
100.00	107.42	108.30	9763.6	886.1	1255.7
101.00	108.60	109.49	9870.6	886.6	1301.7
102.00	109.78	110.68	9977.6	887.1	1348.8
103.00	110.96	111.87	10084.7	887.6	1397.0
104.00	112.13	113.05	10191.7	888.1	1446.4
105.00	113.31	114.24	10298.8	888.7	1496.8
106.00	114.49	115.43	10405.8	889.2	1548.5
107.00	115.67	116.62	10512.8	889.7	1601.2
108.00	116.84	117.80	10619.9	890.2	1655.2
109.00	118.02	118.99	10726.9	890.7	1710.3
110.00	119.20	120.18	10833.9	891.2	1766.6
111.00	120.38	121.36	10941.0	891.7	1824.1
112.00	121.55	122.55	11048.0	892.2	1882.8

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TABLE 4.1-1 (CONTINUED)
OXIDIZER SUMP TANK

HEIGHT OF PROPELLANT	TANK VOLUME UNSTRECHED	TANK VOLUME STRECHED	MASS OF PROPELLANT	CENTER OF MASS	MOMENT OF INERTIA(IYY)
113.00	122.73	123.74	11155.1	892.7	1942.7
114.00	123.91	124.93	11262.1	893.2	2003.9
115.00	125.09	126.11	11369.1	893.7	2066.4
116.00	126.26	127.30	11476.2	894.2	2130.0
117.00	127.44	128.49	11583.2	894.7	2195.0
118.00	128.62	129.68	11690.3	895.2	2261.3
119.00	129.79	130.86	11797.3	895.7	2328.8
120.00	130.97	132.05	11904.3	896.2	2397.7
121.00	132.15	133.24	12011.4	896.7	2467.8
122.00	133.33	134.43	12118.4	897.2	2539.3
123.00	134.50	135.61	12225.5	897.7	2612.2
124.00	135.68	136.80	12332.5	898.2	2686.4
125.00	136.86	137.99	12439.5	898.7	2762.0
126.00	138.04	139.17	12546.6	899.2	2838.9
127.00	139.21	140.36	12653.6	899.7	2917.3
128.00	140.39	141.55	12760.6	900.2	2997.0
128.30	140.75	141.91	12792.8	900.3	3021.2
129.00	141.57	142.74	12867.7	900.7	3078.1
130.00	142.74	143.92	12974.5	901.2	3160.5
131.00	143.91	145.10	13080.7	901.7	3243.9
132.00	145.07	146.27	13186.0	902.2	3328.0
132.90	146.10	147.31	13279.8	902.6	3404.0
133.00	146.22	147.42	13290.2	902.7	3412.5
134.00	147.35	148.56	13393.1	903.2	3497.4
135.00	148.46	149.69	13494.1	903.6	3582.1
136.00	149.55	150.78	13593.0	904.1	3666.2
137.00	150.61	151.85	13689.2	904.6	3749.4
138.00	151.63	152.89	13782.7	905.0	3831.3
139.00	152.63	153.89	13872.9	905.4	3911.4
140.00	153.58	154.85	13959.5	905.8	3989.5
141.00	154.49	155.77	14042.3	906.2	4065.0
142.00	155.36	156.64	14120.9	906.6	4137.6
143.00	156.17	157.46	14195.0	907.0	4206.7
144.00	156.93	158.23	14264.2	907.3	4272.0
145.00	157.64	158.94	14328.2	907.6	4333.0
146.00	158.28	159.59	14386.7	907.9	4389.2
147.00	158.86	160.17	14439.4	908.1	4440.2

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TABLE 4.1-1 (CONTINUED)

OXIDIZER SUMP TANK

HEIGHT OF PROPELLANT	TANK VOLUME UNSTRECHED	TANK VOLUME STRECHED	MASS OF PROPELLANT	CENTER OF MASS	MOMENT OF INERTIA(IYY)
148.00	159.37	160.69	14485.8	908.4	4485.5
149.00	159.81	161.13	14525.8	908.6	4524.7
150.00	160.17	161.50	14558.9	908.7	4557.4
151.00	160.46	161.78	14584.9	908.9	4583.1
152.00	160.66	161.99	14603.3	909.0	4601.4
153.00	160.78	162.11	14613.9	909.0	4612.0
153.87	160.81	162.14	14616.5	909.0	4614.6

TABLE 4.1-2
TRAPPED SPS MASS PROPERTIES

	Weight Pounds	Center of Gravity Inches		
		X _A	Y _A	Z _A
<u>SERVICE MODULE</u>				
(1) SPS - Trapped Outside Tanks				
Engine - Fuel	29.6	846.9	6.6	0.4
- Oxidizer	47.4	843.0	-7.1	1.6
Feedline - Fuel	29.5	832.0	-48.0	-25.0
- Oxidizer	44.7	832.0	48.0	25.0
Total Fuel	59.1	839.5	-20.7	-12.3
Total Oxidizer	92.1	837.7	19.6	13.0
Total Outside Tanks	151.2	838.4	3.9	3.1
(2) Trapped in Tanks				
Retention Reservoir - Fuel	61.4			
- Oxidizer	97.5			
Vapor - Fuel	3.4			
- Oxidizer	41.1			
Total Inside Tanks	203.4			

NOTES:

(1) SPS propellant trapped outside tanks should be subtracted from the total SPS propellant load for a particular mission to arrive at the tanked SPS propellant. This tanked amount is then used in the preceding tables to arrive at the appropriate SPS propellant Mass Properties.

(2) Propellant trapped inside tanks does not include the amount required to cover the zero-g screens prior to deorbit. This amount varies with mission requirements, and is available monthly in the Apollo/Soyuz Weight Status Summary.

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TABLE 4.1-3
SPS PROPELLANT DENSITY EQUATIONS (S/C 111)

Equations for calculating SPS fuel and oxidizer densities are given below. In order to calculate the density for fuel or oxidizer of a given load on a particular mission using the measured density furnished by KSC the following steps are necessary:

- A. Use the appropriate equation below and calculate the fuel or oxidizer density at the given pressure and temperature of the KSC sample. This will usually be 14.7 psia and 25°C for fuel, and 14.7 psia and 4°C for oxidizer.
- B. Use the appropriate equation below and calculate the fuel or oxidizer density at the final system pressure and temperature. This will usually be 25 \pm 5 psia and 70 \pm 5°F.
- C. Subtract the density obtained in Step A from the measured density of the KSC sample, and add this amount (may be either positive or negative) to the density obtained from Step B.

A-50 Density Equation

$$\rho_F = [57.6095 - 0.058533(^{\circ}\text{C})] (C_F)$$

where: ρ_F = A-50 density in lb/ft³

°C = Temperature in degrees centigrade

C_F = Compressibility factor - Obtain this number from the pressure - compressibility graph on Figure 4.1-1 of this section.

N₂O₄ Density Equation

$$\rho_0 = [93.1048 - 0.14252(^{\circ}\text{C})] (C_0)$$

where: ρ_0 = N₂O₄ density in lb/ft

°C = Temperature in degrees centigrade

C_0 = Compressibility factor - Obtain this number from the pressure - compressibility graph on Figure 4.1-2 of this section.

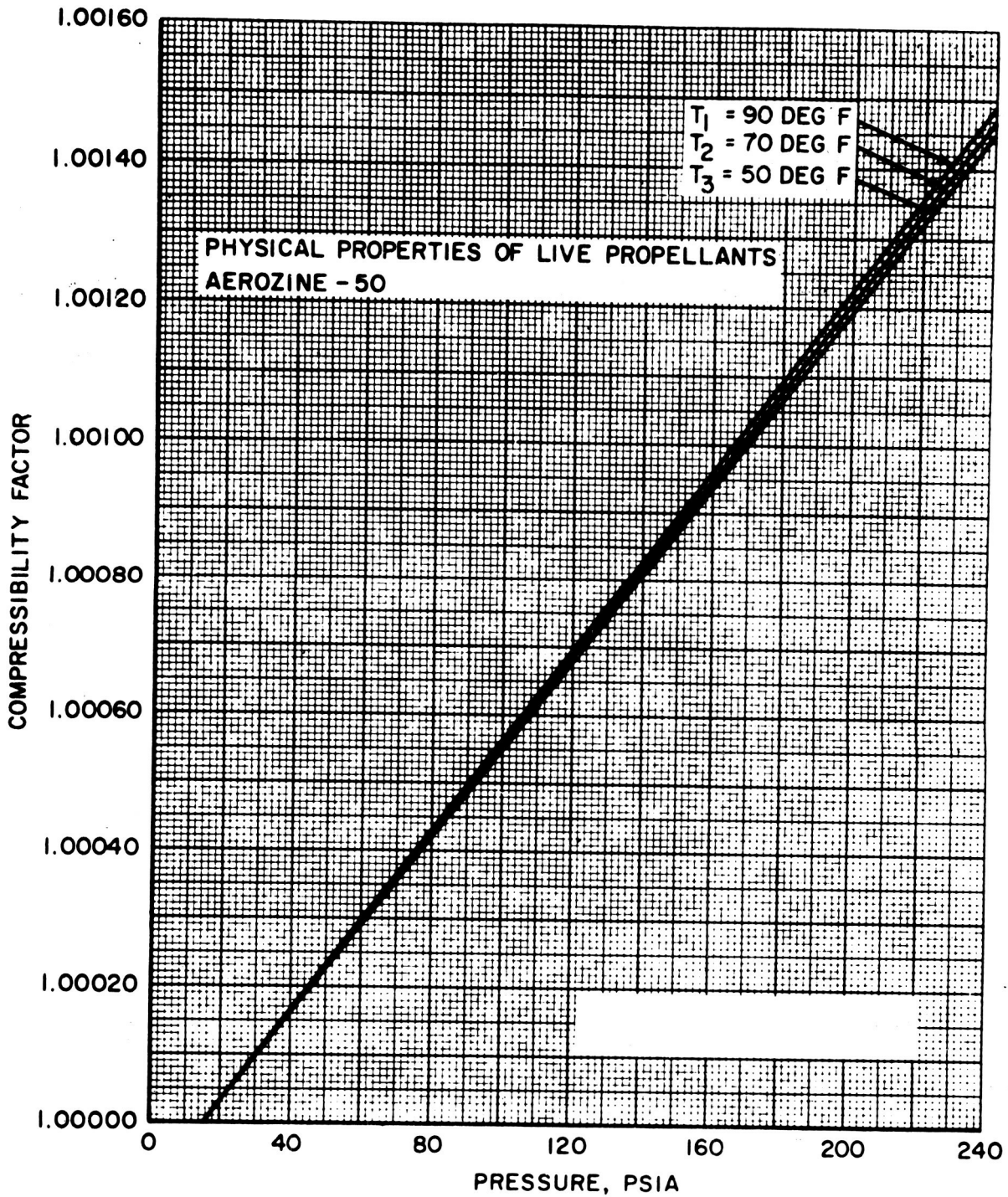


FIGURE 4.1-1. AEROZINE-50 COMPRESSIBILITY CORRECTION FACTOR

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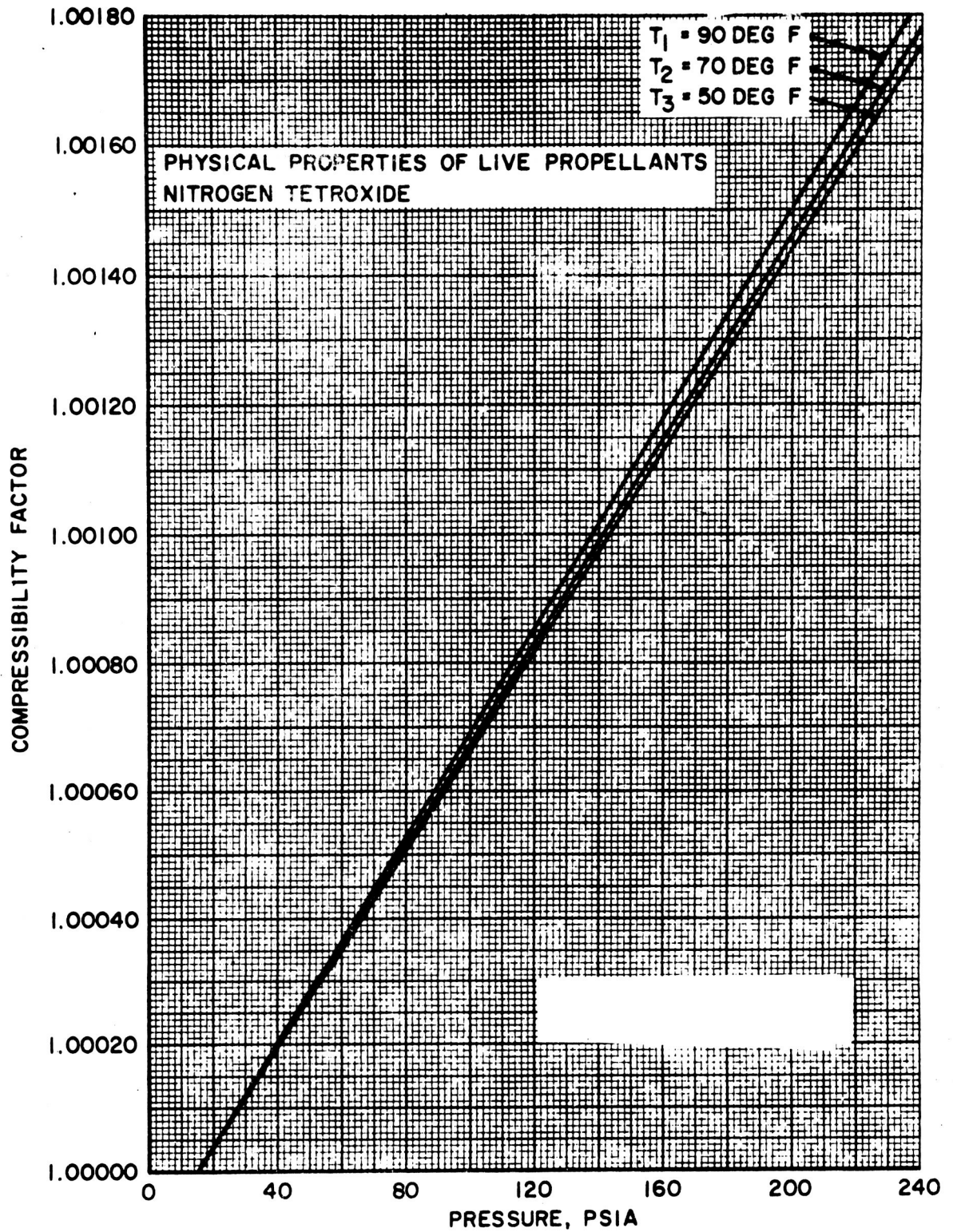


FIGURE 4.1-2. NITROGEN TETROXIDE COMPRESSIBILITY CORRECTION FACTOR

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TABLE 4.2-1

CSM - CONSUMABLE LOADS AND UNCERTAINTIES

This table contains the consumable loads, associated tolerances, and/or uncertainties at nominal loading temperatures and pressures.

	WEIGHT POUNDS	⁽¹⁾ CENTER OF GRAVITY INCHES		
		X _A	Y _A	Z _A
<u>COMMAND MODULE</u>				
Nominal Load				
RCS ⁽²⁾				
Loaded System 1 - Fuel	43.8+0.9	1022.6	-38.7	52.8
System 1 - Oxidizer	90.6+1.8	1022.6	26.6	59.8
System 2 - Fuel	43.8+0.9	1022.6	-52.8	38.7
System 2 - Oxidizer	90.6+1.8	1022.6	2.3	65.5
Loaded - Fuel	87.6	1022.6	-45.8	45.8
- Oxidizer	181.2	1022.6	14.5	62.7
Total Loaded	268.8+2.8	1022.6	-5.2	57.1
Maximum Trapped				
System 1 - Fuel	6.0	1022.6	-38.7	52.8
System 1 - Oxidizer	10.0	1022.6	26.6	59.8
System 2 - Fuel	5.6	1022.6	-52.8	38.7
System 2 - Oxidizer	10.3	1022.6	2.3	65.5
Trapped - Fuel	11.6	1022.6	-45.5	46.0
- Oxidizer	20.3	1022.5	14.3	62.7
Total Trapped (Maximum)	31.9	1022.5	-7.5	56.6
Deliverable ⁽⁶⁾				
System 1 - Fuel	37.8+0.9	1022.6	-38.7	52.8
System 1 - Oxidizer	80.6+1.8	1022.6	26.6	59.8
System 2 - Fuel	38.2+0.9	1022.6	-52.8	38.7
System 2 - Oxidizer	80.3+1.8	1022.6	2.3	65.5
Deliverable - Fuel	76.0	1022.6	-45.8	45.7
- Oxidizer	160.9	1022.6	14.5	62.6
Total Deliverable	236.9+2.8	1022.6	-4.9	57.2

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TABLE 4.2-1. (CONTINUED)
SM RCS NOMINAL PROPELLANT LOADS (APOLLO COORDINATES)

Description	Weight (lb)	Center of Gravity (in.)		
		X	Y	Z
Nominal Loads				
<u>Quad A</u>				
Fuel - Primary	69.9	964.8	8.0	-68.5
Fuel - Secondary	40.3	985.1	-7.0	-69.0
Oxidizer	225.4	926.9	8.0	-68.5
Total Quad A	335.6	941.8	6.2	-68.6
<u>Quad B</u>				
Fuel - Primary	69.9	964.8	64.5	-26.5
Fuel - Secondary	40.3	985.1	68.0	-11.0
Oxidizer	225.4	926.9	64.5	-26.5
Total Quad B	335.6	941.8	64.9	-24.6
<u>Quad C</u>				
Fuel - Primary	69.9	964.8	-8.0	68.5
Fuel - Secondary	40.3	985.1	7.0	69.0
Oxidizer	225.4	926.9	-8.0	68.5
Total Quad C	335.6	941.8	-6.2	68.6
<u>Quad D</u>				
Fuel - Primary	69.9	964.8	-64.5	26.5
Fuel - Secondary	40.3	985.1	-68.0	11.0
Oxidizer	225.4	926.9	-64.5	26.5
Total Quad D	335.6	941.8	-64.9	24.6
Total Door Systems	1342.4	941.8	0.0	0.0
<u>PSM⁽⁵⁾</u>				
Tanks				
Fuel - 1	123.5	931.8	31.3	-41.0
Fuel - 2	123.5	931.8	23.2	-61.5
Fuel - 3	123.5	931.8	34.7	-55.4
Fuel - 4	123.6	931.8	46.2	-48.6
Oxidizer - 1	199.3	931.8	20.7	-21.8
Oxidizer - 2	199.3	931.8	17.1	-34.5
Oxidizer - 3	199.3	931.8	32.4	-27.8
Oxidizer - 4	199.3	931.8	19.8	-47.5
Oxidizer - 5	199.4	931.8	43.8	-34.0
Total Tanks	1490.7	931.8	29.1	-39.3
Manifold				
Fuel	9.7	TBS	TBS	TBS
Oxidizer	17.2	TBS	TBS	TBS
Total Manifold	26.9	947.3	9.5	-5.3
Total PSM	1517.6	932.1	28.8	-38.7
Total Primary Fuel	279.6	964.8	0.0	0.0
Total Secondary Fuel	161.2	985.1	0.0	0.0
Total Door System Fuel	440.8	972.2	0.0	0.0
Total PSM Fuel	503.8	932.1	33.4	-50.7
Total Loads Fuel	944.6	950.8	17.8	-27.0
Total Door System Oxidizer	901.6	926.9	0.0	0.0
Total PSM Oxidizer	1013.8	932.1	26.5	-32.6
Total Loads Oxidizer	1915.4	929.7	14.0	-17.3
Total Loads	2860.0	936.7	15.3	-20.5

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TABLE 4.2-1. (CONTINUED)
SM RCS NOMINAL PROPELLANT LOADS (APOLLO COORDINATES)

Systems	Weight (lb)	Center of Gravity (in.)		
		X	Y	Z
Maximum Trapped				
<u>Quad A</u>				
Fuel - Primary	1.1	964.8	8.0	-68.5
Fuel - Secondary	.6	985.1	-7.0	-69.0
Oxidizer	3.8	926.9	8.0	-68.5
Total Quad A	5.5	940.8	6.4	-68.6
<u>Quad B</u>				
Fuel - Primary	1.1	964.8	64.5	-26.5
Fuel - Secondary	.6	985.1	68.0	-11.0
Oxidizer	3.8	926.9	64.5	-26.5
Total Quad B	5.5	940.8	64.9	-24.8
<u>Quad C</u>				
Fuel - Primary	1.1	964.8	-8.0	68.5
Fuel - Secondary	.6	985.1	7.0	69.0
Oxidizer	3.8	926.9	-8.0	68.5
Total Quad C	5.5	940.8	-6.4	68.6
<u>Quad D</u>				
Fuel - Primary	1.1	964.8	-64.5	26.5
Fuel - Secondary	.6	985.1	-68.0	11.0
Oxidizer	3.8	926.9	-64.5	26.5
Total Quad D	5.5	940.8	-64.9	24.8
Total Door Systems	22.0	940.8	0.0	0.0
<u>PSM</u>				
Tanks				
Fuel - 1	1.6	931.8	31.3	-41.0
Fuel - 2	1.6	931.8	23.2	-61.5
Fuel - 3	1.6	931.8	34.7	-55.4
Fuel - 4	1.7	931.8	46.2	-48.6
Oxidizer - 1	2.7	931.8	20.7	-21.8
Oxidizer - 2	2.7	931.8	17.1	-34.5
Oxidizer - 3	2.7	931.8	32.4	-27.8
Oxidizer - 4	2.8	931.8	19.8	-47.5
Oxidizer - 5	2.8	931.8	43.8	-34.0
Total Tanks	20.2	931.8	29.2	-39.1
Manifold				
Fuel	9.7	TBS	TBS	TBS
Oxidizer	17.2	TBS	TBS	TBS
Total Manifold	26.9	947.3	9.5	-5.3
Total PSM	47.1	940.7	17.9	-19.8
Total Primary Fuel	4.4	964.8	0.0	0.0
Total Secondary Fuel	2.4	985.1	0.0	0.0
Total Door System Fuel	6.8	972.0	0.0	0.0
Total PSM Fuel	16.2	941.1	19.3	-23.9
Total Trapped Fuel	23.0	950.2	13.6	-16.8
Total Door Systems Oxidizer	15.2	926.9	0.0	0.0
Total PSM Oxidizer	30.9	940.4	17.2	-17.7
Total Trapped Oxidizer	46.1	935.9	11.5	-11.8
Total Trapped	69.1	940.7	12.2	-13.5

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TABLE 4.2-1 (CONTINUED)
SM RCS NOMINAL PROPELLANT LOADS (APOLLO COORDINATES)

Systems	Weight (lb)	Center of Gravity (in.)		
		X	Y	Z
Deliverable				
<u>Quad A</u>				
Fuel - Primary	68.8	964.8	8.0	-68.5
Fuel - Secondary	39.7	985.1	-7.0	-69.0
Oxidizer	221.6	926.9	8.0	-68.5
Total Quad A	330.1	941.8	6.2	-68.6
<u>Quad B</u>				
Fuel - Primary	68.8	964.8	64.5	-26.5
Fuel - Secondary	39.7	985.1	68.0	-11.0
Oxidizer	221.6	926.9	64.5	-26.5
Total Quad B	330.1	941.8	64.9	-24.6
<u>Quad C</u>				
Fuel - Primary	68.8	964.8	-8.0	68.5
Fuel - Secondary	39.7	985.1	7.0	69.0
Oxidizer	221.6	926.9	-8.0	68.5
Total Quad C	330.1	941.8	-6.2	68.6
<u>Quad D</u>				
Fuel - Primary	68.8	964.8	-64.5	26.5
Fuel - Secondary	39.7	985.1	-68.0	11.0
Oxidizer	221.6	926.9	-64.5	26.5
Total Quad D	330.1	941.8	-64.9	24.6
Total Door Systems	1320.4	941.8	0.0	0.0
<u>PSM</u>				
Fuel - 1	121.9	931.8	31.3	-41.0
Fuel - 2	121.9	931.8	23.2	-61.5
Fuel - 3	121.9	931.8	34.7	-55.4
Fuel - 4	121.9	931.8	46.2	-48.6
Oxidizer - 1	196.6	931.8	20.7	-21.8
Oxidizer - 2	196.6	931.8	17.1	-34.5
Oxidizer - 3	196.6	931.8	32.4	-27.8
Oxidizer - 4	196.5	931.8	19.8	-47.5
Oxidizer - 5	196.6	931.8	43.8	-34.0
Total PSM	1470.5	931.8	29.1	-39.3
Total Primary Fuel	275.2	964.8	0.0	0.0
Total Secondary Fuel	158.8	985.1	0.0	0.0
Total Door Systems Fuel	434.0	972.2	0.0	0.0
Total PSM Fuel	487.6	931.8	33.9	-51.6
Total Deliverable Fuel	921.6	950.8	17.9	-27.3
Total Door System Oxidizer	886.4	926.9	0.0	0.0
Total PSM Oxidizer	982.9	931.8	26.8	-33.1
Total Deliverable Oxidizer	1869.3	929.5	14.1	-17.4
Total Deliverable ⁽⁶⁾	2790.9	936.5	15.4	-20.7

TABLE 4.2-1 (CONTINUED)
SM RCS NOMINAL PROPELLANT LOADS (APOLLO COORDINATES)

	WEIGHT POUNDS	CENTER OF GRAVITY INCHES		
		X _A	Y _A	Z _A
CSM MISCELLANEOUS CONSUMABLES				
CM/RCS - Helium	1.0	1022.6	-3.1	25.8
CM/ECS				
Oxygen - Entry ⁽³⁾	6.7	1031.1	-26.9	-34.2
Potable Water ⁽⁴⁾		1022.6	-63.5	-16.4
Waste Water		1022.6	-19.7	62.5
SM/RCS - Helium				
- Door	5.44	983.9	0.0	0.0
- PSM	9.50	973.1	14.7	-23.5
SM/SPS Helium - Storage Bottles	43.8	985.5	0.0	0.0
- Tanks	2.7	976.0	0.0	0.0
SM/Nitrogen	1.3	874.0	3.0	-3.0
SM/EPS/ECS				
Oxygen - Hydrogen ⁽⁷⁾				
H ₂ Tank 2	29.3	859.4	-40.7	41.2
H ₂ Tank 1	29.3	892.9	-40.7	41.2
O ₂ Tank 1	330.1	920.8	-20.9	26.9
O ₂ Tank 2	330.1	920.8	-27.4	54.5
Total - H ₂	58.6	876.2	-40.7	41.2
- O ₂	660.2	920.8	-24.2	40.7
Total On Board	718.8	917.2	-25.5	40.7
Unusable				
- H ₂	1.2	859.4	-40.7	41.2
- H ₂	1.2	892.9	-40.7	41.2
- O ₂	6.6	920.8	-20.9	26.9
- O ₂	6.6	920.8	-27.4	54.5
Unusable - H ₂	2.4	876.2	-40.7	41.2
- O ₂	13.2	920.8	-24.2	40.7
Total Unusable	15.6	917.2	-25.5	40.7
Usable				
- H ₂	28.1	859.4	-40.7	41.2
- H ₂	28.1	892.9	-40.7	41.2
- O ₂	323.5	920.8	-20.9	26.9
- O ₂	323.5	920.8	-27.4	54.5
Usable - H ₂	56.2	876.2	-40.7	41.2
- O ₂	647.0	920.8	-24.2	40.7
Total Usable	703.2	917.2	-25.5	40.7

TABLE 4.2-1 (CONTINUED)

- NOTES: (1) Referenced to the Apollo Coordinate System
- (2) All RCS propellant weight uncertainties prior to loading are based on the maximum and minimum permissible load deviation for the nominal load at 70°F.
- (3) Potable water tank nominal capacity is 40 pounds.
- (4) Waste water tank nominal capacity is 60 pounds.
- (5) PSM RCS weights represent maximum load. Actual load will be based on mission requirements.
- (6) Deliverable SM/RCS propellant is that amount which can be expelled from the tanks assuming nominal mixture ratio. For pre-mission budget planning the minimum guaranteed usable propellant equals deliverable, less TBS pounds loading uncertainty and less TBS pounds gauging inaccuracy.
- (7) See Section 3 for planned earth launch weight.

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TABLE 4.2-2

SM RCS QUAD A MASS PROPERTIES

The following table presents the mass properties for SM RCS Quad A as a function of propellant remaining. For all weights Z-c.g. = -68.6 inches, IXX = 0.0, IYZ = IYZ = 0.0.

TOTAL WT. Pounds	X-c.g. Inches	Y-c.g. Inches	IYV Slug Ft ²	IZZ Slug Ft ²	IXY Slug Ft ²	PROPELLANT REMAINING (Pounds)			
						Pri. Fuel	Sec. Fuel	Sec. Oxidizer	
335.6	941.8	6.2	45.1	46.8	-5.7	69.9	40.3	140.4	85.0
326.6	941.9	6.2	44.0	45.7	-5.6	66.9	40.3	137.4	82.0
317.6	942.0	6.1	42.9	44.6	-5.6	63.9	40.3	134.4	79.0
308.6	942.2	6.0	41.9	43.6	-5.6	60.9	40.3	131.4	76.0
299.6	942.3	6.0	40.8	42.5	-5.6	57.9	40.3	128.4	73.0
290.6	942.5	5.9	39.7	41.4	-5.6	54.9	40.3	125.4	70.0
281.6	942.7	5.9	38.6	40.3	-5.5	51.9	40.3	122.4	67.0
272.6	942.9	5.8	37.5	39.2	-5.5	48.9	40.3	119.4	64.0
263.6	943.0	5.7	36.4	38.1	-5.5	45.9	40.3	116.4	61.0
254.6	943.3	5.6	35.3	37.0	-5.5	42.9	40.3	113.4	58.0
245.6	943.5	5.6	34.2	35.9	-5.4	39.9	40.3	110.4	55.0
236.6	943.7	5.5	33.1	34.7	-5.4	36.9	40.3	107.4	52.0
227.6	944.0	5.3	32.0	33.6	-5.4	33.9	40.3	104.4	49.0
218.6	944.3	5.2	30.9	32.5	-5.3	30.9	40.3	101.4	46.0
209.6	944.8	5.1	29.7	31.3	-5.3	27.9	40.3	98.4	43.0
200.6	944.9	5.0	28.6	30.2	-5.2	24.9	40.3	95.4	40.0
191.6	945.3	4.8	27.5	29.0	-5.2	21.9	40.3	92.4	37.0
182.6	945.7	4.7	26.3	27.8	-5.1	18.9	40.3	89.4	34.0
173.6	946.1	4.5	25.1	26.6	-5.1	15.9	40.3	86.4	31.0
164.6	946.6	4.3	23.9	25.4	-5.0	12.9	40.3	83.4	28.0
155.6	947.2	4.1	22.7	24.2	-4.9	9.9	40.3	80.4	25.0
146.6	947.8	3.9	21.5	22.9	-4.9	6.9	40.3	77.4	22.0
137.6	948.5	3.6	20.2	21.6	-4.8	3.9	40.3	74.4	19.0
130.1	949.1	3.4	19.1	20.5	-4.7	1.4	40.3	71.9	16.5
121.1	949.5	3.4	17.1	18.4	-4.3	1.4	37.3	68.9	13.5
112.1	950.0	3.4	15.1	16.3	-3.9	1.4	34.3	65.9	10.5
103.1	950.5	3.5	13.1	14.2	-3.5	1.4	31.3	62.9	7.5
86.6	951.8	3.5	9.4	10.3	-2.8	1.4	25.8	57.4	2.0
77.6	951.6	3.6	8.4	9.2	-2.5	1.4	22.8	51.4	2.0
68.6	951.2	3.7	7.5	8.1	-2.2	1.4	19.8	45.4	2.0
59.6	950.9	3.8	6.5	7.1	-1.9	1.4	16.8	39.4	2.0
50.6	950.4	3.9	5.5	6.0	-1.5	1.4	13.8	33.4	2.0
41.6	949.7	4.1	4.5	4.9	-1.2	1.4	10.8	27.4	2.0
32.6	948.6	4.1	3.5	3.8	-0.9	1.4	7.8	21.4	2.0
23.6	946.7	5.0	2.5	2.7	-0.6	1.4	4.8	15.4	2.0
11.3	939.0	7.1	0.9	1.0	-0.1	1.4	0.7	7.2	2.0

TABLE 4.2-2 (CONTINUED)
SM RCS QUAD B MASS PROPERTIES

The following table presents the mass properties for SM RCS Quad B as a function of propellant remaining. For all weights Y-c.g. = 64.9 inches, IXZ = 0.0, IXY = IYZ = 0.0.

TOTAL WT. Pounds	X-c.g. Inches	Z-c.g. Inches	IYV Slug Ft ²	IZZ Slug Ft ²	IXZ Slug Ft ²	PROPELLANT REMAINING (Pounds)			
						Pri. Fuel	Sec. Fuel	Pri. Oxidizer	Sec. Oxidizer
335.6	941.8	-24.6	46.9	45.2	5.8	69.9	40.3	140.4	85.0
326.6	941.9	-24.6	45.8	44.1	5.8	66.9	40.3	137.4	82.0
317.6	942.0	-24.5	44.8	43.0	5.8	63.9	40.3	134.4	79.0
308.6	942.2	-24.5	43.7	41.9	5.8	60.9	40.3	131.4	76.0
299.6	942.3	-24.4	42.6	40.9	5.8	57.9	40.3	128.4	73.0
290.6	942.5	-24.4	41.5	39.8	5.7	54.9	40.3	125.4	70.0
281.6	942.7	-24.3	40.4	38.7	5.7	51.9	40.3	122.4	67.0
272.6	942.9	-24.2	39.3	37.6	5.7	48.9	40.3	119.4	64.0
263.6	943.0	-24.1	38.2	36.5	5.7	45.9	40.3	116.4	61.0
254.6	943.3	-24.1	37.1	35.4	5.6	42.9	40.3	113.4	58.0
245.6	943.5	-24.0	36.0	34.3	5.6	39.9	40.3	110.4	55.0
236.6	943.7	-23.9	34.8	33.2	5.6	36.9	40.3	107.4	52.0
227.6	944.0	-23.8	33.7	32.1	5.5	33.9	40.3	104.4	49.0
218.6	944.3	-23.6	32.6	31.0	5.5	30.9	40.3	101.4	46.0
209.6	944.6	-23.5	31.4	29.8	5.5	27.9	40.3	98.4	43.0
200.6	944.9	-23.4	30.3	28.7	5.4	24.9	40.3	95.4	40.0
191.6	945.3	-23.2	29.1	27.5	5.4	21.9	40.3	92.4	37.0
182.6	945.9	-23.1	27.9	26.4	5.3	18.9	40.3	89.4	34.0
173.6	946.1	-22.9	26.7	25.2	5.3	15.9	40.3	86.4	31.0
164.6	946.6	-22.7	25.5	24.0	5.2	12.9	40.3	83.4	28.0
155.6	947.2	-22.5	24.3	22.8	5.1	9.9	40.3	80.4	25.0
146.6	947.8	-22.2	23.0	21.5	5.0	6.9	40.3	77.4	22.0
137.6	948.5	-22.0	21.7	20.3	4.9	3.9	40.3	74.4	19.0
130.1	949.1	-21.7	20.6	19.2	4.8	1.4	40.3	71.9	16.5
121.1	949.5	-21.7	18.5	17.2	4.4	1.4	37.3	68.9	13.5
112.1	950.0	-21.8	16.4	15.2	4.0	1.4	34.3	65.9	10.5
103.1	950.5	-21.8	14.3	13.2	3.6	1.4	31.3	62.9	7.5
86.6	951.8	-21.9	10.3	9.4	2.9	1.4	25.8	57.4	2.0
77.6	951.6	-22.0	9.3	8.5	2.6	1.4	22.8	51.4	2.0
68.6	951.3	-22.0	8.2	7.5	2.2	1.4	19.8	45.4	2.0
59.6	950.9	-22.1	7.1	6.5	1.9	1.4	16.8	39.4	2.0
50.6	950.4	-22.3	6.0	5.5	1.6	1.4	13.8	33.4	2.0
41.6	949.7	-22.5	4.9	4.6	1.3	1.4	10.8	27.4	2.0
32.6	948.6	-22.8	3.8	3.6	1.0	1.4	7.8	21.4	2.0
23.6	946.7	-23.4	2.7	2.5	0.6	1.4	4.8	15.4	2.0
11.3	939.0	-25.5	1.0	0.9	0.1	1.4	0.7	7.2	2.0

TABLE 4.2-2 (CONTINUED)
SM RCS QUAD C MASS PROPERTIES

The following table presents the mass properties for SM RCS Quad C as a function of propellant remaining. For all weights Z-c.g. = 68.6 inches, IXZ = 0.0, IXZ = IYZ = 0.0.

TOTAL WT. Pounds	X-c.g. Inches	Y-c.g. Inches	IVY Slug Ft ²	IZZ Slug Ft ²	IXV Slug Ft ²	PROPELLANT REMAINING (Pounds)			
						Pri. Fuel	Sec. Fuel	Pri. Oxidizer	Sec. Oxidizer
335.6	941.8	-6.2	45.1	46.8	5.7	69.9	40.3	140.4	85.0
326.6	941.9	-6.2	44.0	45.7	5.6	66.9	40.3	137.4	82.0
317.6	942.0	-6.1	42.9	44.6	5.6	63.9	40.3	134.4	79.0
308.6	942.2	-6.0	41.9	43.6	5.6	60.9	40.3	131.4	76.0
299.6	942.3	-6.0	40.8	42.5	5.6	57.9	40.3	128.4	73.0
290.6	942.5	-5.9	39.7	41.4	5.6	54.9	40.3	125.4	70.0
281.6	942.7	-5.9	38.6	40.3	5.5	51.9	40.3	122.4	67.0
272.6	942.9	-5.8	37.5	39.2	5.5	48.9	40.3	119.4	64.0
263.6	943.0	-5.7	36.4	38.1	5.5	45.9	40.3	116.4	61.0
254.6	943.3	-5.6	35.3	37.0	5.5	42.9	40.3	113.4	58.0
245.6	943.5	-5.5	34.2	35.9	5.4	39.9	40.3	110.4	55.0
236.6	943.7	-5.5	33.1	34.7	5.4	36.9	40.3	107.4	52.0
227.6	944.0	-5.3	32.0	33.6	5.4	33.9	40.3	104.4	49.0
218.6	944.3	-5.2	30.9	32.5	5.3	30.9	40.3	101.4	46.0
209.6	944.6	-5.1	29.7	31.3	5.3	27.9	40.3	98.4	43.0
200.6	944.9	-5.0	28.6	30.2	5.2	24.9	40.3	95.4	40.0
191.6	945.3	-4.9	27.5	29.0	5.2	21.9	40.3	92.4	37.0
182.6	945.7	-4.7	26.3	27.8	5.1	18.9	40.3	89.4	34.0
173.6	946.1	-4.5	25.1	26.6	5.1	15.9	40.3	86.4	31.0
164.6	946.6	-4.3	23.9	25.4	5.0	12.9	40.3	83.4	28.0
155.6	947.2	-4.1	22.7	24.2	4.9	9.9	40.3	80.4	25.0
146.6	947.8	-3.9	21.5	22.9	4.9	6.9	40.3	77.4	22.0
137.6	948.5	-3.6	20.2	21.6	4.8	3.9	40.3	74.4	19.0
130.1	949.1	-3.4	19.1	20.5	4.7	1.4	40.3	71.9	16.5
121.1	949.5	-3.4	17.1	18.4	4.3	1.4	37.3	68.9	13.5
112.1	950.0	-3.4	15.1	16.3	3.9	1.4	34.3	65.9	10.5
103.1	950.5	-3.5	13.1	14.2	3.5	1.4	31.3	62.9	7.5
86.6	951.8	-3.5	9.4	10.3	2.8	1.4	25.8	57.4	2.0
77.6	951.6	-3.6	8.4	9.2	2.5	1.4	22.8	51.4	2.0
68.6	951.3	-3.7	7.5	8.1	2.2	1.4	19.8	45.4	2.0
59.6	950.9	-3.8	6.5	7.1	1.9	1.4	16.8	39.4	2.0
50.6	950.4	-3.9	5.5	6.0	1.5	1.4	13.8	33.4	2.0
41.6	949.7	-4.1	4.5	4.9	1.2	1.4	10.8	27.4	2.0
32.6	948.6	-4.4	3.5	3.8	0.9	1.4	7.8	21.4	2.0
23.6	946.7	-5.0	2.5	2.7	0.6	1.4	4.8	15.4	2.0
11.3	939.0	-7.1	0.9	1.0	0.1	1.4	0.7	7.2	2.0

TABLE 4.2-2 (CONTINUED)
SM RCS QUAD D MASS PROPERTIES

The following table presents the mass properties for SM RCS Quad D as a function of propellant remaining. For all weights Y-c.g. = 65.9 inches
IXX = 0.0, IXY = IYZ = 0.0.

TOTAL WT. Pounds	X-c.g. Inches	Z-c.g. Inches	IVY Slug Ft ²	IZZ Slug Ft ²	IXZ Slug Ft ²	PROPELLANT REMAINING (Pounds)			
						Pri. Fuel	Sec. Fuel	Sec. Oxidizer	
335.6	941.8	24.6	46.9	45.2	-5.8	69.9	40.3	140.4	85.0
326.6	941.9	24.6	45.8	44.1	-5.8	66.9	40.3	137.4	82.0
317.6	942.0	24.5	44.8	43.0	-5.8	63.9	40.3	134.4	79.0
308.6	942.2	24.5	43.7	41.9	-5.8	60.9	40.3	131.4	76.0
299.6	942.3	24.4	42.6	40.9	-5.8	57.9	40.3	128.4	73.0
290.6	942.5	24.4	41.5	39.8	-5.7	54.9	40.3	125.4	70.0
281.6	942.7	24.3	40.4	38.7	-5.7	51.9	40.3	122.4	67.0
272.6	942.9	24.2	39.3	37.6	-5.7	48.9	40.3	119.4	64.0
263.6	943.0	24.1	38.2	36.5	-5.7	45.9	40.3	116.4	61.0
254.6	943.3	24.1	37.1	35.4	-5.6	42.9	40.3	113.4	58.0
245.6	943.5	24.0	36.0	34.3	-5.6	39.9	40.3	110.4	55.0
236.6	943.7	23.9	34.8	33.2	-5.6	36.9	40.3	107.4	52.0
227.6	944.0	23.8	33.7	32.1	-5.5	33.9	40.3	104.4	49.0
218.6	944.3	23.6	32.6	31.0	-5.5	30.9	40.3	101.4	46.0
209.6	944.6	23.5	31.4	29.8	-5.5	27.9	40.3	98.4	43.0
200.6	944.9	23.4	30.3	28.7	-5.4	24.9	40.3	95.4	40.0
191.6	945.3	23.2	29.1	27.5	-5.4	21.9	40.3	92.4	37.0
182.6	945.7	23.1	27.9	26.4	-5.3	18.9	40.3	89.4	34.0
173.6	946.1	22.9	26.7	25.2	-5.3	15.9	40.3	86.4	31.0
164.6	946.6	22.7	25.5	24.0	-5.2	12.9	40.3	83.4	28.0
155.6	947.2	22.5	24.3	22.8	-5.1	9.9	40.3	80.4	25.0
146.6	947.8	22.2	23.0	21.5	-5.0	6.9	40.3	77.4	22.0
137.6	948.5	22.0	21.7	20.3	-4.9	3.9	40.3	74.4	19.0
130.1	949.1	21.7	20.6	19.2	-4.8	1.4	40.3	71.9	16.5
121.1	949.5	21.7	18.5	17.2	-4.4	1.4	37.3	68.9	13.5
112.1	950.0	21.8	16.4	15.2	-4.0	1.4	34.3	65.9	10.5
103.1	950.5	21.8	14.3	13.2	-3.6	1.4	31.3	62.9	7.5
86.6	951.8	21.9	10.3	9.4	-2.9	1.4	25.8	57.4	2.0
77.6	951.6	22.0	9.3	8.5	-2.6	1.4	22.8	54.4	2.0
68.6	951.3	22.0	8.2	7.5	-2.2	1.4	19.8	45.4	2.0
59.6	950.9	22.1	7.1	6.5	-1.9	1.4	16.8	39.4	2.0
50.6	950.4	22.3	6.0	5.5	-1.6	1.4	13.8	33.4	2.0
41.6	949.7	22.5	4.9	4.6	-1.3	1.4	10.8	27.4	2.0
32.6	948.6	22.8	3.8	3.6	-1.0	1.4	7.8	21.4	2.0
23.6	946.7	23.4	2.7	2.5	-0.6	1.4	4.8	15.4	2.0
11.3	939.0	25.5	1.0	0.9	-0.1	1.4	0.7	7.2	2.0

TABLE 4.2-2 (CONTINUED)
SM RCS PSM PROPELLANT MASS PROPERTIES (APOLLO COORDINATES)*

WEIGHT (lb)	CENTER OF GRAVITY (in.)			MOMENT OF INERTIA (slug-ft ²)			PRODUCT OF INERTIA (slug-ft ²)		
	X	Y	Z	Ixx	Iyy	Izz	Ixy	Ixz	Iyz
.0	931.8	29.1	-39.3	0.	0.	0.	0.	0.	0.
100.0	931.8	29.1	-39.3	5.	3.	2.	0.	0.	0.
200.0	931.8	29.1	-39.3	11.	6.	4.	0.	0.	-1.
300.0	931.8	29.1	-39.3	16.	9.	7.	0.	0.	-1.
400.0	931.8	29.1	-39.3	21.	12.	9.	0.	0.	-1.
500.0	931.8	29.1	-39.3	26.	16.	11.	0.	0.	-1.
600.0	931.8	29.1	-39.3	32.	19.	13.	0.	0.	-2.
700.0	931.8	29.1	-39.3	37.	22.	15.	0.	0.	-2.
800.0	931.8	29.1	-39.3	42.	25.	17.	0.	0.	-2.
900.0	931.8	29.1	-39.3	48.	28.	20.	0.	0.	-2.
1000.0	931.8	29.1	-39.3	53.	31.	22.	0.	0.	-3.
1100.0	931.8	29.1	-39.3	58.	34.	24.	0.	0.	-3.
1200.0	931.8	29.1	-39.3	63.	37.	26.	0.	0.	-3.
1300.0	931.8	29.1	-39.3	69.	40.	28.	0.	0.	-3.
1400.0	931.8	29.1	-39.3	74.	44.	30.	0.	0.	-4.
1517.6	931.8	29.1	-39.3	79.	47.	33.	0.	0.	-4.

*Mixture Ratio = 2.0

4.3 CM/RCS, SM/RCS, AND SM/PSM LOAD CALCULATION TABLES AND LOADING WINDOWS

CM/RCS, SM/RCS, and SM/PSM

Tables 4.3-1 through 4.3-7 are CM/RCS, SM/RCS, and SM/PSM load calculation tables to be completed by KSC for each CSM mission. Figures 4.3-1 through 4.3-7 are the loading windows to be used by KSC in their calculations.

CSM/RCS Mass Calculations for Horizontal Tanks

The primary method for determining the amount of RCS propellant loaded in the CSM horizontal tanks is by actual propellant weight as determined by using the bleed unit scales. The weight as determined by the bleed unit scales is verified by PV calculation as outlined in Tables 4.3-1 and 4.3-3 through 4.3-7. If for an individual tank the propellant weight as determined by the bleed unit scales and the propellant weight as determined by the PV calculation do not correlate, then KSC and MSC will jointly determine which of the above methods will be used.

TABLE 4.3-1
COMMAND MODULE RCS LOADING REQUIREMENTS, PARAMETERS, AND CALCULATIONS

	Load Parameters and Calculations			
	Fuel		Oxidizer	
	Tank A	Tank B	Tank A	Tank B
A. Tank Volume @ 0.0 psig (in ³)	_____	_____	_____	_____
A1. Liquid Line Volume (in ³)	_____	_____	_____	_____
A2. Total A + A1 (in ³)	_____	_____	_____	_____
B. Initial Weight in Bleed Unit Prior to Loading (lb)	_____	_____	_____	_____
C. Final Weight in Bleed Unit After Loading (lb)	_____	_____	_____	_____
D. Propellant Load by Weight Tank (lb) (item B less item C)	_____	_____	_____	_____
E. Loading Temperature (°F)	_____	_____	_____	_____
F. Specification Load @ 70 ±5°F (lb)	_____	_____	_____	_____
G. Total CM/RCS Propellant Load from Item D Above or Item P Below (lb)	_____	+0.3	_____	+0.3

ULLAGE CALCULATION

G1. Density (lb/in ³). Solve the following equation where T = temperature in E above and ρ_F = fuel density, ρ_0 = oxidizer density.	_____	_____	_____	_____
$\rho_F = 0.0329456 - (0.186979)(10^{-4})(T)$				
$\rho_0 = 0.451591(10^{-4})(11.8-T) + 0.05475906$				
H. Specification Ullage @ E Above				
Maximum	_____	_____	_____	_____
Minimum	_____	_____	_____	_____
I. Tank Stretch Factor (in ³ /psi)	_____	_____	_____	_____
J. Volume of GHE-GSE Line (in ³)	_____	_____	_____	_____
K. Volume of SC GHE Line (in ³)	_____	_____	_____	_____
L. GSE Line Pressure (psig)	_____	_____	_____	_____
M. Bladder Pressure (psig)	_____	_____	_____	_____
N. Stabilized Equilibrium Pressure (psig)	_____	_____	_____	_____
O. Ullage Volume (in ³). Solve the following equation by substituting the values contained in the above indicated steps.	_____	_____	_____	_____
Ullage Volume = $J \frac{L - N}{N - M} - I (N + M + 14.7) - K$				
P. Propellant Load by PV (lb)	_____	_____	_____	_____

TABLE 4.3-2
SERVICE MODULE RCS PROPELLANT LOAD SUMMATION

Actual:

	QUAD A (Pounds)	
Secondary Fuel _____		
Primary Fuel _____		Total Oxidizer _____ <u>+2.3</u>
Total _____ <u>+0.7</u>		

	QUAD B (Pounds)	
Secondary Fuel _____		
Primary Fuel _____		Total Oxidizer _____ <u>+2.3</u>
Total _____ <u>+0.7</u>		

	QUAD C (Pounds)	
Secondary Fuel _____		
Primary Fuel _____		Total Oxidizer _____ <u>+2.3</u>
Total _____ <u>+0.7</u>		

	QUAD D (Pounds)	
Secondary Fuel _____		
Primary Fuel _____		Total Oxidizer _____ <u>+2.3</u>
Total _____ <u>+0.7</u>		

	PSM (Pounds)	
Total Fuel _____		Total Oxidizer _____
Total SM/RCS Propellant Loaded (1b)		
Fuel _____ <u>+1.4</u>		Oxidizer _____ <u>+4.6</u>

TABLE 4.3-3

SERVICE MODULE RCS LOADING PARAMETERS AND CALCULATIONS - QUAD A

<u>Fuel</u>		<u>Oxidizer</u>	
<u>Secondary Fuel</u>		<u>Secondary Oxidizer</u>	
A.	Loading Temperature (°F) _____	A.	Tank Volume (in ³) @ 0.0 psig _____
B.	Tank Volume (in ³) @ 0.0 psig _____	A1.	Liquid Line Volume (in ³) _____
B1.	Liquid Line Volume (in ³) _____	B.	Tank Stretch Factor (in ³ /psi) <u>0.045</u>
C.	Tank Stretch Factor (in ³ /psi) _____ <u>0.034</u>	<u>Primary Oxidizer</u>	
D.	Initial Weight of Bleed Unit Prior to Loading (lb) _____	C.	Tank Volume (in ³) @ 0.0 psig _____
E.	Final Weight of Bleed Unit After Loading (lb) _____	C1.	Liquid Line Volume (in ³) _____
*F.	Resulting Load (lb) (item D less item E) _____	D.	Tank Stretch Factor (in ³ /psi) <u>0.088</u>
G.	Specification Nominal Load at 70 ±5°F (lb) _____	<u>PV Parameters for Combined Primary and Secondary Oxidizer Tanks</u>	
H.	Volume of GHE-GSE Line (in ³) _____	E.	Volume of GHE-GSE Line (in ³) _____
I.	Volume of SC GHE Line (in ³) _____	F.	Volume of SC GHE Line (in ³) _____
J.	GSE Line Pressure (psig) _____	G.	GSE Line Pressure (psig) _____
K.	Bladder Pressure (psig) _____	H.	Bladder Pressure (psig) _____
L.	Stabilized Equilibrium Pressure (psig) _____	I.	Stabilized Equilibrium Pressure (psig) _____
M.	Primary Liquid Close-Out Pressure (psig) _____	J.	Loading Temperature (°F) _____
N.	Specification Ullage @ A Above Maximum _____ Minimum _____	K.	Oxidizer Density (lb/in ³). Solve equation (4) below where T = temperature @ J Above. _____
O.	Ullage Volume (in ³). Solve the following equation by substituting the values contained in the indi- cated steps. _____ Ullage Volume = $H \left(\frac{J - L}{L - K} \right) -$ $(C + S) (L + K + 14.7) + S(M) - I$	L.	Specification Value @ Temperature J Above (lb) Maximum _____ Minimum _____
	<u>Primary Fuel</u>	M.	PV Calculated Oxidizer Load (lb). Solve equations (5) and (6) below by substituting the values contained in the above indicated steps where U = volume of tank gas (in ³) in both tanks and He system, and F ₀ = PV calculated oxidizer load for both tanks. _____ <u>±2.3</u>
P.	Loading Temperature (°F) _____	N.	Specification Nominal Value @ Tempera- ture J Above (lb) _____
Q.	Tank Volume (in ³) @ 0.0 psig _____	(4)	Oxidizer Density = $0.451591(10^{-4})$ $(11.8 - T) + 0.05475906$
R.	Liquid Line Volume (in ³) _____	(5)	$U = E \left(\frac{G - I}{I - H} \right) - (B + D) (I + H + 14.7)$
S.	Tank Stretch Factor (in ³ /psi) _____ <u>0.0652</u>	(6)	$F_0 = K(A + C + A1 + C1 - U + F)$

TABLE 4.3-3' (CONTINUED)
 SERVICE MODULE RCS LOADING PARAMETERS AND CALCULATIONS - QUAD A

Primary Fuel (Continued)

T. Fuel Density (lb/in³). Solve equation (1) below where T = temperature @ P above _____

PV Parameters and Combined Primary and Secondary Fuel Tanks

U. Volume of GHE-GSE Line (in³) _____

V. Volume of SC GHE Line (in³) _____

W. GSE Line Pressure (psig) _____

X. Bladder Pressure (psig) _____

Y. Stabilized Equilibrium Pressure (psig) _____

Z. Specification PV Value @ Temperature P Above (lb)

Maximum _____

Minimum _____

Z1. PV Calculated Fuel Load (lb) _____
 Solve equations (2) and (3) below by substituting the values contained in the above indicated steps where U_v = volume or tanked gas (in³) in the primary tank and F_L = PV calculated fuel load.

Z2. Specification Nominal Value @ Temperature H Above (lb)

Z3. Total Fuel Load (lb) _____ +0.7
 (item F plus item Z1)

(1) Fuel density = 0.0329456 -
 (0.186979) (10⁻⁴) (T)

(2) $U_v = U \left(\frac{W - Y}{Y - X} \right) - (C + S) (Y + X + 14.7)$

*(3) $F_L + T (Q + R - U_v = V = B = B1 - \frac{F}{T})$

*Z4. Secondary Fuel Load by PV (lb) _____

*If secondary fuel load is determined by PV calculation, then in equation three (3), substitute item Z4 for item F.

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TABLE 4.3-4

SERVICE MODULE RCS LOADING PARAMETERS AND CALCULATIONS - QUAD B

<u>Fuel</u>		<u>Oxidizer</u>	
<u>Secondary Fuel</u>		<u>Secondary Oxidizer</u>	
A.	Loading Temperature (°F) _____	A.	Tank Volume (in ³) @ 0.0 psig _____
B.	Tank Volume (in ³) @ 0.0 psig _____	A1.	Liquid Line Volume (in ³) _____
B1.	Liquid Line Volume (in ³) _____	B.	Tank Stretch Factor (in ³ /psi) <u>0.045</u>
C.	Tank Stretch Factor (in ³ /psi) _____ <u>0.034</u>	<u>Primary Oxidizer</u>	
D.	Initial Weight of Bleed Unit Prior to Loading (lb) _____	C.	Tank Volume (in ³) @ 0.0 psig _____
E.	Final Weight of Bleed Unit After Loading (lb) _____	C1.	Liquid Line Volume (in ³) _____
*F.	Resulting Load (lb) (item D less item E) _____	D.	Tank Stretch Factor (in ³ /psi) <u>0.088</u>
G.	Specification Nominal Load at 70 ±5°F (lb) _____	<u>PV Parameters for Combined Primary and Secondary Oxidizer Tanks</u>	
H.	Volume of GHE-GSE Line (in ³) _____	E.	Volume of GHE-GSE Line (in ³) _____
I.	Volume of SC GHE Line (in ³) _____	F.	Volume of SC GHE Line (in ³) _____
J.	GSE Line Pressure (psig) _____	G.	GSE Line Pressure (psig) _____
K.	Bladder Pressure (psig) _____	H.	Bladder Pressure (psig) _____
L.	Stabilized Equilibrium Pressure (psig) _____	I.	Stabilized Equilibrium Pressure (psig) _____
M.	Primary Liquid Close-Out Pressure (psig) _____	J.	Loading Temperature (°F) _____
N.	Specification Ullage @ A Above Maximum _____ Minimum _____	K.	Oxidizer Density (lb/in ³). Solve equation (4) below where T = temperature @ J Above. _____
O.	Ullage Volume (in ³). Solve the following equation by substituting the values contained in the indi- cated steps. _____	L.	Specification Value @ Temperature J Above (lb) Maximum _____ Minimum _____
	Ullage Volume = $H \left(\frac{J - L}{L - K} \right) -$ $(C + S) (L + K + 14.7) + S(M) - I$	M.	PV Calculated Oxidizer Load (lb). Solve equations (5) and (6) below by substituting the values contained in the above indicated steps where U = volume of tank gas (in ³) in both tanks and He system, and F ₀ = PV calculated oxidizer load for both tanks. _____ <u>±2.3</u>
	<u>Primary Fuel</u>	N.	Specification Nominal Value @ Tempera- ture J Above (lb) _____
P.	Loading Temperature (°F) _____	(4)	Oxidizer Density = $0.451591(10^{-4})$ $(11.8 - T) + 0.05475906$
Q.	Tank Volume (in ³) @ 0.0 psig _____	(5)	$U = E \left(\frac{G - I}{I - H} \right) - (B + D) (I + H + 14.7)$
R.	Liquid Line Volume (in ³) _____	(6)	$F_0 = K(A + C + A1 + C1 - U + F)$
S.	Tank Stretch Factor (in ³ /psi) _____ <u>0.0652</u>		

TABLE 4.3-4 (CONTINUED)
 SERVICE MODULE RCS LOADING PARAMETERS AND CALCULATIONS - QUAD B

Primary Fuel (Continued)

T. Fuel Density (lb/in³). Solve equation (1) below where T = temperature @ P above _____

PV Parameters and Combined Primary and Secondary Fuel Tanks

U. Volume of GHE-GSE Line (in³) _____

V. Volume of SC GHE Line (in³) _____

W. GSE Line Pressure (psig) _____

X. Bladder Pressure (psig) _____

Y. Stabilized Equilibrium Pressure (psig) _____

Z. Specification PV Value @ Temperature P Above (lb)

Maximum _____

Minimum _____

Z1. PV Calculated Fuel Load (lb) _____
 Solve equations (2) and (3) below by substituting the values contained in the above indicated steps where U_V = volume or tanked gas (in³) in the primary tank and F_L = PV calculated fuel load.

Z2. Specification Nominal Value @ Temperature H Above (lb)

Z3. Total Fuel Load (lb) _____ ±0.7
 (item F plus item Z1)

(1) Fuel density = $0.0329456 - (0.186979) (10^{-4}) (T)$

(2) $U_V = U \left(\frac{W - Y}{Y - X} \right) - (C + S) (Y + X + 14.7)$

* (3) $F_L + T (Q + R - U_V = V = B = B1 - \frac{F}{T})$

*Z4. Secondary Fuel Load by PV (lb) _____

*If secondary fuel load is determined by PV calculation, then in equation three (3), substitute item Z4 for item F.

TABLE 4.3-5

SERVICE MODULE RCS LOADING PARAMETERS AND CALCULATIONS - QUAD C

<u>Fuel</u>		<u>Oxidizer</u>	
<u>Secondary Fuel</u>		<u>Secondary Oxidizer</u>	
A.	Loading Temperature (°F) _____	A.	Tank Volume (in ³) @ 0.0 psig _____
B.	Tank Volume (in ³) @ 0.0 psig _____	A1.	Liquid Line Volume (in ³) _____
B1.	Liquid Line Volume (in ³) _____	B.	Tank Stretch Factor (in ³ /psi) <u>0.045</u>
C.	Tank Stretch Factor (in ³ /psi) _____ <u>0.034</u>	<u>Primary Oxidizer</u>	
D.	Initial Weight of Bleed Unit Prior to Loading (lb) _____	C.	Tank Volume (in ³) @ 0.0 psig _____
E.	Final Weight of Bleed Unit After Loading (lb) _____	C1.	Liquid Line Volume (in ³) _____
*F.	Resulting Load (lb) (item D less item E) _____	D.	Tank Stretch Factor (in ³ /psi) <u>0.088</u>
G.	Specification Nominal Load at 70 ±5°F (lb) _____	<u>PV Parameters for Combined Primary and Secondary Oxidizer Tanks</u>	
H.	Volume of GHE-GSE Line (in ³) _____	E.	Volume of GHE-GSE Line (in ³) _____
I.	Volume of SC GHE Line (in ³) _____	F.	Volume of SC GHE Line (in ³) _____
J.	GSE Line Pressure (psig) _____	G.	GSE Line Pressure (psig) _____
K.	Bladder Pressure (psig) _____	H.	Bladder Pressure (psig) _____
L.	Stabilized Equilibrium Pressure (psig) _____	I.	Stabilized Equilibrium Pressure (psig) _____
M.	Primary Liquid Close-Out Pressure (psig) _____	J.	Loading Temperature (°F) _____
N.	Specification Ullage @ A Above Maximum _____ Minimum _____	K.	Oxidizer Density (lb/in ³). Solve equation (4) below where T = temperature @ J Above. _____
O.	Ullage Volume (in ³). Solve the following equation by substituting the values contained in the indicated steps. _____	L.	Specification Value @ Temperature J Above (lb) Maximum _____ Minimum _____
	Ullage Volume = $H \left(\frac{J - L}{L - K} \right) - (C + S) (L + K + 14.7) + S(M) - I$	M.	PV Calculated Oxidizer Load (lb). Solve equations (5) and (6) below by substituting the values contained in the above indicated steps where U = volume of tank gas (in ³) in both tanks and He system, and F ₀ = PV calculated oxidizer load for both tanks. _____ <u>±2.3</u>
	<u>Primary Fuel</u>	N.	Specification Nominal Value @ Temperature J Above (lb) _____
P.	Loading Temperature (°F) _____		(4) Oxidizer Density = $0.451591(10^{-4}) (11.8 - T) + 0.05475906$
Q.	Tank Volume (in ³) @ 0.0 psig _____		(5) $U = E \left(\frac{G - I}{I - H} \right) - (B + D) (I + H + 14.7)$
R.	Liquid Line Volume (in ³) _____		(6) $F_0 = K(A + C + A1 + C1 - U + F)$
S.	Tank Stretch Factor (in ³ /psi) _____ <u>0.0652</u>		

TABLE 4.3-5 (CONTINUED)
 SERVICE MODULE RCS LOADING PARAMETERS AND CALCULATIONS - QUAD C

Primary Fuel (Continued)

T. Fuel Density (lb/in³). Solve equation (1) below where T = temperature @ P above _____

PV Parameters and Combined
 Primary and Secondary Fuel Tanks

U. Volume of GHE-GSE Line (in³) _____

V. Volume of SC GHE Line (in³) _____

W. GSE Line Pressure (psig) _____

X. Bladder Pressure (psig) _____

Y. Stabilized Equilibrium Pressure (psig) _____

Z. Specification PV Value @ Temperature P Above (lb)

Maximum _____

Minimum _____

Z1. PV Calculated Fuel Load (lb) _____
 Solve equations (2) and (3) below by substituting the values contained in the above indicated steps where U_V = volume or tanked gas (in³) in the primary tank and F_L = PV calculated fuel load.

Z2. Specification Nominal Value @ Temperature H Above (lb)

Z3. Total Fuel Load (lb) ±0.7
 (item F plus item Z1)

(1) Fuel density = 0.0329456 -
 (0.186979) (10⁻⁴) (T)

(2) $U_V = U \left(\frac{W - Y}{Y - X} \right) - (C + S) (Y + X + 14.7)$

*(3) $F_L + T (Q + R - U_V = V = B = B1 - \frac{F}{T})$

*Z4. Secondary Fuel Load by PV (lb) _____

*If secondary fuel load is determined by PV calculation, then in equation three (3), substitute item Z4 for item F.

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TABLE 4.3-6

SERVICE MODULE RCS LOADING PARAMETERS AND CALCULATIONS - QUAD D

<u>Fuel</u>		<u>Oxidizer</u>	
<u>Secondary Fuel</u>		<u>Secondary Oxidizer</u>	
A.	Loading Temperature (°F) _____	A.	Tank Volume (in ³) @ 0.0 psig _____
B.	Tank Volume (in ³) @ 0.0 psig _____	A1.	Liquid Line Volume (in ³) _____
B1.	Liquid Line Volume (in ³) _____	B.	Tank Stretch Factor (in ³ /psi) <u>0.045</u>
C.	Tank Stretch Factor (in ³ /psi) _____	<u>Primary Oxidizer</u>	
	<u>0.034</u>	C.	Tank Volume (in ³) @ 0.0 psig _____
D.	Initial Weight of Bleed Unit Prior to Loading (lb) _____	C1.	Liquid Line Volume (in ³) _____
E.	Final Weight of Bleed Unit After Loading (lb) _____	D.	Tank Stretch Factor (in ³ /psi) <u>0.088</u>
*F.	Resulting Load (lb) (item D less item E) _____	<u>PV Parameters for Combined Primary and Secondary Oxidizer Tanks</u>	
G.	Specification Nominal Load at 70 ±5°F (lb) _____	E.	Volume of GHE-GSE Line (in ³) _____
H.	Volume of GHE-GSE Line (in ³) _____	F.	Volume of SC GHE Line (in ³) _____
I.	Volume of SC GHE Line (in ³) _____	G.	GSE Line Pressure (psig) _____
J.	GSE Line Pressure (psig) _____	H.	Bladder Pressure (psig) _____
K.	Bladder Pressure (psig) _____	I.	Stabilized Equilibrium Pressure (psig) _____
L.	Stabilized Equilibrium Pressure (psig) _____	J.	Loading Temperature (°F) _____
M.	Primary Liquid Close-Out Pressure (psig) _____	K.	Oxidizer Density (lb/in ³). Solve equation (4) below where T = temperature @ J Above. _____
N.	Specification Ullage @ A Above	L.	Specification Value @ Temperature J Above (lb)
	Maximum _____		Maximum _____
	Minimum _____		Minimum _____
O.	Ullage Volume (in ³). Solve the following equation by substituting the values contained in the indicated steps. _____	M.	PV Calculated Oxidizer Load (lb). Solve equations (5) and (6) below by substituting the values contained in the above indicated steps where U = volume of tank gas (in ³) in both tanks and He system, and F ₀ = PV calculated oxidizer load for both tanks. _____
	Ullage Volume = $H \left(\frac{J - L}{L - K} \right) - (C + S) (L + K + 14.7) + S(M) - I$		<u>±2.3</u>
	<u>Primary Fuel</u>	N.	Specification Nominal Value @ Temperature J Above (lb) _____
P.	Loading Temperature (°F) _____	(4)	Oxidizer Density = $0.451591(10^{-4}) (11.8 - T) + 0.05475906$
Q.	Tank Volume (in ³) @ 0.0 psig _____	(5)	$U = E \left(\frac{G - I}{I - H} \right) - (B + D) (I + H + 14.7)$
R.	Liquid Line Volume (in ³) _____	(6)	$F_0 = K(A + C + A1 + C1 - U + F)$
S.	Tank Stretch Factor (in ³ /psi) _____		
	<u>0.0652</u>		

TABLE 4.3-6 (CONTINUED)
 SERVICE MODULE RCS LOADING PARAMETERS AND CALCULATIONS - QUAD D

Primary Fuel (Continued)

T. Fuel Density (lb/in³). Solve equation (1) below where T = temperature @ P above _____

PV Parameters and Combined Primary and Secondary Fuel Tanks

U. Volume of GHE-GSE Line (in³) _____

V. Volume of SC GHE Line (in³) _____

W. GSE Line Pressure (psig) _____

X. Bladder Pressure (psig) _____

Y. Stabilized Equilibrium Pressure (psig) _____

Z. Specification PV Value @ Temperature P Above (lb)

Maximum _____

Minimum _____

Z1. PV Calculated Fuel Load (lb) _____
 Solve equations (2) and (3) below by substituting the values contained in the above indicated steps where U_V = volume or tanked gas (in³) in the primary tank and F_L = PV calculated fuel load.

Z2. Specification Nominal Value @ Temperature H Above (lb) _____

Z3. Total Fuel Load (lb) _____ ±0.7
 (item F plus item Z1)

(1) Fuel density = 0.0329456 -
 (0.186979) (10⁻⁴) (T)

(2) $U_V = U \left(\frac{W - Y}{Y - X} \right) - (C + S) (Y + X + 14.7)$

* (3) $F_L + T (Q + R - U_V = V = B = B1 - \frac{F}{T})$

*Z4. Secondary Fuel Load by PV (lb) _____

*If secondary fuel load is determined by PV calculation, then in equation three (3), substitute item Z4 for item F.

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TABLE 4.3-7
SERVICE MODULE RCS LOADING PARAMETERS AND CALCULATIONS - PSM

TBS

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4.3-12

TABLE 4.3-8

CSM RCS TANK VOLUMES

COMMAND MODULE 111 RCS TANK VOLUMES

<u>System</u>	<u>Serial Number</u>	<u>Gross Tank Volume, in³</u>	<u>Internal Equipment Volume, in³</u>	<u>Net Tank Volume, in³</u>
System 1				
Fuel	_____	_____	_____	_____
Oxidizer	_____	_____	_____	_____
System 2				
Fuel	_____	_____	_____	_____
Oxidizer	_____	_____	_____	_____

SERVICE MODULE 111 RCS TANK VOLUMES

<u>System</u>	<u>Serial Number</u>	<u>Gross Tank Volume, in³</u>	<u>Internal Equipment Volume, in³</u>	<u>Net Tank Volume, in³</u>
<u>Quad A</u>				
Primary Oxidizer	_____	_____	_____	_____
Secondary Oxidizer	_____	_____	_____	_____
Primary Fuel	_____	_____	_____	_____
Secondary Fuel	_____	_____	_____	_____
<u>Quad B</u>				
Primary Oxidizer	_____	_____	_____	_____
Secondary Oxidizer	_____	_____	_____	_____
Primary Fuel	_____	_____	_____	_____
Secondary Fuel	_____	_____	_____	_____
<u>Quad C</u>				
Primary Oxidizer	_____	_____	_____	_____
Secondary Oxidizer	_____	_____	_____	_____
Primary Fuel	_____	_____	_____	_____
Secondary Fuel	_____	_____	_____	_____
<u>Quad D</u>				
Primary Oxidizer	_____	_____	_____	_____
Secondary Oxidizer	_____	_____	_____	_____
Primary Fuel	_____	_____	_____	_____
Secondary Fuel	_____	_____	_____	_____

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TABLE 4.3-8 (CONTINUED)

CSM RCS TANK VOLUMES

SERVICE MODULE 111 RCS TANK VOLUMES (CONTINUED)

<u>System</u>	<u>Serial Number</u>	<u>Gross Tank Volume, in³</u>	<u>Internal Equipment Volume, in³</u>	<u>Net Tank Volume, in³</u>
<u>PSM</u>				
Fuel Tank 1	_____	_____	_____	_____
Fuel Tank 2	_____	_____	_____	_____
Fuel Tank 3	_____	_____	_____	_____
Fuel Tank 4	_____	_____	_____	_____
Oxidizer Tank 1	_____	_____	_____	_____
Oxidizer Tank 2	_____	_____	_____	_____
Oxidizer Tank 3	_____	_____	_____	_____
Oxidizer Tank 4	_____	_____	_____	_____
Oxidizer Tank 5	_____	_____	_____	_____

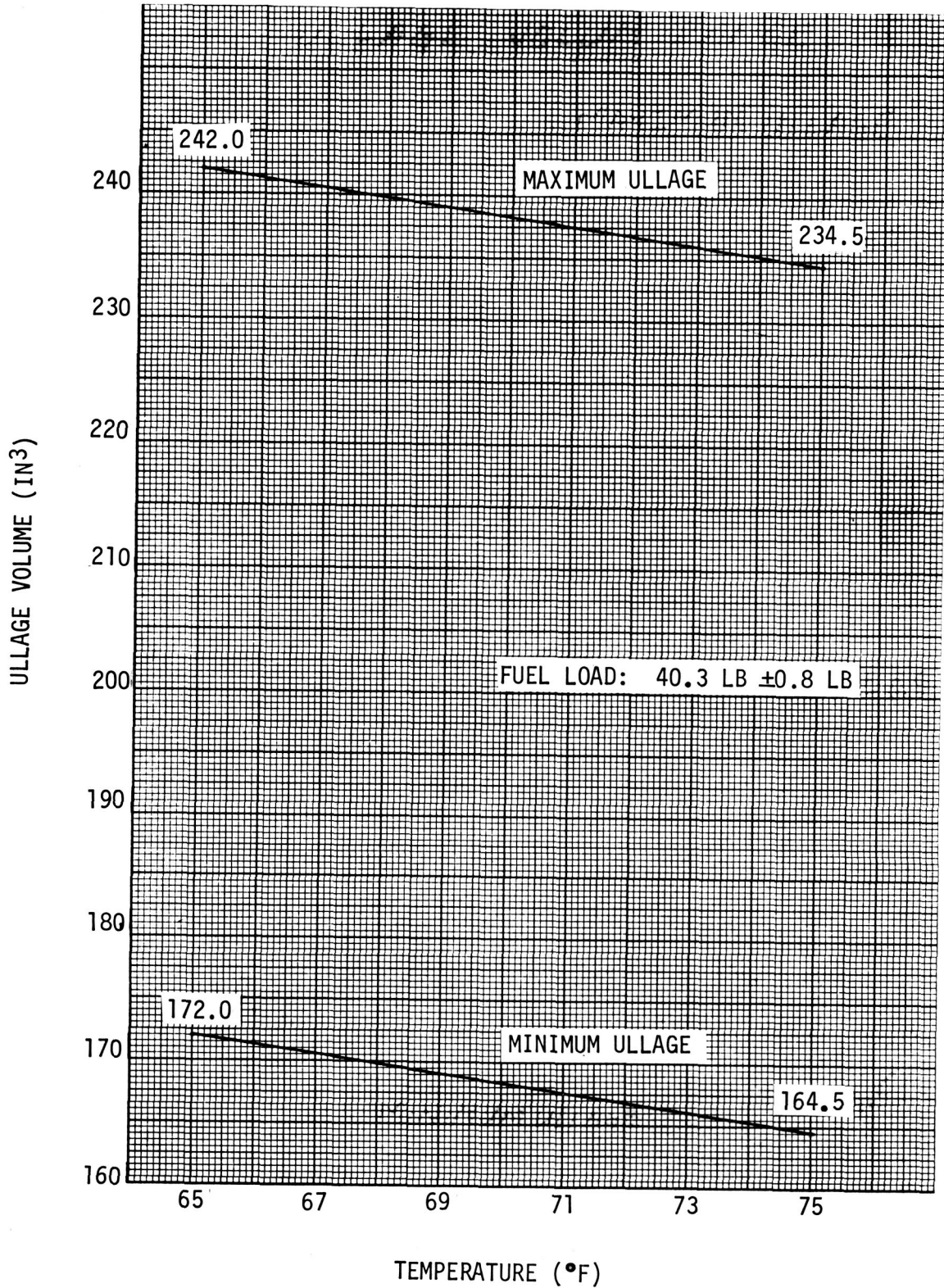


FIGURE 4.3-1. SM SECONDARY FUEL TANK ULLAGE VOLUME RANGE

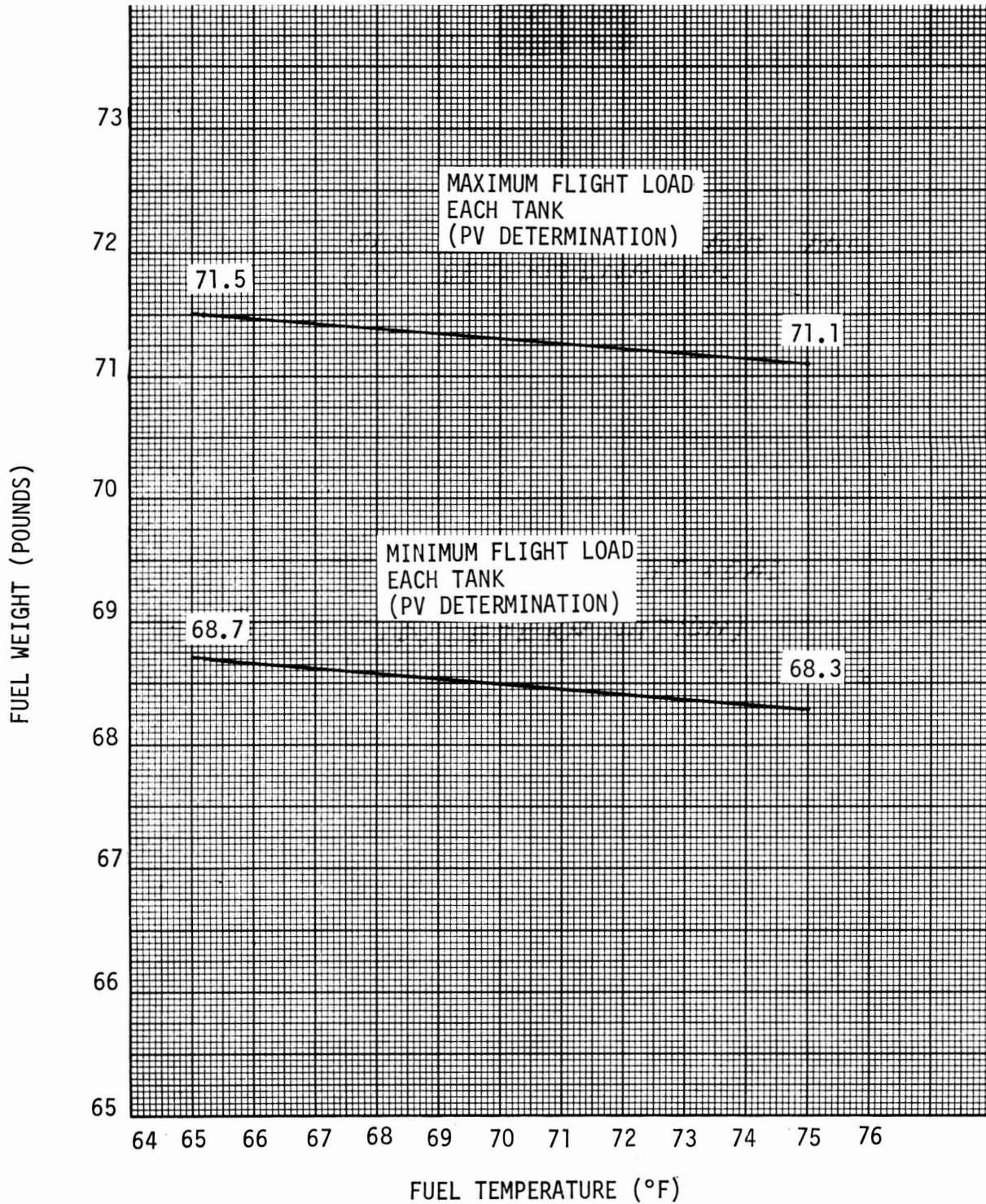


FIGURE 4.3-2. SM RCS PRIMARY FUEL TANK LOAD WINDOW

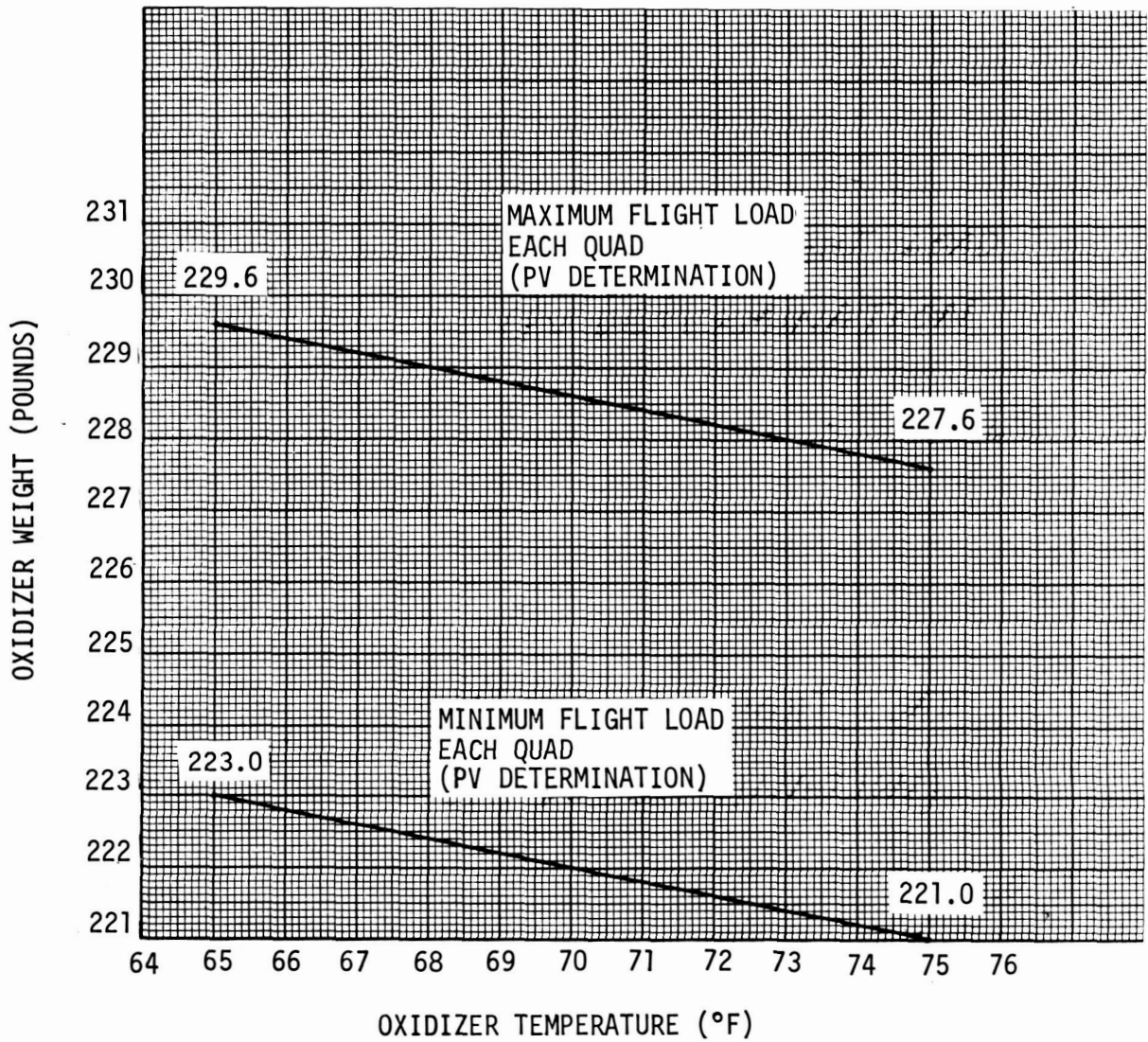


FIGURE 4.3-3. SM RCS COMBINED PRIMARY-SECONDARY
OXIDIZER TANK LOAD WINDOW

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TBS

FIGURE 4.3-4. SM RCS COMBINED PSM FUEL LOADING WINDOW

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TBS

FIGURE 4.3-5. SM RCS COMBINED PSM OXIDIZER FUEL LOADING WINDOW

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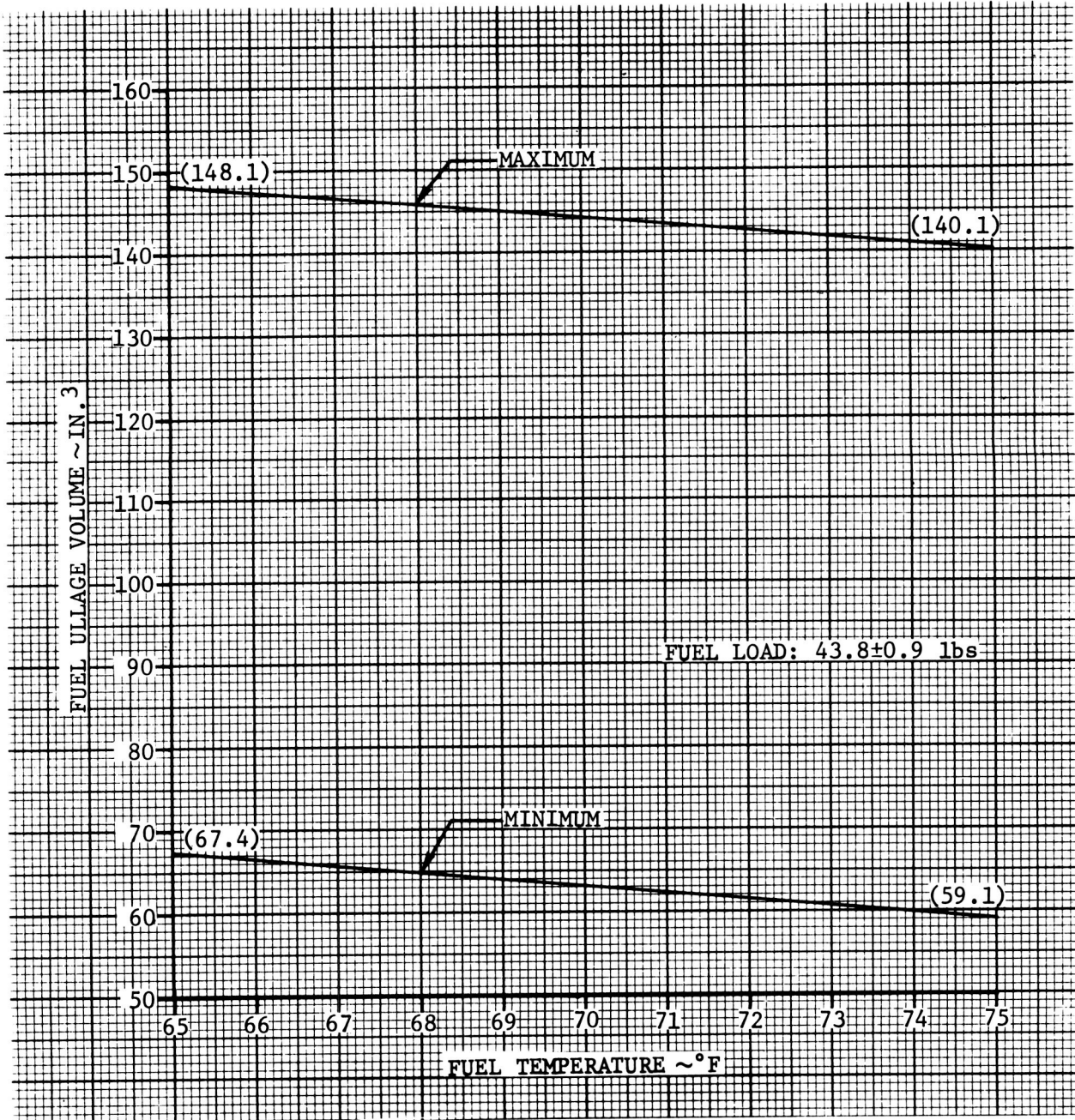


FIGURE 4.3-6. CM RCS FUEL LOADING WINDOW

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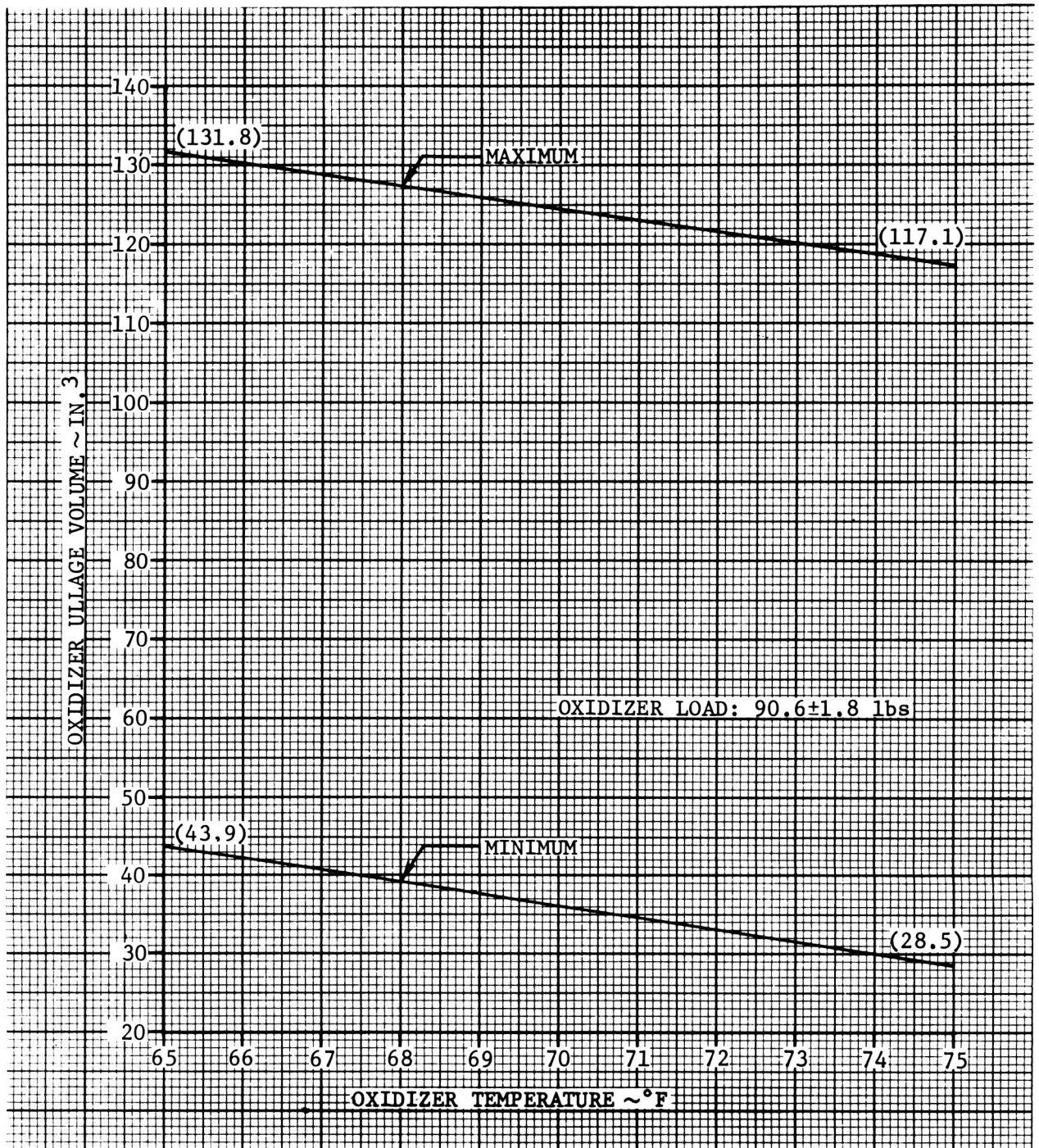


FIGURE 4.3-7. CM RCS OXIDIZER LOADING WINDOW

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TABLE 5-1
DOCKING MODULE CONSUMABLE LOADS

TBS