REMTECH INC.

RTR 032-03

ET TPS DEVELOPMENT CRITERIA AND FLIGHT INSTRUMENTATION PROGRAM

November 1986

by

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Prepared under Contract NAS8-32969

For

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FORWARD

This is the final report presenting work which was conducted for Marshall Space Flight Center (MSFC) in response to requirements of Contract NAS8-32116. The work presented was performed at REMTECH's Huntsville Office and is entitled "ET TPS Development Criteria and Flight Instrumentation Program".

The NASA technical coordination for this study was provided by Mr. Lee D. Foster of the Unsteady Aerodynamics and Thermal Environment Branch of the Systems Dynamics Laboratory.

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Section 1.0

INTRODUCTION

The Thermal Protection System (TPS) for the External Tank (ET) is designed to maintain primary structure, subsystem components, and propellants within design temperature limits. In addition, the TPS must be designed such that no ice can form on the surfaces of the ET during prelaunch (propellant loading and hold) that might shed during ascent flight and impact/damage the Orbiter TPS. The TPS system for the ET basically consists of two materials. The primary TPS material, CPR-488, which coats all of the external skin of the ET (and some protuberances) is a low density closed cell foam which is applied by automatic spraying devices. CPR-488, serves both as a cryogenic insulator and as an ablator to protect the structure from exceeding limit temperatures due to aerodynamic heating. The other material used to protect structure and protuberances from high heating is SLA-561. This material is used where heating exceeds the capability of CPR-488 (≈ 10 Btu/ft^2-sec).

The objective of this study was to verify the design thermal environments for the Space Shuttle External Tank. These environments encompassed a myriad of potential flight cases which included: (1) nominal and dispersed trajectories launched from KSC and Vandenberg and (2) AOA, TAL, RTLS, and ATO abort cases. Many iterations of environments have been produced by RI during the evolution of the Space Shuttle system which required an analysis and assessment of each environment provided by RI to MSFC. In order to properly assess the environments, REMTFCH had to acquire all wind tunnel and flight heat transfer data measured on various scaled models and on six External Tanks flown during the flight test program. A significant effort was expended in the analysis and application of this data to develop math/computer models. Various versions of the aeroheating computer code "MINIVER" were tailored to calculate ascent aeroheating environments for the ET. Throughout the course of this study, REMTECH has submitted comprehensive monthly progress reports (Ref. 1) that described the significant results accomplished under this contract. The 103 progress reports provide the detailed documentation of the study results. This final report essentially summarizes the significant environment assessment results.

Section 2.0

SHUTTLE ASCENT DESIGN THERMAL TRAJECTORY

The trajectory for which the design aeroheating environments for the ET were calculated is for a December launch from the Vandenberg Western Test Range. It is a 3σ dispersed trajectory that incorporated a right quartering head wind. This trajectory assumes that one of the Orbiter engine fails and is shut down at 260 seconds after lift-off. This results in what is referred to as an abort-once-around (AOA) trajectory. The SRB's separate at 126 seconds with the remaining two SSME's engines cutting off at 582 seconds. The ET/Orbiter separates at 611 seconds.

The altitude and velocity profiles for the ascent thermal design trajectory as a function of time for first stage flight are presented in Figure 1 and for second stage flight are presented in Figure 2. The nominal and dispersed angles of attack for first and second stage flight are given in Figures 3 and 4. The nominal and dispersed angles of yaw for first and second stage flight are presented on Figures 5 and 6.

The approach used by RI to develop the dispersed thermal design trajectory is summarized in Table 1. The reference trajectory was developed at JSC. The dispersion analysis and the development of the 3σ dispersed trajectory was conducted by RI. Table 2 shows the parameters and deviations from their nominal levels that were used to generate the ascent thermal design trajectory which gives a heating indicator thermal load of 389 Btu/ft^2 at the

AOA/RTLS mode boundary (t = 260 seconds). Any one SSME failure that occurs before this time results in a RTLS abort. A SSME failure after this time results in an AOA abort. Various abort mode profiles are illustrated in Figure 7.

TABLE 1 Approach Used to Develop Dispersed Ascent Thermal Design Trajectory

- NOMINAL TRAJECTORY RESULTS FROM TOTAL SYSTEM ANALYSIS CYCLE (LOADS, PERFORMANCE) AND PROVIDES REFERENCE TRAJECTORY FOR DISPERSED TRAJECTORY DEVELOPMENT.
- HEAT LOAD INDICATOR AT AOA/RTLS MODE BOUNDARY IS CALCULATED FOR REFERENCES TRAJECTORY.
- $\pm 3\sigma$ LEVELS OF ALL TRAJECTORY DRIVERS DEFINED.
- TRAJECTORY FOR EACH DISPERSION SOURCE (+) GENERATED THAT PROVIDES HEAT INDICATOR LOADS FOR EACH INDIVIDUAL DISPERSION (Q_I).
- $\Delta Q = Q_i - Q_R$ ARE RSS'ED TO GIVE THE SYSTEM DISPERSION LEVELS.
- WIND EFFECTS (DIRECTION, PERCENTILE) ARE GIVEN BY SIMILAR TRAJECTORY ANALYSIS FOR ΔQ_W.
- COMPOSITE TRAJECTORY IS THEN GENERATED THAT MATCHES Q_T AT THE AOA/RTLS MODE BOUNDARY (MB).
- AN SSME ENGINE OUT IS ASSUMED AT THE AOA/RTLS M.B. AND TRAJECTORY IS SHAPED FROM THIS POINT TO MECO FOR AN AOA.
- RESULTANT TRAJECTORY IS THE ASCENT THERMAL DESIGN TRAJECTORY.

TABLE 2 Dispersions Used to Develop Ascent Design Trajectory

DISPERSION SOURCE	PERTURBATION	ΔQ (BTU/FT^2)
ATMOSPHERE	HOT	9
SRB TVC	.525°	36
Z ACCELEROMETER	.034 G'S	37
PITCHING MOMENT (ΔC_M)	TOL.	41
IMU (PITCH)	-.5°	24
SSME TVC	1.066°	15
SRB THRUST	4.16%	8
NORMAL FORCE (ΔC_N)	TOL.	10
STATISTICAL COMBINATION	-----	69

HEATING INDICATOR LOADS AT AOA/RTLS MODE BOUNDARY

SOURCE OF H.I. LOAD	Q
NOMINAL TRAJECTORY QR	233
SYSTEM DISPERSIONS ($\Sigma \Delta Q$)RSS	69
RIGHT QUARTERING HEAD WIND ΔQ_W	87
TOTAL	389

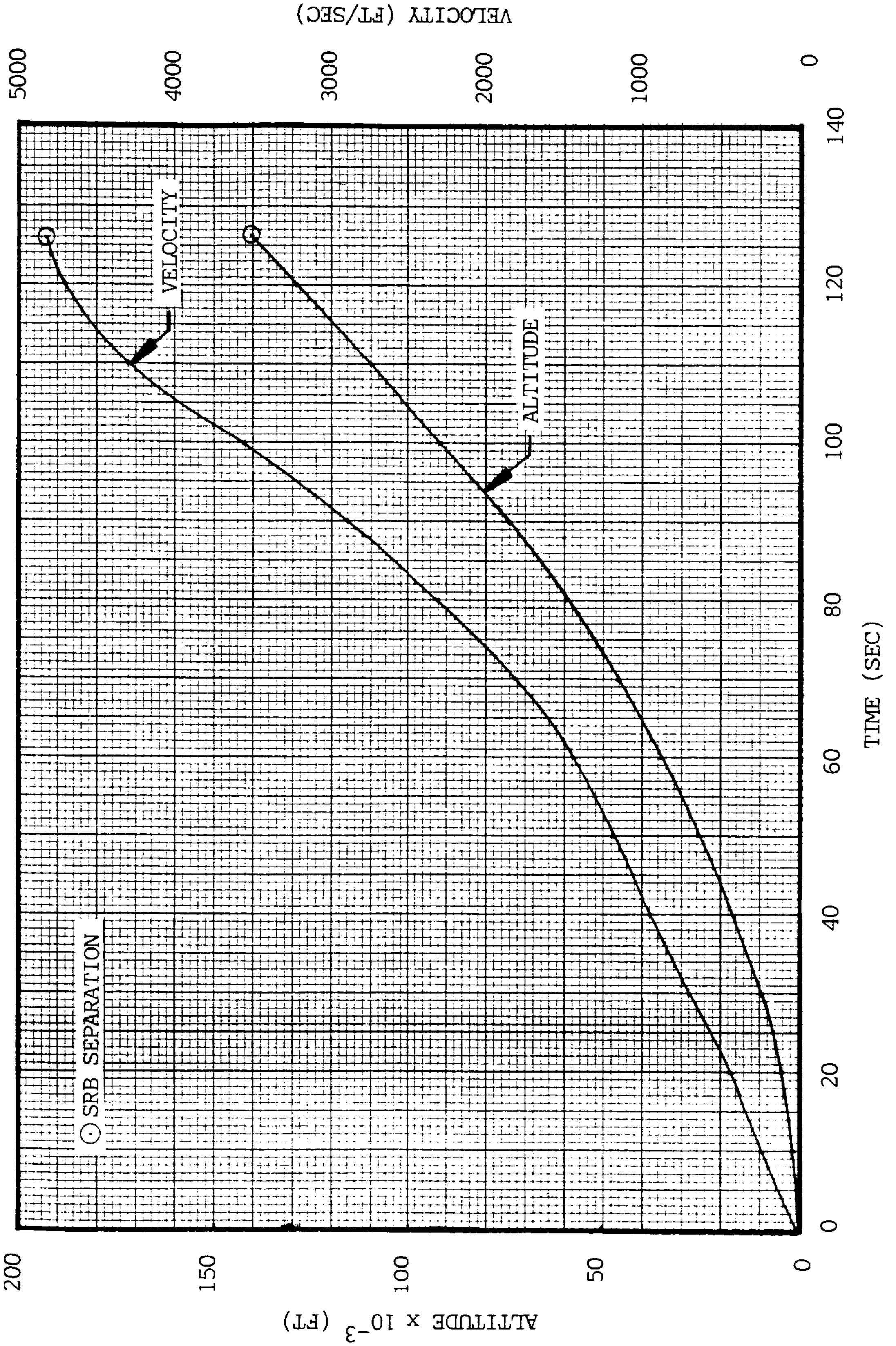

Fig. 1 Shuttle Ascent Thermal Design Trajectory - First Stage Flight

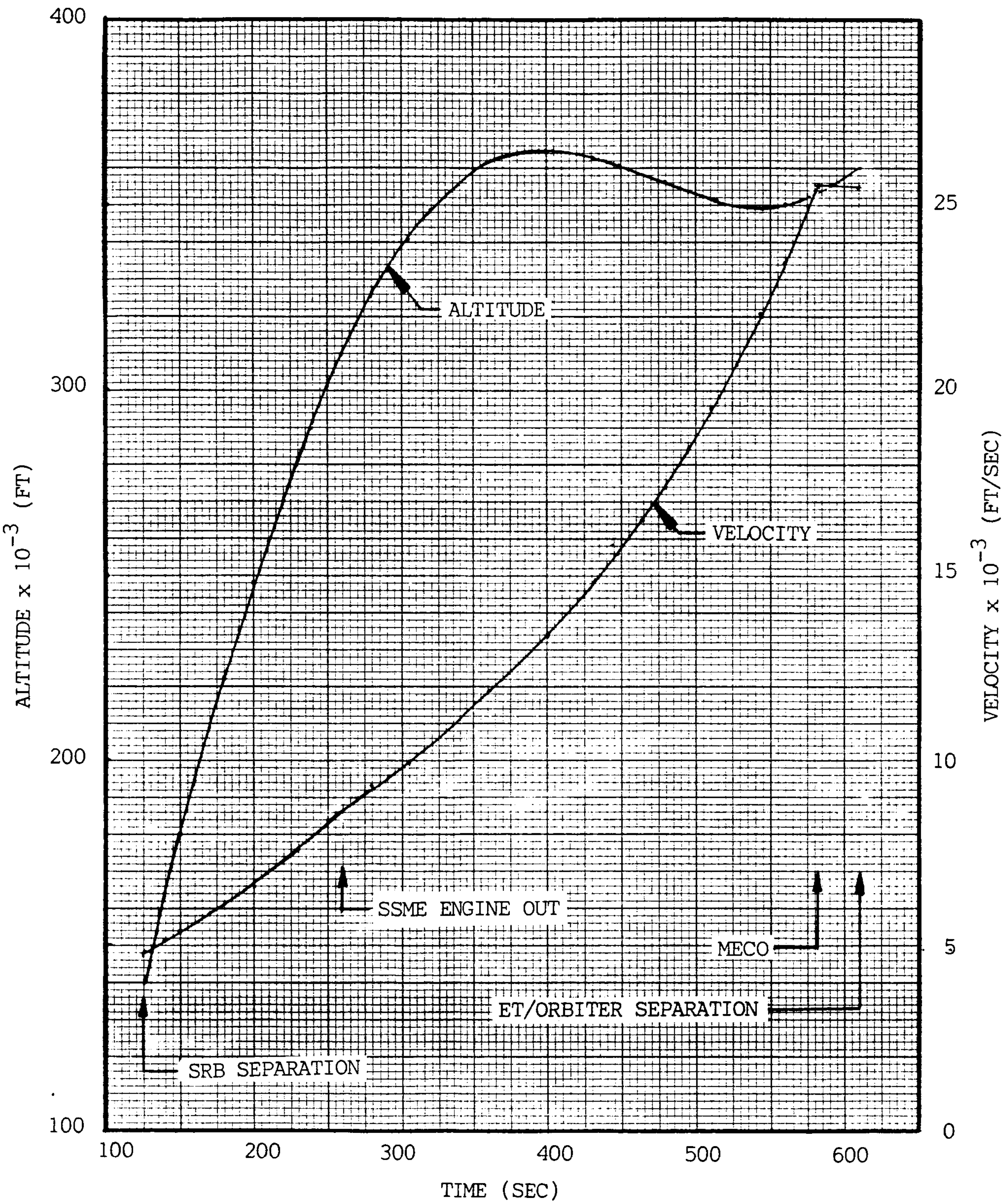

Fig. 2 Shuttle Ascent Design Trajectory - Second Stage Flight

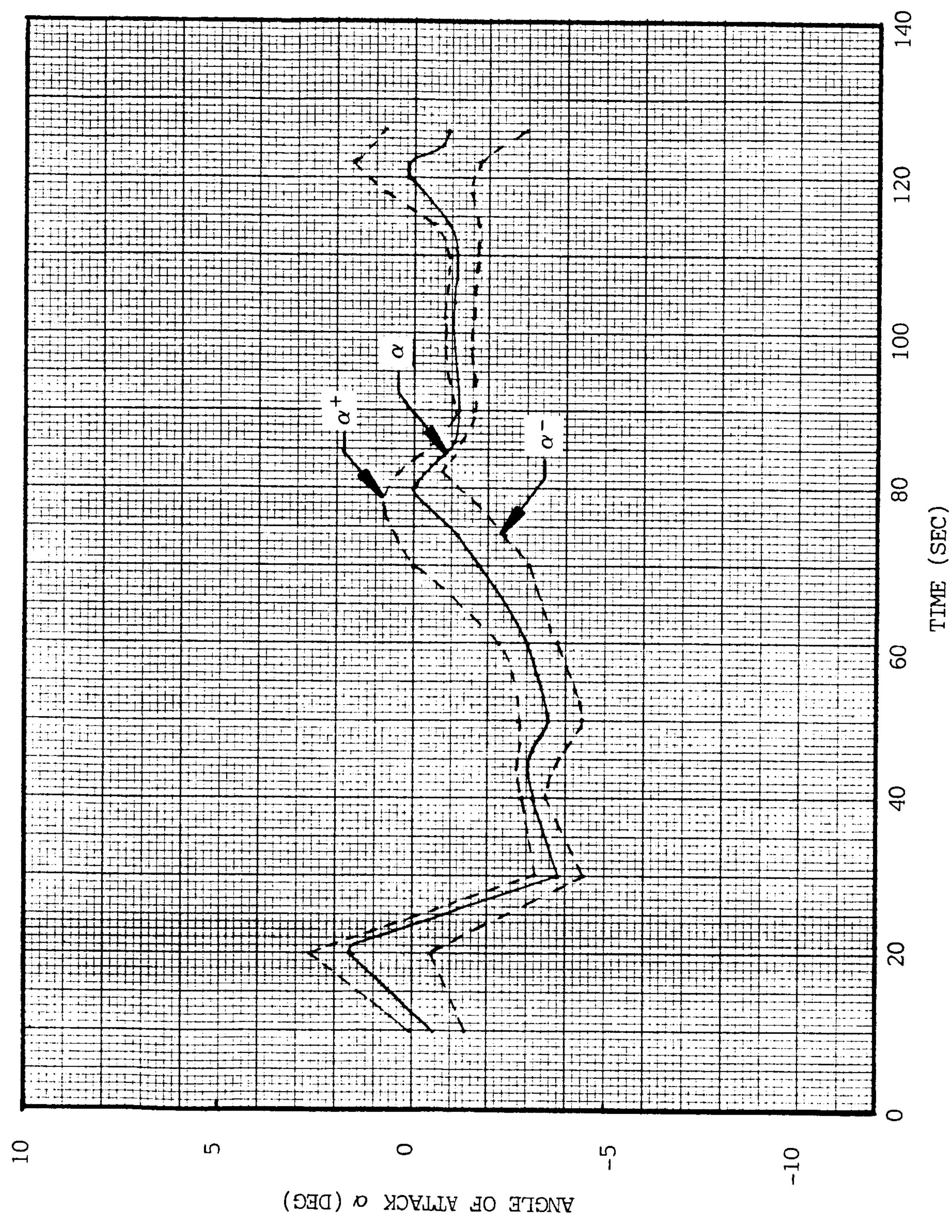

Fig. 3 Nominal and Dispersed Angles of Attack for First Stage Flight

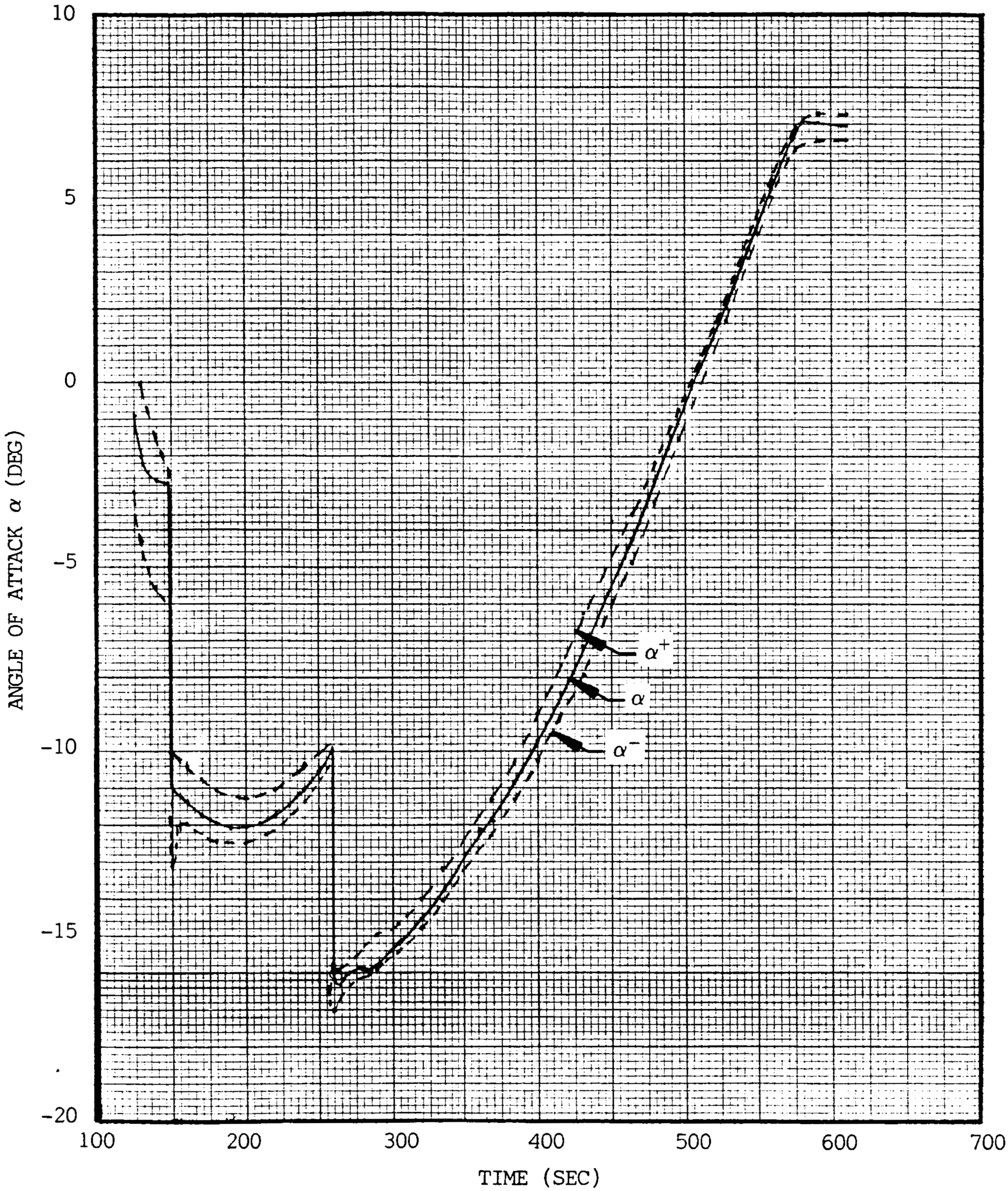

Fig. 4 Nominal and Dispersed Angles of Attack for Second Stage Flight

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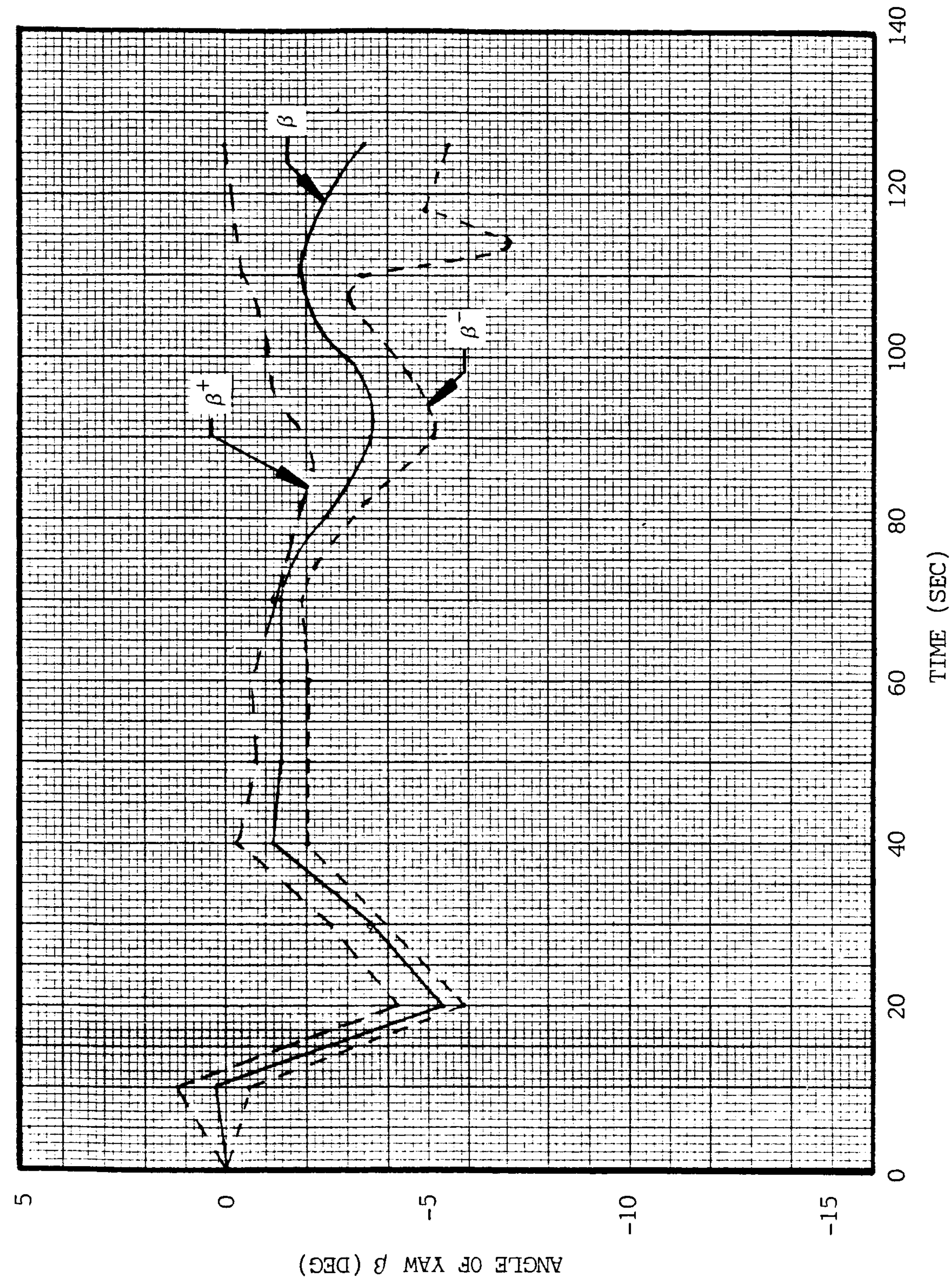


Fig. 5 Nominal and Dispersed Angles of Yaw for First Stage Flight

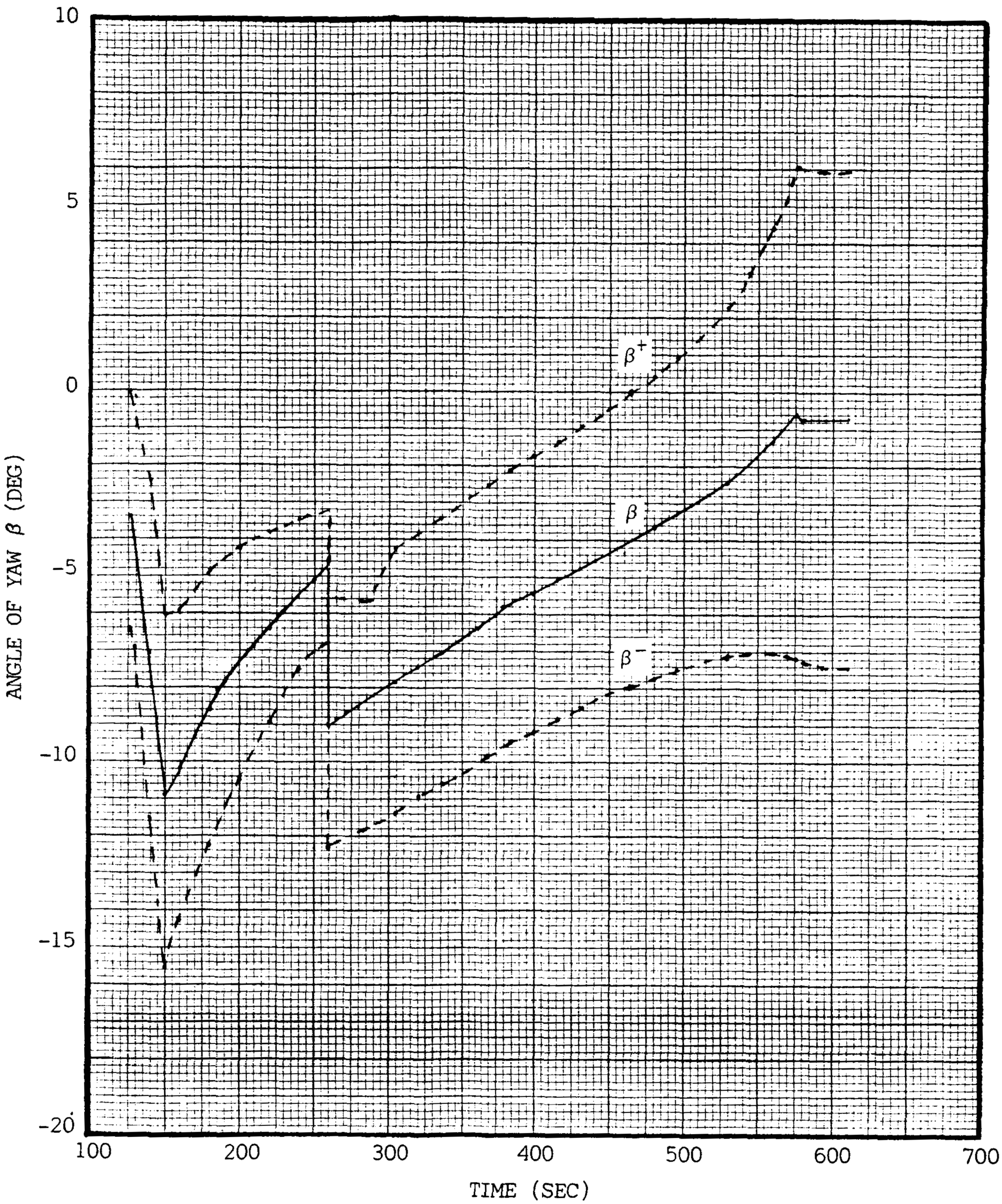


Fig. 6 Nominal and Dispersed Angles of Yaw for Second Stage Flight

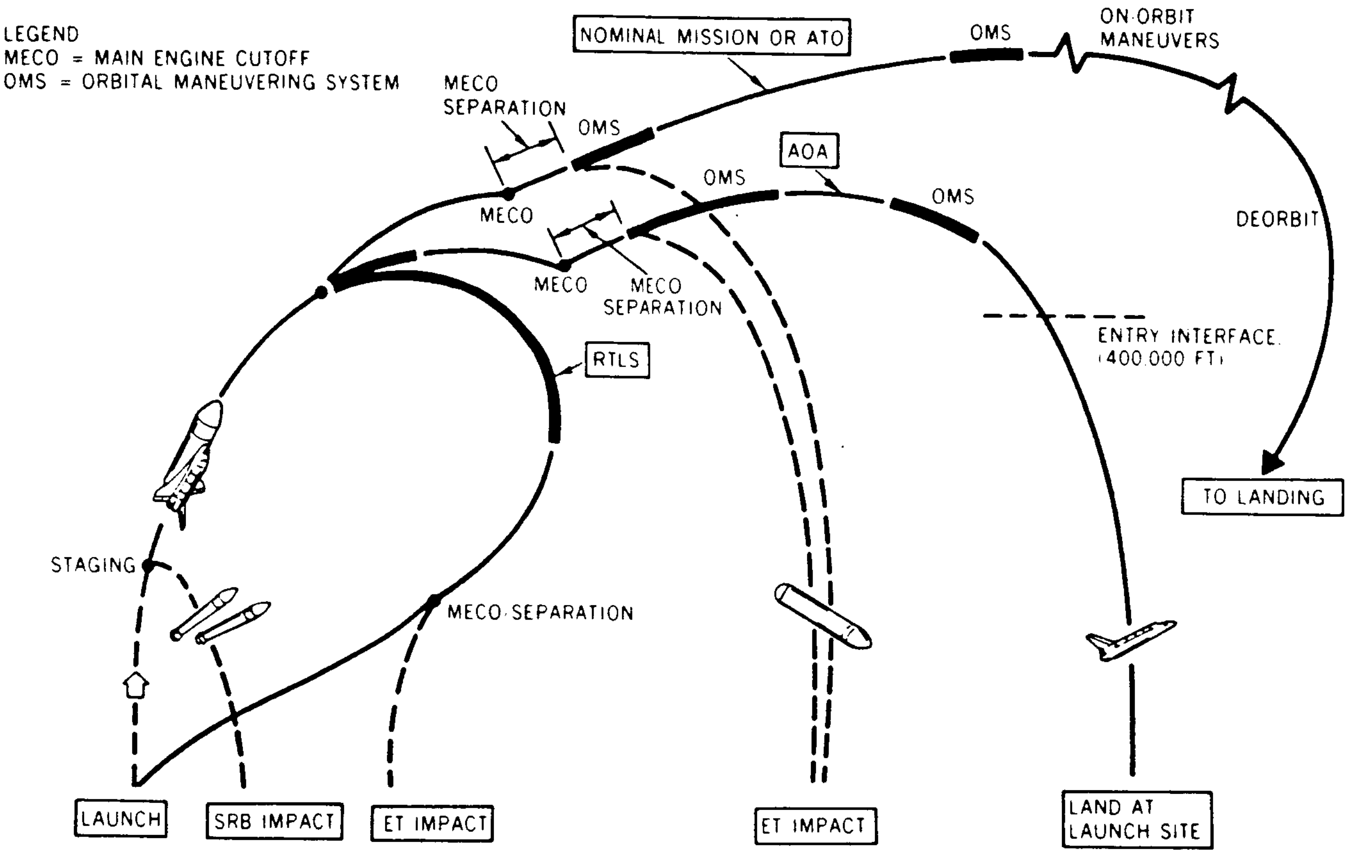


Fig. 7 Abort Mode Profiles

Section 3.0

ET DESIGN THERMAL ENVIRONMENTS AND TPS REQUIREMENTS

The final aeroheating design environments for the ET were provided to MSFC by RI during November 1986 (Ref. 2). Design thermal environments are defined for 625 surface locations on the ET main body and protuberances. Tables 1 thru 4 (given at the end of this section) present a summary of the maximum heating rate and the heat load for each acreage body point. An acreage body point is defined as any point on the main body of the ET and includes all points near/adjacent to protuberances. For convenience of the user, the acreage environment summaries are broken into four tables: (1) the nose spike and the nose cone, (2) the LO_2 tank, (3) the intertank and (4) the LH_2 tank. The body points and environment summaries are given in ascending order of X_T.

The environments for the protuberance points are summarized in Tables 5 - 8 for the four sections of the ET described above. These are also given in ascending order of X_T.

RI has generated four versions of IVBC-3 thermal environments for the ET from 1983 - 1986. REMTECH checked the environments for all body points for each environment set and provided the COR with assessment results that identified those body points with environment discrepancies. The documentation required to verify the discrepancies are presented in the monthly progress reports and presentation material prepared for the Space Shuttle Thermal Panel meetings. The studies conducted by REMTECH that assessed the environments resulted in the required revisions published by RI. The objective of the studies was met in that there is now an acceptable set of ET design thermal environments for the ET. A discussion of the heating levels and conditions that drive the heating for each body section are given in the following paragraphs.

Nose - Spike and Cone Acreage Heating and TPS - Table 1 shows that the maximum heating rate (15 Btu/ft^{2}sec) and heat load (1840 Btu/ft^2) on the tip of the nose spike are for body point 60133. The 10^{o} cone is relatively cool with a maximum heating rate of 4.7 Btu/ft^2 sec and heat load of 577 Btu/ft^2. The heating rates on the 40^{o} cone run from $\approx$13 to 23 Btu/ft^{2}sec with heat loads ranging from $\approx$ 1100 to 1900 Btu/ft^2. Body Point 70700 on the 40^{o} cone is the point of maximum heating. The maximum heating occurs when $M_\infty \cong$ 4 with peak interference factors around 5.0 due to the flow field disturbences created by the bi-conic nose shape. The TPS requirement for the 40^{o} cone is shown in Figure 9.

40^{o} Cone Protuberance Heating and TPS - The protuberances on the 40^{o} nose cone (Table 5) consist of a fairing, two LO_2 tank vent louvers, a tumble value, and the first GO_2 pressurization line and cable tray bracket. The highest heating occurs on the forward face of the fairing (body point 60109) where the maximum heating rate is 28.4 Btu/ft^{2}sec and the heat load is 1900 Btu/ft^2. REMTECH conclusions that were drawn from an analysis of the wind tunnel and flight data are the following: (1) the acreage adjacent to the fairing is not significantly amplified due to the presence of the fairing and (2) the heating on the fairing face is approximately 1.5 times higher than the 40° cone acreage heating. The RI IVBC-3 environment shows a ratio of ≈ 1.22 for fairing/acreage which was accepted since the RI predictions for the 707xx acreage body points were $\approx 30\%$ higher than REMTECH's predictions. The TPS requirement for the fairing is shown in Figure 9.

<u>LO_2 Tank Acreage Heating</u> - The LO_2 tank acreage ($371 \leq X_T \leq 852.8$) is subjected to both undisturbed and protuberance disturbed flow fields. The region in the near vicinity of the GO_2 pressurization line, cable tray, and support brackets is where the flow is disturbed and amplified heating occurs. Table 2 provides the maximum heating rate and heat load for all acreage body points on the LO_2 tank. Figure 8 presents the maximum heating rates as a function of X_T for all the LO_2 body points. Maximum heating to the undisturbed area of the LO_2 tank ($\approx 90\%$ of surface area) varies from 9 Btu/ft^{2}sec near the nose down to ≈ 2 Btu/ft^{2}sec on the barrel section.

The heating at the disturbed points varies from 14.3 Btu/ft^{2}sec near the nose to 3.5 Btu/ft^{2}sec on the barrel section. All the surface acreage is thermally protected with a layer of foam insulation (CPR-488).

The current TPS configuration for ET acreage is shown in Figure 9. This configuration (with the exception of the note stating that no SLA will be on the LH_2 tank for LWT 23 and up) is the baseline throught LWT 43. The major change for LWT 44 and up is that there will be no SLA on LO_2 tank and the foam thickness will be increased to 1.9" around the brackets for thermal protection in those high heating areas.

<u>LO_2 Tank Protuberance Heating and TPS</u> - The environments for the LO_2 tank protuberance are summarized in Table 6. The front faces of the brackets and flanges are subjected to the highest heating. The highest aeroheating environment on the entire ET is predicted for the front face of the bracket at station 402.84 where $\dot{q}_{max}$ = 30.3 Btu/Ft^{2}sec and the heat load is 2055 Btu/Ft^2. It is assumed that the heating environment for the cable tray and the GO_2 pressurization line is identical. The TPS requirements through LWT 43 for the LO_2 tank cable tray and brackets are shown in Figure 10. There is no TPS on any of the pressurization lines and flanges.

<u>Intertank Acreage Heating and TPS</u> - The environments for the 73 intertank acreage points are given in Table 3. Each intertank side in the vicinity of the forward ET/SRB attachment is subjected to a severe heating environment. Heating rates up to 20.3 Btu/ft^{2}sec with heat loads to 953 Btu/ft^2 are encountered at each side region. The heating levels on top of the intertank due to impingement by the Orbiter bow shock reach peak rates of up to 8.3 Btu/ft^{2}sec and heat loads to 447 Btu/ft^2. The TPS requirements through LWT 43 for the intertank acreage is shown in Figure 9. For LWT 44 and up the TPS will only consist of CPR-488 with no intentional smoothing

(removing stringer effects) of the surface in the high heating regions.

<u>Intertank Protuberance Heating and TPS</u> - The environments for 49 intertank protuberance points are given in Table 7. The highest heating rate (26.5 Btu/ft^2sec) for any protuberance on the I/T occurs at the stagnation point of the boltcatcher (body pt. 80110). The cable trays that are mounted on the ET/SRB attachment structure also encounter severe heating environments (heating rates to 20 Btu/ft^2sec and heat loads to 964 Btu/ft^2). Significant heating also occurs on the ET/Orbiter forward attachment, the LO_2 feedline fairing, and bracket/flange forward faces.

<u>LH_2 Tank Acreage Heating and TPS</u> - The environments for the LH_2 acreage body points are given in Table 4. The LH_2 tank is subjected to both aerodynamic heating and plume convective heating due to reverse flow. The groundrules that were established for the users of the aeroheating and baseheating environments are as follows: (1) aerodynamic heating should be applied to all surfaces for $X_T \leq 1871$ for the total duration of ascent flight, (2) between $X_T = 1871$ to $X_T = 2000$, aerodynamic heating should be applied to the first 95 seconds and then the more severe of either aerodynamic or plume convective heating should be applied until the end of first stage flight, and (3) between $X_T = 2000$ and $X_T = 2058$, aerodynamic heating should be applied to the first 95 seconds and plume convection heating should be applied from 95 seconds until the end

of first stage flight. The values shown in Table 4 for maximum heating rates and heat loads represent only the aerodynamic heating. The criteria defined above must be applied for those points aft of station 1871. The current TPS requirements for the LH_2 tank are shown in Figure 9. For LWT 23 and up, there will be no SLA on the LH_2 surface acreage. The next Shuttle flight planned for spring 1988 will use LWT 21.

<u>LH_2 Protuberance Heating and TPS</u> - There are numerous protuberances on the LH_2 tank. These protuberance are subjected to both aerodynamic and plume convection heating. The groundrules that determine when aerodynamic or plume convection heating are applicable follows: (1) all forward facing protuberances shall use only aerodynamic heating environments throughout the ascent flight, (2) for X_T = 1871 to X_T = 2000 aeroheating environments should be used for the first 95 seconds and the larger of aeroheating or base convection heating should be applied after 95 seconds, and (3) for X_T = 2000 to X_T = 2058, aeroheating should be applied for the first 95 seconds and plume convection heating should be applied to the aft facing and side surfaces of the protuberances. The maximum aeroheating rates and heat loads for all LH_2 tank protuberances are given in Table 8. The TPS requirements for most of these protuberances are given in Figure 12.

The intent of this section was to summarize the current design aeroheating environments and briefly describe the baseline TPS requirements. Complete and detailed descriptions of the environments and TPS requirements are given in References 3 and 4 respectfully.

TABLE 1 ET DESIGN ENVIRONMENTS - NOSE SPIKE AND 40 DEG CONE

BODY PT. NUMBER	COORDINATES X_T	θ_T	LOCATION DESCRIPTION	RI IVBC-3 QRATE(1)	QLOAD(2)
7000	----	----	STAG PT FOR 1 FT SPHERE	5.68	715.6
60133	327.66	0.0	30 CONICAL NOSE TIP	14.98	1840.3
60101	328.00	0.0	↓	11.31	1593.4
60122	328.00	180.0	↓	10.75	1349.1
70300	329.00	0.0	↓	10.21	1329.2
70350	329.00	180.0	↓	9.64	1147.4
70375	329.00	270.0	↓	10.87	1380.5
70400	335.00	0.0	10 NOSE CONE	4.03	498.8
70450	335.00	180.0	↓	3.58	414.9
70475	335.00	270.0	↓	4.73	576.9
60130	338.00	0.0	↓	3.83	467.1
70500	342.24	0.0	40 CONE	15.25	1434.4
70550	342.24	180.0	↓	12.81	1122.1
70575	342.24	270.0	↓	13.50	1297.6
70600	345.50	0.0	↓	18.38	1593.5
70650	345.50	180.0	↓	15.45	1250.1
70675	345.50	270.0	↓	16.28	1435.6
60111	349.00	14.0	↓	22.01	1574.2
70700	354.50	0.0	↓	23.23	1863.2
70750	354.50	180.0	↓	19.52	1436.5
70775	354.50	270.0	↓	20.57	1643.1
60112	357.00	8.0	↓	18.61	1365.0
70800	364.50	0.0	↓	19.02	1542.7
70850	364.50	180.0	↓	15.98	1217.8
70875	364.50	270.0	↓	16.85	1379.4

(1) Represents maximum heat transfer rate in Btu/ft^2-sec.
(2) Represents the total heat load from lift-off to ET/Orbiter separation in Btu/ft^2.

TABLE 2 ET DESIGN ENVIRONMENTS - LO_2 TANK ACREAGE

BODY PT. NUMBER	COORDINATES X_T	T	RI IVBC-3 QRATE	QLOAD
70900	375.10	0.0	8.97	817.3
70950	375.10	180.0	8.89	825.5
70956	375.10	202.5	8.83	816.9
70963	375.10	225.0	8.96	845.6
70969	375.10	247.5	8.99	849.1
70975	375.10	270.0	9.00	846.8
70981	375.10	292.5	8.87	808.0
70988	375.10	315.0	9.01	829.8
70994	375.10	337.5	8.93	816.9
60400	402.50	357.4	9.23	750.0
60405	402.50	16.9	11.56	875.0
60407	402.50	24.3	14.34	1016.1
60409	402.50	31.5	12.21	909.2
60411	402.50	38.7	9.31	753.0
60413	402.50	46.1	9.30	764.6
60418	402.50	65.6	10.55	760.3
60500	409.90	0.1	8.41	706.2
60507	409.90	24.9	10.91	819.7
60509	409.90	31.5	7.62	648.6
60510	409.90	38.1	7.45	653.8
60517	409.90	62.9	9.62	734.2
71000	421.30	0.0	6.60	594.5
71050	421.30	180.0	6.76	598.0
71056	421.30	202.5	6.78	597.7
71063	421.30	225.0	6.89	604.4
71069	421.30	247.5	7.88	681.2
71075	421.30	270.0	7.93	683.4
71081	421.30	292.5	6.95	606.7
71088	421.30	315.0	6.80	600.0
71094	421.30	337.5	6.69	595.0
60601	422.30	3.2	7.54	648.8
60607	422.30	25.8	8.96	699.0
60609	422.30	31.5	7.00	614.7
60610	422.30	37.2	8.06	670.3
60617	422.30	59.8	8.19	665.2
60701	432.10	5.0	7.35	628.5
60707	432.10	23.7	12.27	940.0
60709	432.10	31.5	12.76	940.1
60711	432.10	39.4	10.78	821.6
60716	432.10	58.0	8.00	626.2
60802	437.60	5.9	7.22	615.4
60806	437.60	21.5	9.99	747.7
60807	437.60	26.5	12.32	937.5
60809	437.60	31.5	12.19	931.1
60810	437.60	36.5	9.95	762.0

TABLE 2 (Continued)

60816	437.60	57.1	8.86	706.9
71100	453.60	0.0	5.95	532.9
71150	453.60	180.0	6.30	539.8
71175	453.60	270.0	6.13	557.2
71200	467.40	0.0	5.69	486.5
71250	467.40	180.0	6.00	521.8
71263	467.40	225.0	5.63	512.4
71275	467.40	270.0	5.91	514.4
71288	467.40	315.0	5.89	509.0
60907	474.20	23.7	8.76	617.5
60909	474.20	31.5	10.59	755.9
60911	474.20	39.3	9.08	661.1
60915	474.20	53.5	6.23	511.3
61009	512.10	31.5	8.86	641.5
61109	512.62	31.5	6.68	493.5
71300	513.60	0.0	4.97	410.4
71350	513.60	180.0	4.49	399.3
71356	513.60	202.5	4.02	366.8
71363	513.60	225.0	4.03	362.0
71369	513.60	247.5	4.13	358.2
71375	513.60	270.0	4.95	440.7
71381	513.60	292.5	4.24	361.9
71388	513.60	315.0	4.27	369.6
71394	513.60	337.5	4.35	376.9
61111	551.30	37.3	7.39	518.8
61114	551.30	49.0	3.75	320.9
61209	591.40	31.5	5.27	409.7
71400	606.00	0.0	3.22	280.8
71450	606.00	180.0	3.38	265.7
71456	606.00	202.5	2.86	252.0
71463	606.00	225.0	2.83	246.6
71469	606.00	247.5	2.89	241.9
71475	606.00	270.0	3.71	311.8
71481	606.00	292.5	3.01	248.7
71488	606.00	315.0	3.05	258.2
71494	606.00	337.5	3.15	266.6
61309	632.30	31.5	4.34	332.4
61311	632.30	36.4	4.40	338.3
61313	632.30	46.3	2.83	236.3
61409	673.90	31.5	2.95	239.7
71500	698.00	0.0	2.16	208.7
71550	698.00	180.0	2.40	180.4
71556	698.00	202.5	1.91	170.6
71563	698.00	225.0	1.89	167.8
71569	698.00	247.5	1.89	165.1
71575	698.00	270.0	2.47	210.8
71581	698.00	292.5	1.97	168.0
71588	698.00	315.0	2.03	175.3
71594	698.00	337.5	2.10	183.0

TABLE 2 (Concluded)

61509	715.80	31.5	2.51	215.6
71600	751.50	0.0	1.76	160.0
71650	751.50	180.0	1.66	148.5
71675	751.50	270.0	1.97	172.6
61609	759.20	31.5	2.10	186.1
61610	759.20	33.8	3.52	263.7
61611	759.20	36.0	2.02	181.4
61613	759.20	45.1	1.65	147.8
61709	762.20	31.5	2.03	150.6
61809	773.70	31.5	2.25	169.6
61909	786.20	31.5	2.36	191.7
62009	793.10	31.5	2.88	216.5
71700	796.50	0.0	2.10	160.7
71750	796.50	180.0	2.21	164.1
71756	796.50	202.5	2.21	162.8
71763	796.50	225.0	2.21	161.6
71769	796.50	247.5	2.21	160.2
71775	796.50	270.0	2.58	192.4
71781	796.50	292.5	1.92	139.3
71788	796.50	315.0	1.92	144.7
71794	796.50	337.5	2.05	153.3
62109	827.10	31.5	2.86	215.6
71800	841.50	0.0	2.15	168.7
71850	841.50	180.0	2.18	161.5
71875	841.50	270.0	2.56	191.7

TABLE 3 ET DESIGN ENVIRONMENTS - INTERTANK ACREAGE

BODY PT.	COORDINATES		RI IVBC-3	
NUMBER	X_T	θ_T	QRATE	QLOAD
7300	884.85	0.0	1.86	137.1
7309	884.85	180.0	1.95	130.7
7307	884.85	225.0	1.58	107.8
7305	884.85	270.0	9.45	465.3
7304	884.85	292.5	2.00	142.9
7302	884.85	315.0	2.00	147.6
7301	884.85	337.5	1.81	136.6
7306	884.86	247.5	1.61	113.9
6410	890.00	141.3	2.51	201.6
6413	900.00	142.6	2.19	175.2
6394	905.00	31.5	1.33	119.9
7320	929.14	0.0	1.69	131.1
7329	929.14	180.0	2.08	124.4
7325	929.14	270.0	9.89	530.2
7355	961.22	270.0	16.54	809.9
1002	965.22	270.0	20.32	953.6
1007	970.22	270.5	20.00	887.3
1009	970.22	271.0	19.72	876.9
1005	971.22	270.0	20.29	889.4
1011	971.22	271.6	19.36	856.5
7350	973.43	0.0	1.72	133.3
7359	973.43	180.0	2.06	123.4
7354	973.43	292.5	5.90	321.7
6301	983.46	23.5	5.24	316.1
1012	991.07	270.0	11.81	512.2
7365	994.40	270.0	11.76	510.3
7360	1006.65	0.0	1.89	139.8
6368	1006.65	15.0	2.32	155.4
6369	1006.65	19.0	3.41	193.0
6367	1006.65	29.0	2.83	170.0
7369	1006.65	180.0	2.05	122.0
1746	1021.70	13.5	3.22	193.2
1738	1021.70	29.3	2.78	173.4
7387	1025.80	225.0	2.62	169.0
7386	1025.80	247.5	2.10	156.6
6331	1026.00	16.5	3.89	253.6
7380	1038.03	0.0	2.39	158.7
7385	1038.03	270.0	1.31	123.4
7381	1038.03	337.5	2.63	175.2
7400	1069.40	0.0	2.85	189.3
6408	1069.40	15.0	3.97	251.0
6409	1069.40	19.0	3.89	258.9
6407	1069.40	29.0	3.39	208.0
7409	1069.40	180.0	2.10	124.2
7406	1069.40	247.5	1.49	128.3

TABLE 3 (Concluded)

7405	1069.40	270.0	1.31	123.6
7404	1069.40	292.5	1.82	147.8
7401	1069.40	337.5	2.94	200.4
6395	1074.40	36.0	4.42	248.7
56282	1080.05	32.5	3.21	210.6
7420	1102.62	0.0	6.78	417.4
6429	1102.62	19.0	4.72	321.8
6427	1102.62	29.0	2.09	197.7
6424	1102.62	37.7	4.72	266.8
7429	1102.62	180.0	2.25	129.9
7427	1102.62	225.0	2.48	162.7
7426	1102.62	247.5	1.52	129.3
7425	1102.62	270.0	1.30	123.7
7424	1102.62	292.5	1.64	137.5
7422	1102.62	315.0	4.42	231.8
7421	1102.62	337.5	3.77	245.2
6286	1111.20	23.5	5.09	313.1
1100	1111.85	343.0	4.64	321.6
1107	1111.85	348.0	3.76	286.9
1101	1121.08	343.0	7.08	410.8
1108	1121.08	348.0	5.55	369.1
7430	1123.15	0.0	8.36	447.2
7439	1123.15	180.0	2.24	129.2
7437	1123.15	225.0	2.22	156.9
7436	1123.15	247.5	1.50	129.1
7435	1123.15	270.0	1.30	124.1
7434	1123.15	292.5	1.55	134.5
7431	1123.15	337.5	4.35	260.1

TABLE 4 ET DESIGN ENVIRONMENTS - LH_2 TANK ACREAGE

BODY PT. NUMBER	COORDINATES X_T	θ_T	RI IVBC-3 QRATE	QLOAD
56283	1124.50	32.5	4.89	276.1
7432	1132.15	315.0	6.25	296.6
7440	1137.29	0.0	6.47	406.4
7449	1137.29	180.0	1.10	101.9
7447	1137.29	225.0	1.23	108.8
7446	1137.29	247.5	1.19	107.1
7445	1137.29	270.0	1.07	102.5
7444	1137.29	292.5	1.14	104.5
7442	1137.29	315.0	2.41	176.2
7441	1137.29	337.5	3.33	240.5
1115	1139.53	12.0	6.72	418.6
1122	1139.53	12.0	6.32	354.7
1105	1139.53	343.0	5.30	371.1
1110	1139.53	348.0	4.78	337.1
56505	1149.99	32.5	8.45	399.0
50108	1151.80	30.9	2.93	215.6
50109	1151.80	30.9	3.04	223.9
50111	1151.80	30.9	2.05	153.4
7450	1167.21	0.0	4.26	312.9
7459	1167.21	180.0	1.72	112.2
7457	1167.21	225.0	1.74	128.3
7455	1167.21	270.0	1.06	98.0
7452	1167.21	315.0	2.16	163.7
7451	1167.21	337.5	2.89	232.2
7470	1201.51	0.0	2.85	208.7
7475	1201.51	270.0	1.66	124.0
56515	1204.74	32.5	11.63	573.8
7479	1209.51	180.0	1.84	111.6
7480	1229.96	0.0	3.65	219.2
6489	1229.96	19.0	4.85	271.7
7489	1229.96	180.0	1.88	112.9
7485	1229.96	260.0	1.66	123.4
56525	1269.24	32.5	10.43	554.3
50308	1270.20	30.9	5.19	342.0
50309	1270.20	30.9	5.50	361.4
50311	1270.20	30.9	4.15	277.4
7520	1297.83	0.0	3.53	204.7
7529	1297.83	180.0	1.91	112.4
7525	1297.83	270.0	1.64	121.5
6587	1334.37	23.5	1.23	149.4
6588	1358.90	23.5	1.59	172.2
7550	1359.15	0.0	2.02	155.4
6555	1359.15	40.0	1.65	118.9
7559	1359.15	180.0	1.38	105.8
7557	1359.15	225.0	1.14	95.3

TABLE 4 (Continued)

7556	1359.15	247.5	1.14	95.2
7555	1359.15	270.0	1.63	120.4
7554	1359.15	292.5	1.23	100.4
7552	1359.15	315.0	1.76	134.4
7551	1359.15	337.5	1.31	127.4
6589	1366.38	23.5	2.24	211.0
6590	1371.99	23.5	2.64	241.7
6593	1375.26	23.5	3.18	270.1
6594	1380.41	23.5	1.09	139.2
6595	1383.91	23.5	1.19	140.7
6596	1387.65	23.5	1.19	137.6
50508	1399.40	30.9	4.21	303.5
50509	1399.40	30.9	4.50	323.2
50511	1399.40	30.9	2.94	218.7
6597	1401.00	23.5	0.94	118.8
7620	1486.49	0.0	2.67	186.6
7629	1486.49	180.0	2.00	112.5
7625	1486.49	270.0	2.47	147.0
56534	1591.74	32.5	6.11	401.2
50808	1593.20	30.9	1.77	178.5
50809	1593.20	30.9	2.15	199.0
50811	1593.20	30.9	0.93	105.8
56535	1597.19	32.5	4.21	210.7
7690	1615.67	0.0	2.04	154.3
6699	1615.67	19.0	3.32	195.7
7699	1615.67	180.0	1.84	119.8
7697	1615.67	225.0	1.20	97.6
7696	1615.67	247.5	1.14	96.7
7695	1615.67	270.0	2.04	137.3
7694	1615.67	292.5	1.50	117.1
7692	1615.67	315.0	1.44	122.6
7691	1615.67	337.5	1.70	126.4
6603	1618.69	23.5	2.60	213.7
6606	1621.96	23.5	3.06	239.4
7760	1743.02	0.0	1.34	126.5
7769	1743.02	180.0	1.73	113.6
7767	1743.02	225.0	1.61	103.3
7766	1743.02	247.5	1.22	98.6
7764	1743.02	292.5	1.87	125.6
7762	1743.02	315.0	1.43	110.5
7761	1743.02	337.5	1.15	106.6
1401	1822.38	309.4	2.63	214.9
6614	1865.39	23.5	2.47	147.9
1404	1868.51	309.4	4.73	386.0
6617	1868.66	23.5	3.39	197.3
7830	1872.20	0.0	2.49	163.9
7839	1872.20	180.0	1.35	100.0
7837	1872.20	225.0	1.38	107.6
7836	1872.20	247.5	1.36	110.8

TABLE 4 (Continued)

7835	1872.20	270.0	3.15	164.2
7834	1872.20	292.5	4.24	203.9
7832	1872.20	315.0	1.89	140.9
7831	1872.20	337.5	1.87	133.5
7850	1898.04	0.0	2.77	189.1
7859	1898.04	180.0	1.53	95.8
7855	1898.04	270.0	1.99	147.6
7852	1898.04	315.0	2.50	189.4
56565	1914.24	32.5	9.89	494.0
1406	1914.65	304.0	5.39	305.3
1409	1914.65	315.0	3.07	225.9
51308	1916.00	30.9	2.14	177.2
51309	1916.00	30.9	2.31	189.6
51311	1916.00	30.9	1.57	129.9
1414	1936.79	330.2	3.51	222.4
6632	1955.30	23.5	1.56	140.6
6633	1962.78	23.5	2.20	166.4
6634	1968.39	23.5	2.70	194.9
6637	1971.66	23.5	3.81	260.0
6638	1976.81	23.5	1.11	112.3
56575	1978.74	32.5	9.39	460.9
6639	1980.31	23.5	1.03	114.5
6640	1984.05	23.5	0.99	111.8
6909	1999.54	19.0	2.47	189.4
51608	2028.00	30.9	7.02	436.9
51609	2028.00	30.9	7.41	460.2
50111	2028.00	30.9	2.05	153.4
1021	2031.65	289.5	5.26	311.5
1300	2032.00	355.0	12.58	533.8
6929	2036.45	19.0	11.14	569.8
7920	2036.46	0.0	8.73	432.6
7929	2036.46	180.0	1.41	95.1
7925	2036.46	270.0	4.19	214.6
7922	2036.46	315.0	2.68	190.2
7921	2036.46	337.5	6.03	281.3
1041	2040.75	250.5	3.28	203.3
1023	2048.45	289.5	7.71	352.5
1043	2048.75	250.5	7.82	331.0
1025	2052.65	289.5	9.35	520.9
1205	2053.50	312.6	8.87	541.9
1303	2053.50	355.0	13.81	597.8
1046	2053.75	250.5	13.24	501.4
7930	2058.00	0.0	4.77	252.9
7939	2058.00	180.0	1.23	93.9
7937	2058.00	225.0	2.16	143.1
1054	2058.00	247.0	6.49	311.7
7935	2058.00	270.0	6.58	242.4
1032	2058.00	283.9	8.89	486.6
1211	2058.00	319.4	7.99	423.2

TABLE 4 (Concluded)

7931	2058.00	337.5	4.24	192.6
1307	2058.00	357.1	9.78	517.9
1309	2058.00	358.8	9.80	517.0
1704	2058.60	340.0	5.27	320.7
1047	2063.25	250.5	3.80	214.8
1705	2063.60	340.0	9.65	444.0
1206	2064.00	312.6	6.40	272.1
1305	2064.50	355.0	12.55	533.0
1026	2065.45	289.5	5.50	258.5
1306	2067.50	355.0	12.75	538.0
1207	2072.00	312.6	6.60	273.6
1049	2075.25	250.5	5.68	250.4
1028	2075.95	289.5	5.98	272.0
1050	2083.25	250.5	4.63	267.9
1712	2084.40	343.8	4.69	422.4
1713	2084.40	344.5	6.14	383.9
1715	2084.40	346.3	5.09	324.1
1716	2084.40	350.5	3.63	234.5

TABLE 5 ET DESIGN ENVIRONMENTS - NOSE CONE PROTUBERANCES

BODY PT.	COORDINATES		LOCATION DESCRIPTION	RI IVBC-3	
NUMBER	X_T	T		QRATE	QLOAD
60109	353.00	31.5	FAIRING FWD.	28.41	1900.4
60203	357.00	9.5	FAIRING SIDE FACE	22.39	1635.1
60209	357.00	31.5	FAIRING FWD. FACE	26.16	1669.7
60303	364.00	9.5	FAIRING SIDE FACE	19.46	1389.2
80000	364.00	22.0	TUMBLE VALVE TOP	10.97	927.2
80002	364.00	22.0	TUMBLE VALVE SIDE	6.87	678.2
80003	364.00	22.0	TUMBLE VALVE BACK	6.87	678.2
80004	364.00	22.0	TUMBLE VALVE COVER	10.97	933.0
60309	364.00	31.5	FAIRING TOP FACE	22.97	1544.3
60320	364.00	313.5	VENT LOUVER FRAME	16.61	1335.8
60319	365.00	31.5	FAIRING LIP BACK FACE	3.03	300.9
60324	365.00	313.5	VENT LOUVER	1.65	178.2
60326	365.00	313.5	VENT LOUVER	1.65	178.2
60325	366.00	313.5	VENT LOUVER	16.49	1323.5
60327	366.00	313.5	VENT LOUVER	1.65	178.5
60321	368.00	328.6	VENT LOUVER FRAME	13.59	1109.6
60310	370.04	30.9	BRACKET FORWARD FACE	18.15	1434.3
60322	371.00	313.5	VENT LOUVER FRAME	14.43	1124.5
60323	372.00	313.5	VENT LOUVER FRAME	10.33	914.4

TABLE 6 ET DESIGN ENVIRONMENTS - LO_2 TANK PROTUBERANCES

BODY PT.	COORDINATES		LOCATION DESCRIPTION	RI IVBC-3	
NUMBER	X_T	θ_T		QRATE	QLOAD
82994	375.10	31.5	CABLE TRAY TOP2	15.24	1150.5
80115	394.75	30.9	GO2 P/L FLANGE	26.29	1819.9
60420	402.84	31.5	BRACKET FWD FACE	30.31	2054.7
82094	421.30	31.5	C/T & P/L TOP & SIDES	14.29	984.3
60820	438.00	31.5	BRACKET FWD FACE	24.24	1838.9
82194	453.60	31.5	C/T & P/L TOP & SIDES	11.13	832.2
82294	467.40	31.5	C/T & P/L TOP & SIDES	7.90	631.6
60920	474.66	31.5	BRACKET FWD FACE	20.26	1440.6
61020	512.62	31.5	BRACKET FWD FACE	18.40	1324.7
82394	513.60	31.5	C/T & P/L TOP & SIDES	7.41	560.3
61120	558.87	31.5	BRACKET FWD FACE	13.91	994.6
61220	592.00	31.5	BRACKET FWD FACE	11.27	840.8
82494	606.00	31.5	C/T & P/L TOP & SIDES	5.47	406.4
80119	610.51	30.5	GO2 P/L FLANGE	9.17	715.5
61420	675.48	31.5	BRACKET FWD FACE	7.36	566.7
82594	698.00	31.5	C/T & P/L TOP & SIDES	3.58	277.7
82694	751.50	31.5	C/T & P/L TOP & SIDES	2.73	219.7
61620	758.85	31.5	BRACKET FWD FACE	4.85	375.4
81609	759.20	31.5	C/T WITH ORDNANCE	5.61	398.4
81809	773.70	31.5	C/T WITH ORDNANCE	2.60	197.2
62120	826.56	31.5	BRACKET FWD FACE	4.78	368.4
80123	849.00	30.5	GO2 P/L FLANGE	4.76	383.9

TABLE 7 ET DESIGN ENVIRONMENTS - INTERTANK PROTUBERANCES

BODY PT.	COORDINATES		LOCATION DESCRIPTION	RI IVBC-3	
NUMBER	X_T	θ_T		QRATE	QLOAD
5282	852.80	30.9	GO2 P/L	2.42	182.8
80165	861.90	30.9	BRACKET FWD. FACE	4.63	348.2
80166	861.90	30.9	BRACKET BACK FACE	1.78	142.2
80167	861.90	30.9	BRACKET SIDE FACE	1.61	141.2
5416	879.00	141.3	RANGE S. ANT. FWD. FACE	3.94	251.5
5417	884.00	141.3	RANGE S. ANT. TOP FACE	2.30	185.1
5302	884.85	30.9	GO2 P/L	2.34	181.4
5418	887.00	141.3	RANGE S. ANT. BACK FACE	1.38	117.1
80168	895.90	30.9	BRACKET FWD. FACE	4.05	293.7
80169	895.90	30.9	BRACKET BACK FACE	1.67	139.5
5398	899.0	32.6	C/T TOP LO2	2.60	196.9
5397	908.10	35.0	C/T FAIRING AFT FACE	1.08	100.3
80147	922.75	30.9	BRACKET FWD. FACE	4.59	323.5
80148	922.75	30.9	BRACKET BACK FACE	1.85	146.4
5322	929.10	30.9	GO2 P/L	3.20	222.7
80150	949.75	30.9	BRACKET FWD. FACE	4.68	338.4
80151	949.75	30.9	BRACKET BACK FACE	1.82	145.9
80110	959.26	270.0	BOLTCATCHER STAG PT.	26.51	1381.2
80037	971.93	279.0	C/T-SRB FWD. ATTACH	17.14	850.3
5352	973.43	30.9	GO2 P/L	3.31	231.2
80175	976.80	274.0	C/T-SRB FWD. ATTACH	8.89	528.7
80174	976.80	275.0	C/T-SRB FWD. ATTACH	20.22	964.0
80153	980.00	30.9	BRACKET FWD. FACE	4.33	307.9
80154	980.00	30.9	BRACKET BACK FACE	2.35	179.2
5311	998.08	23.1	LO2 FEEDLINE FRNG FRT	13.11	676.4
5351	998.08	23.1	LO2 FEEDLINE FRNG SIDE	7.88	436.2
5362	1006.65	30.9	GO2 P/L	3.41	233.3
966	1012.92	240.0	GH2 VENT DISCONNECT	7.57	431.8
968	1012.92	240.0	CARRIER PLATE	3.10	175.8
5321	1026.12	23.1	LO2 FEEDLINE TOP FRT	1.21	116.1
5382	1038.03	30.9	GO2 P/L	3.85	251.3
80156	1049.00	30.9	BRACKET FWD. FACE	3.63	265.1
80157	1049.00	30.9	BRACKET BACK FACE	2.61	189.0
80158	1049.00	30.9	BRACKET SIDE FACE	2.63	191.9
55305	1063.74	32.5	GH2 P/L FAIRING	4.67	274.4
5401	1069.40	23.5	LO2 FEEDLINE TOP FRT	2.34	190.9
5424	1074.40	37.7	C/T FAIRING-FWD FACE	4.67	274.4
5402	1080.05	30.9	GO2 P/L	4.12	295.1
55403	1080.05	32.5	GH2 P/L	5.12	385.3
80162	1082.00	30.9	BRACKET FWD. FACE	7.52	411.3
80163	1082.00	30.9	BRACKET BACK FACE	5.02	290.1
80164	1082.00	30.9	BRACKET SIDE FACE	5.02	290.1
80127	1088.00	30.9	GO2 P/L FLANGE	8.41	552.6

TABLE 7 (Concluded)

80045	1088.00	330.0	GH2 P/L FLANGE	8.41	553.0
5421	1102.62	23.5	LO2 FEEDLINE TOP FRT	2.98	245.6
5422	1102.62	30.9	GO2 P/L	5.33	309.4
5009	1118.68	23.1	LO2 FEEDLINE TOP FRT	3.11	294.9
200	1120.90	----	ET/ORB FWD ATT STRUT	11.99	1105.3
5431	1123.15	23.1	LO2 FEEDLINE TOP FR	2.91	272.5

TABLE 8 ET DESIGN ENVIRONMENTS - LH_2 TANK PROTUBERANCES

BODY PT. NUMBER	COORDINATES X_T	θ_T	LOCATION DESCRIPTION	RIVBC-3 QRATE	QLOAD
5010	1124.29	23.1	LO2 FEEDLINE TOP-LH2	4.74	337.7
5015	1127.56	23.1	LO2 FEEDLINE TOP-LH2	7.23	477.3
202	1129.90	----	ET/ORB FWD ATT STRUT-BACK	1.92	186.5
900	1129.90	15.0	ET/ORB FWD ATT FTG-FRONT	10.22	722.2
900	1129.90	345.0	ET/ORB FWD ATT FTG-FRONT	10.22	722.2
934	1129.90	15.0	ET/ORB FWD ATT FTG-BACK	3.00	230.6
934	1129.90	345.0	ET/ORB FWD ATT FTG-BACK	3.00	230.6
1500	1129.90	23.1	LO2 FEEDLINE BRACKET-FRT	11.65	754.3
1504	1129.90	23.1	LO2 FEEDLINE BRACKET-BACK	6.21	425.9
80034	1129.90	0.0	ET/ORB YOKE FTG-FRONT	17.64	1170.5
80035	1129.90	0.0	ET/ORB YOKE FTG-BACK	11.74	819.5
5432	1133.80	30.9	GO2 P/L	1.94	152.0
5434	1133.80	35.0	GO2 P/L	4.06	244.5
5018	1139.95	23.1	LO2 FEEDLINE TOP	3.33	262.7
5054	1150.89	35.0	C/T TOP,SIDES,BOTTOM	12.33	842.4
50101	1151.80	30.9	BLUE STREAK RAMP-FRT FACE	4.42	300.2
50102	1151.80	30.9	BLUE STREAK RMP-SIDE INBD	4.42	300.2
50103	1151.80	30.9	BLUE STREAK RMP-SIDE OTBD	4.42	300.2
50104	1151.80	30.9	BLUE STREAK RMP-SIDE INBD	4.06	277.0
50106	1151.80	30.9	BLUE STREAK RMP-TOP FACE	3.49	239.4
50107	1151.80	30.9	BLUE STREAK RMP-BACK FACE	2.65	184.5
1560	1151.84	30.9	BRACKET FRONT FACE	8.76	540.5
1561	1151.84	30.9	BRACKET SIDE FACE	7.02	445.0
1564	1151.84	30.9	BRACKET BACK FACE	3.77	255.7
5114	1204.74	35.0	C/T TOP, SIDES,BOTTOM	11.48	601.3
5482	1229.96	31.5	GO2 P/L	3.12	209.4
55483	1229.96	32.5	GH2 P/L	3.24	230.6
5484	1229.96	35.0	C/T TOP,SIDES,BOTTOM	3.78	243.2
5174	1269.24	35.0	C/T TOP,SIDES,BOTTOM	8.94	565.4
1580	1270.20	30.9	BRACKET FRONT FACE	11.11	700.7
50301	1270.20	30.9	BLUE STREAK RAMP-FRT FACE	6.07	411.8
50302	1270.20	30.9	BLUE STREAK RMP-SIDE INBD	6.07	411.8
50303	1270.20	30.9	BLUE STREAK RMP-SIDE OTBD	6.07	411.8
50304	1270.20	30.9	BLUE STREAK RMP-SIDE INBD	5.59	381.6
50306	1270.20	30.9	BLUE STREAK RMP-TOP FACE	4.86	336.4
50307	1270.20	30.9	BLUE STREAK RMP-BACK FACE	3.58	257.3
1581	1270.30	30.9	BRACKET SIDE FACE	9.97	678.7
1584	1271.30	30.9	BRACKET BACK FACE	4.77	327.7
80131	1327.00	30.9	GO2 P/L FLANGE	10.20	641.6
80049	1327.00	32.5	GH2 P/L FLANGE	10.70	677.9
5551	1359.15	23.5	LO2 FEEDLINE TOP	4.56	316.7
5552	1359.15	30.9	GO2 P/L	3.37	230.7
5045	1375.26	23.1	LO2 FEEDLINE TOP	8.79	595.8
1510	1377.60	23.1	LO2 FEEDLINE BRKT-FRT	9.43	722.6

TABLE 8 (Continued)

1514	1377.60	23.1	LO2 FEEDLINE BRKT-BACK	4.05	337.4
5048	1387.65	23.1	LO2 FEEDLINE TOP	2.91	230.0
50501	1399.40	30.9	BLUE STREAK RAMP-FRT FACE	5.48	396.4
50502	1399.40	30.9	BLUE STREAK RMP-SIDE INBD	5.32	385.8
50503	1399.40	30.9	BLUE STREAK RMP-SIDE OTBD	5.32	385.8
50504	1399.40	30.9	BLUE STREAK RMP-SIDE INBD	5.04	368.2
50506	1399.40	30.9	BLUE STREAK RMP-TOP FACE	4.39	325.9
50507	1399.40	30.9	BLUE STREAK RMP-BACK FACE	3.18	248.4
5621	1486.49	23.1	LO2 FEEDLINE TOP	2.28	172.6
5622	1486.49	30.9	GO2 P/L	2.30	194.5
55623	1486.49	32.5	GH2 P/L	2.15	175.3
80135	1566.00	30.9	GO2 P/L FLANGE - FRONT	8.36	521.4
80137	1566.00	30.9	GO2 P/L FLANGE - SIDE	6.75	456.1
80053	1566.00	32.5	GO2 P/L FLANGE - FRONT	8.56	569.0
5234	1591.74	35.0	C/T TOP,SIDES,BOTTOM	7.71	427.0
50801	1593.20	30.9	BLUE STREAK RAMP-FRT FACE	2.88	296.5
50802	1593.20	30.9	BLUE STREAK RMP-SIDE INBD	2.76	244.6
50803	1593.20	30.9	BLUE STREAK RMP-SIDE OTBD	2.76	243.0
50804	1593.20	30.9	BLUE STREAK RMP-SIDE INBD	2.15	199.0
50806	1593.20	30.9	BLUE STREAK RMP-TOP FACE	1.53	165.2
50807	1593.20	30.9	BLUE STREAK RMP-BACK FACE	1.37	121.2
5068	1605.60	23.5	LO2 FEEDLINE TOP	5.76	369.2
5692	1615.67	30.9	GO2 P/L	2.03	161.9
5694	1615.67	35.0	C/T TOP,SIDES,BOTTOM	2.23	175.3
1520	1623.80	23.1	LO2 FEEDLINE BRKT-FRT	13.63	855.3
1524	1623.80	23.1	LO2 FEEDLINE BRKT-BACK	5.86	395.0
5079	1647.70	23.1	LO2 FEEDLINE TOP	2.36	168.9
5761	1743.02	23.1	LO2 FEEDLINE TOP	2.14	216.8
5762	1743.02	30.9	GO2 P/L	1.72	161.8
80057	1805.00	32.5	GO2 P/L FLANGE	10.74	603.9
5294	1849.74	35.0	C/T TOP,SIDES,BOTTOM	6.89	402.1
1600	1850.60	30.9	BRACKET FRONT FACE	10.30	581.1
1601	1851.60	30.9	BRACKET SIDE FACE-INBD	8.23	479.0
1604	1852.60	30.9	BRACKET BACK FACE	5.50	331.4
5099	1859.78	23.1	LO2 FEEDLINE TOP	3.41	296.1
5105	1868.66	23.1	LO2 FEEDLINE TOP	9.43	573.6
1530	1871.00	23.1	LO2 FEEDLINE BRKT-FRT	12.51	777.3
1534	1871.00	23.1	LO2 FEEDLINE BRKT-BACK	5.38	358.9
5832	1872.20	30.9	GO2 P/L	2.74	186.5
55833	1872.20	32.5	GH2 P/L	3.10	194.5
5834	1872.20	37.7	C/T TOP,SIDES,BOTTOM	3.56	215.6
5108	1881.05	23.1	LO2 FEEDLINE TOP	2.17	186.9
5354	1914.24	35.0	C/T TOP,SIDES,BOTTOM	9.15	477.3
51301	1916.00	30.9	BLUE STREAK RAMP-FRT FACE	3.57	262.8
51302	1916.00	30.9	BLUE STREAK RMP-SIDE INBD	2.70	220.1
51303	1916.00	30.9	BLUE STREAK RMP-SIDE OTBD	2.56	216.5
51304	1916.00	30.9	BLUE STREAK RMP-SIDE INBD	2.31	189.6
51306	1916.00	30.9	BLUE STREAK RMP-TOP FACE	1.78	157.9
51307	1916.00	30.9	BLUE STREAK RMP-BACK FACE	1.19	110.4

TABLE 8 (Continued)

5128	1955.30	23.1	LO2 FEEDLINE TOP	6.83	491.0
352	1970.00	----	ET/ORB THT STRT STAG LINE	5.59	501.1
1540	1973.50	23.1	LO2 FEEDLINE BRKT-FRT	15.09	775.6
1544	1973.50	23.1	LO2 FEEDLINE BRKT-BACK	6.49	357.8
5414	1978.74	35.0	C/T TOP,SIDES,BOTTOM	9.47	490.6
5137	1980.31	23.1	LO2 FEEDLINE TOP	3.51	247.9
1620	1980.80	30.9	BRACKET FRONT FACE	10.65	566.3
1621	1980.80	30.9	BRACKET SIDE FACE-INBD	8.52	467.8
1624	1980.80	30.9	BRACKET BACK FACE	4.58	267.9
5901	1999.54	23.1	LO2 FEEDLINE TOP	2.45	188.6
5902	1999.54	30.9	GO2 P/L	3.67	222.9
5158	2024.09	23.1	LO2 FEEDLINE TOP	7.45	482.0
51601	2028.00	30.9	BLUE STREAK RAMP-FRT FACE	8.51	513.7
51602	2028.00	30.9	BLUE STREAK RMP-SIDE INBD	8.71	525.5
51603	2028.00	30.9	BLUE STREAK RMP-SIDE OTBD	8.34	503.7
51604	2028.00	30.9	BLUE STREAK RMP-SIDE INBD	7.91	479.0
51606	2028.00	30.9	BLUE STREAK RMP-TOP FACE	6.85	417.0
51607	2028.00	30.9	BLUE STREAK RMP-BACK FACE	5.36	330.3
1550	2035.31	23.1	LO2 FEEDLINE BRKT-FWD FACE	15.24	806.8
1554	2035.31	23.1	LO2 FEEDLINE BRKT-BACK FACE	6.55	371.3
5922	2036.45	30.9	GO2 P/L	4.13	284.3
55923	2036.45	32.5	GH2 P/L	4.98	326.3
5924	2036.45	35.0	C/T TOP,SIDES,BOTTOM	5.62	319.6
5165	2038.12	23.1	LO2 FEEDLINE - TOP	3.27	224.5
83000	2043.00	----	GH2 P/L FAIRING-@XBEAM(0°)	13.26	750.8
83001	2043.00	----	GH2 P/L FAIRING-@XBEAM(45°)	13.26	750.8
83002	2043.00	----	GH2 P/L FAIRING-@XBEAM(90°)	9.29	581.8
80143	2044.00	30.9	GO2 P/L FLANGE FRT FACE	9.90	545.8
80043	2044.00	32.5	GH2 P/L FLANGE FRT FACE	10.22	553.8
80005	2058.00	289.41	ET/SRB UPPER FTG. FAIRING	13.38	745.8
560	2058.00	----	ET/ORB SWAY STRUT-MID FWD	10.76	996.4
790	2058.00	----	C/T FWD FACE-BEHIND FOAM RMP	6.78	798.9
979	2071.50	----	BRKT-LO2 FDLINE/CROSSBM-OTBD	1.86	118.3
980	2071.50	----	BRKT-LO2 FDLINE/CROSSBM-INBD	1.86	118.3
601	-----	----	CROSS BEAM FRONT	13.26	752.0
650	-----	----	CROSS BEAM UPPER	9.29	583.0
690	-----	----	CROSS BEAM FRONT	13.26	752.0
738	-----	----	LH2 FEEDLINE-FWD FACE	4.76	595.0
752	-----	----	LO2 PRESS. LINE	14.66	1546.7
772	-----	----	LH2 RECIRC. LINE-FWD FACE	10.33	1124.0
785	-----	----	CABLE TRAY FRONT	12.81	774.6
788	-----	----	CABLE TRAY FRONT	9.29	582.9
791	-----	----	CONDUIT OUTBOARD	1.09	139.5
911	-----	----	ET/SRB AFT ATT STRUT FTG	5.09	336.0
955	-----	----	ET/ORB VERT STRUT FTG	3.52	238.1
961	-----	----	ET/ORB SWAY STRUT FTG	8.96	606.0
963	-----	----	ET/ORB SWAY STRUT FTG	6.92	470.8
981	-----	----	LH2 UMBILICAL PLATE	3.35	201.4
982	-----	----	LH2 UMBILICAL PLATE	3.35	201.4

TABLE 8 (Concluded)

985	-----	----	LH2 UMBILICAL PLATE	3.35	201.4
986	-----	----	LH2 F/L FTG	1.86	118.3
988	-----	----	LH2 F/L FTG	1.86	118.3
991	-----	----	LO2 UMBILICAL PLATE	3.35	201.4
992	-----	----	LO2 UMBILICAL PLATE	3.35	201.4
995	-----	----	LO2 UMBILICAL PLATE	3.35	201.4
80008	-----	----	C/T TOP @ ET/ORB ELECT I/F	1.86	118.3
80009	-----	----	C/T TOP @ ET/ORB ELECT I/F	1.86	118.3
80010	-----	----	C/T BOT. @ ET/ORB ELECT I/F	5.57	354.6
80011	-----	----	C/T FWD @ ET/ORB ELECT I/F	13.26	750.7
80012	-----	----	C/T BACK @ ET/ORB ELECT I/F	3.35	201.4
80013	-----	----	He INJECT BOX ON AFT C/T	13.26	752.0
80016	-----	----	C/T FWD @ ET/ORB ELECT I/F	13.26	750.7
80017	-----	----	C/T BACK @ ET/ORB ELECT I/F	3.35	201.4
80018	-----	----	CROSSBEAM CABLE TOP EDGE	13.26	752.1
82666	-----	----	I/T DOOR HANDLE	3.42	249.5
82999	-----	----	I/T DOOR HANDLE	2.34	172.3

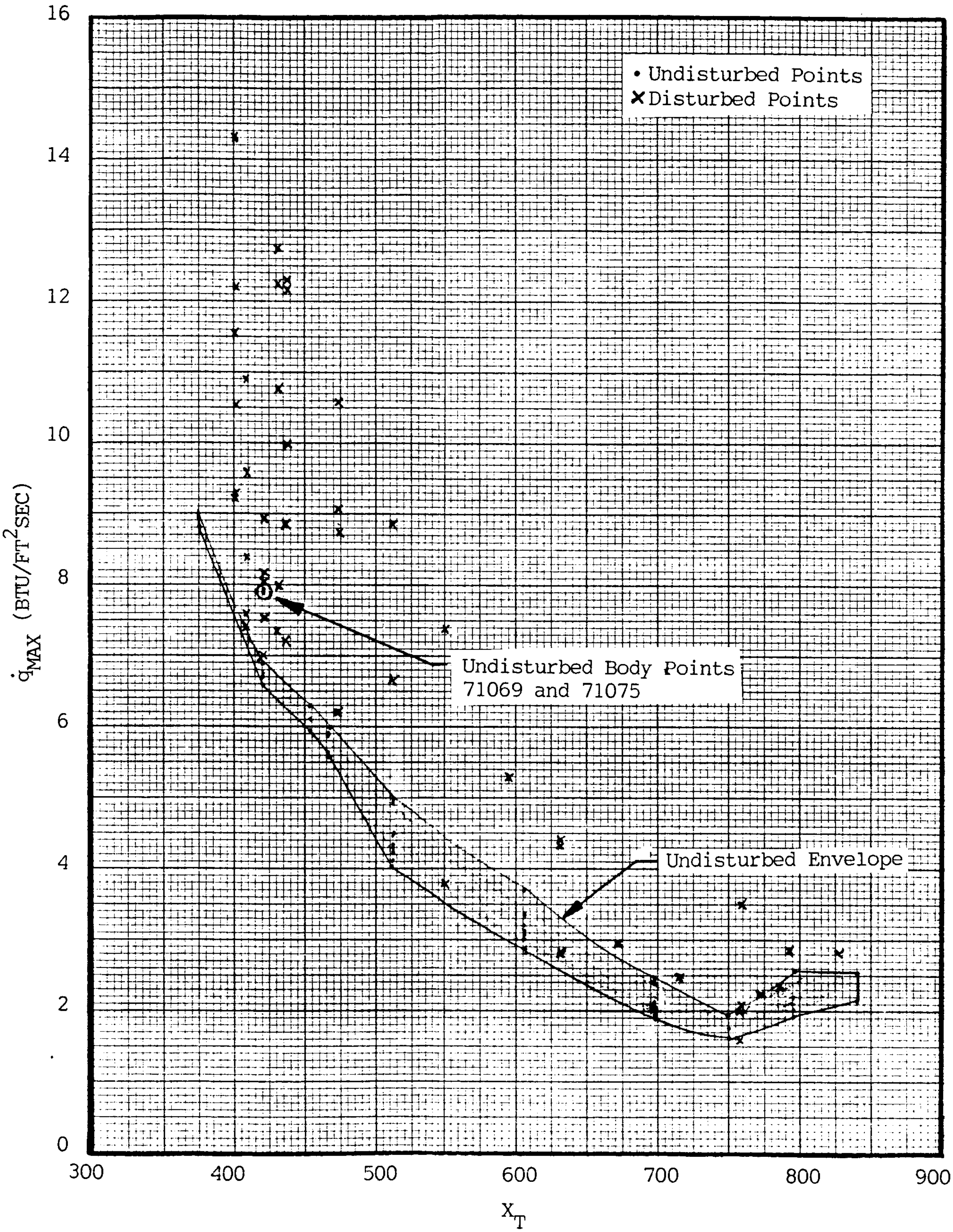


Fig. 8 LO_2 Tank Maximum Heating Rates

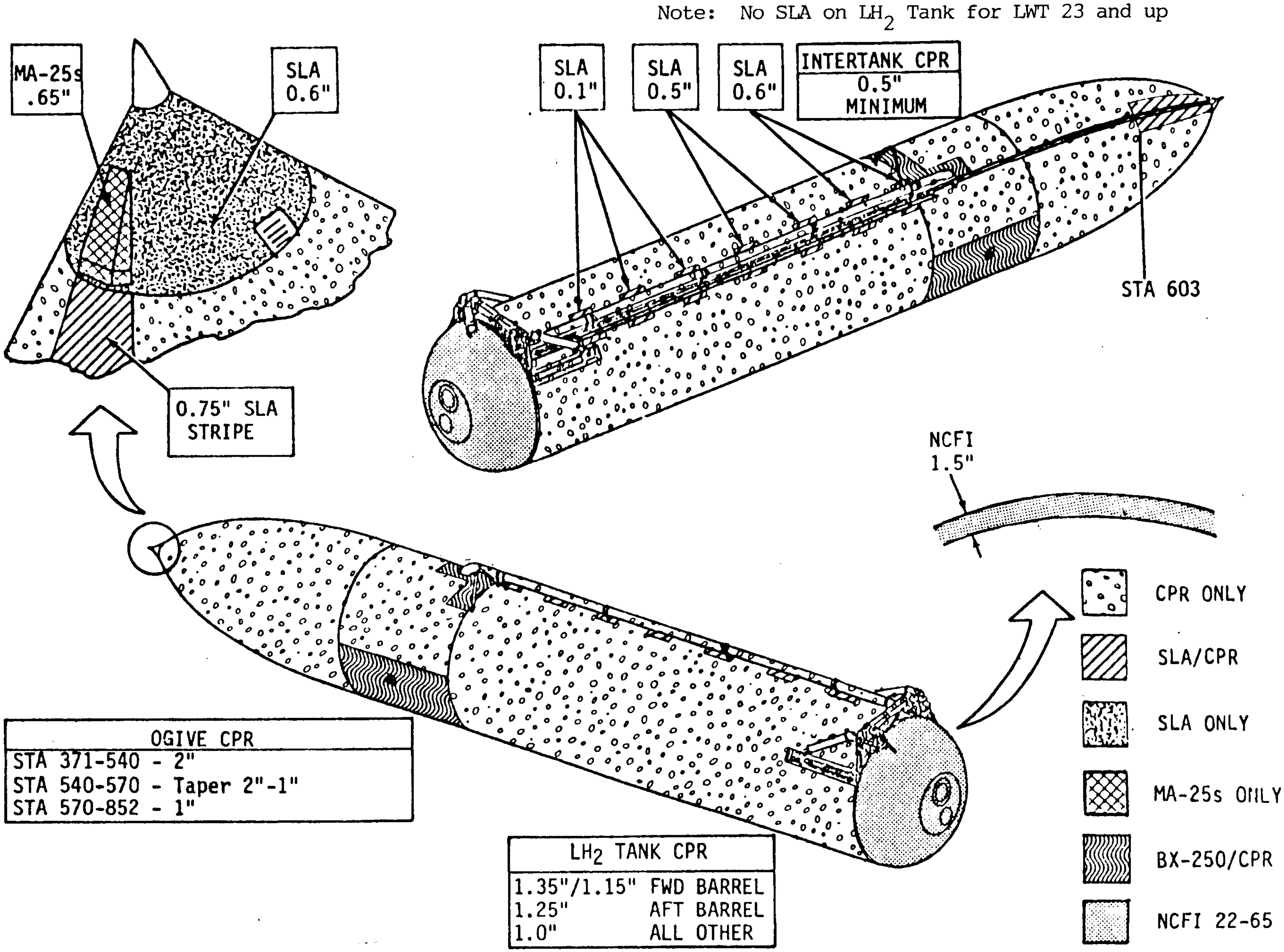
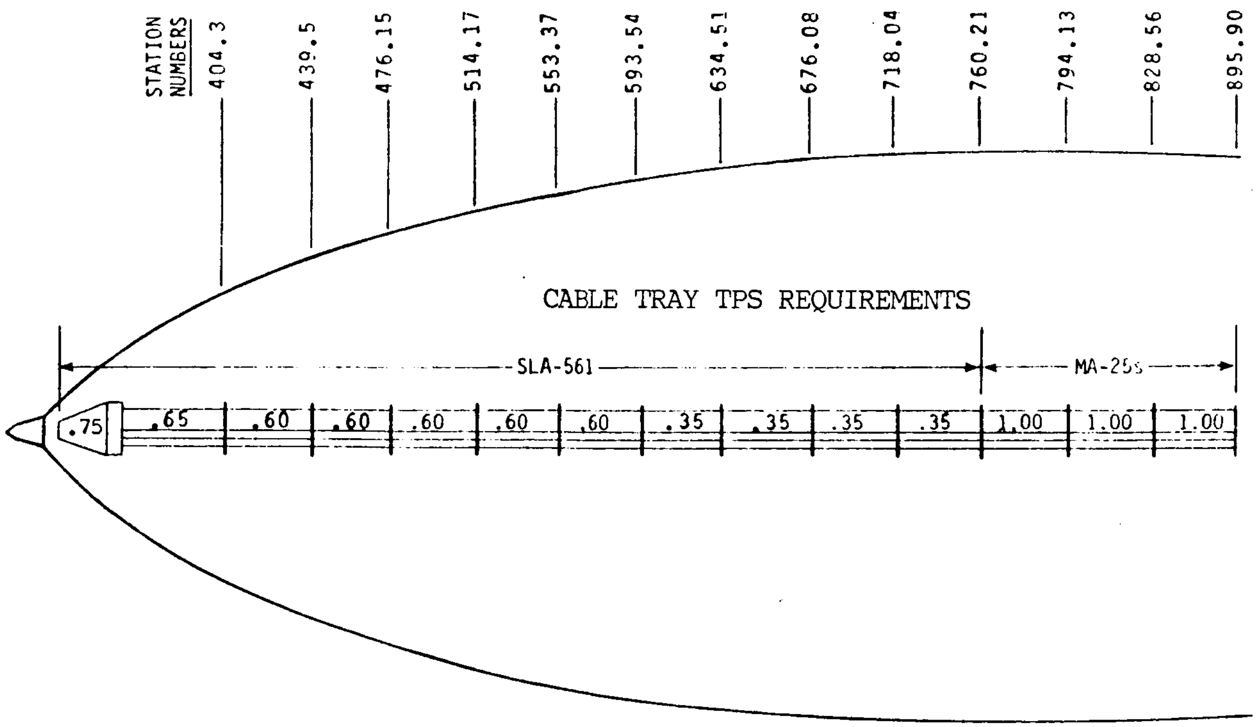


Fig. 9 TPS Configuration for ET Acreage through LWT 43



BRACKET TPS REQUIREMENTS

Station Number	TPS Material	Thickness Required (IN)
371	SLA-561	.50
404	MA-25s/SLA-561	.65/.35*
439	MA-25s/SLA-561	.65/.35*
476	MA-25s/SLA-561	.65/.35*
514	MA-25s/SLA-561	.65/.35*
553	SLA-561	.35
594	SLA-561	.25
635	SLA-561	.20
676	SLA-561	.10
718	SLA-561	.05
760	SLA-561	0
794	SLA-561	0
828	SLA-561	0

*.65 MA-25s on Shield, .35 SLA-561 on Phenolic Bracket

Fig. 10 LO_2 Tank Protuberance TPS Requirements

INTERTANK FAIRINGS TPS REQUIREMENTS

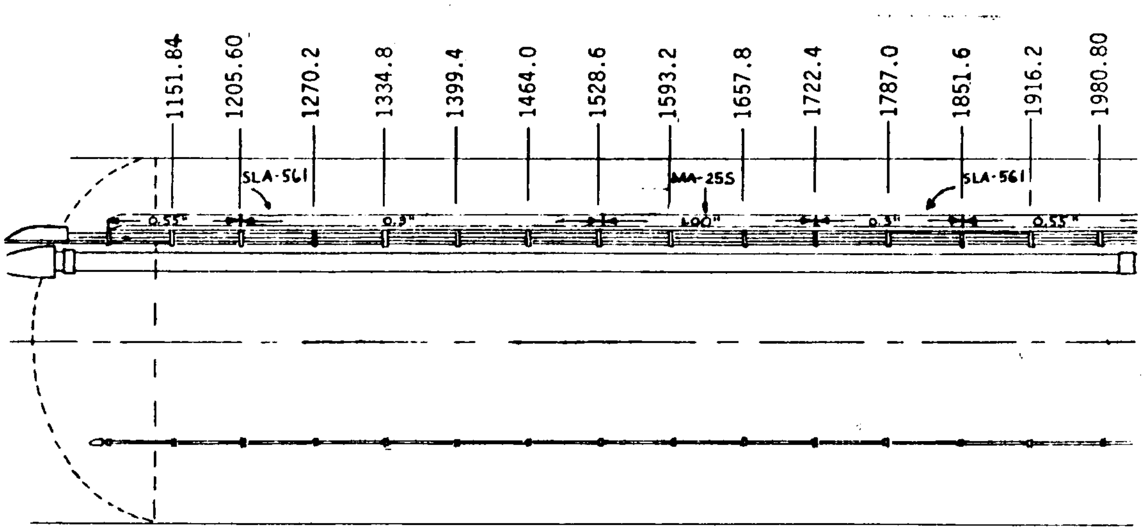
Fairings	SLA-561
LO2 Feedline	0.5"
GH2 Pressurization Line	.23"
Forward Electrical Conduit	0.05"
Aft Electrical Conduit	0.25"
RSS Fairing	0.60"
RSS I/T Tray	0.75"

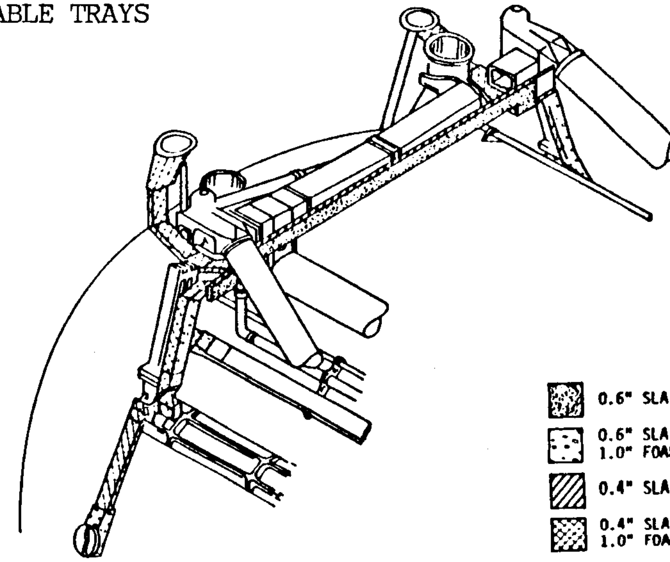
INTERTANK BRACKET TPS REQUIREMENTS

Station Number		Thickness Required (IN)
862	Press/Cable Tray	.40 (SLA)
897.1	Press/Cable Tray	.40
922.5	GO_2 Press Only	.40
949.75	GO_2 Press Only	.40
980.0	GO_2 Press Only	.40
1049	GO_2 Press Only	.40
1082	GO_2/GH_2 Press/ Cable Tray	.40

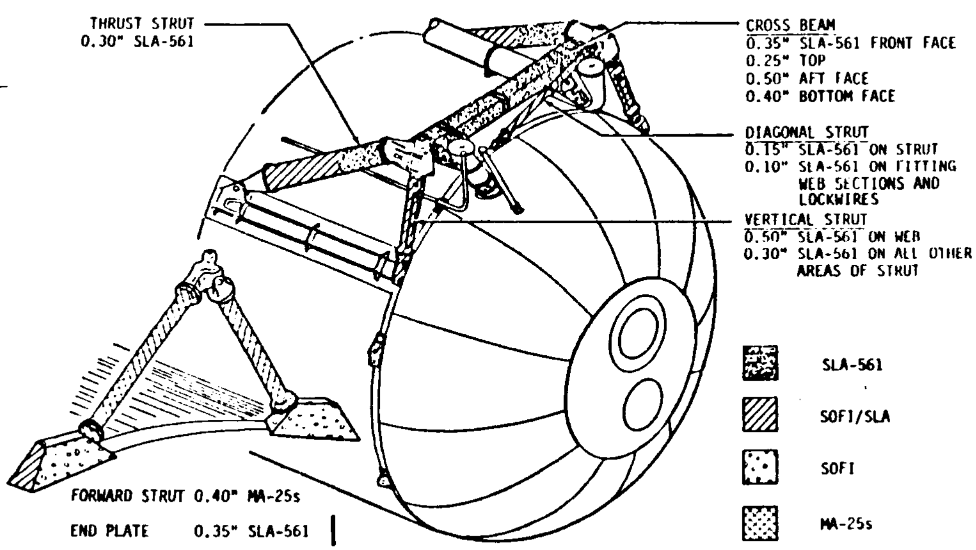
Fig. 11 Intertank Protuberance TPS Requirements

TPS REQUIREMENTS ON LH_2 TANK CABLE TRAYS





TPS REQUIREMENTS ON ATTACH STRUCTURE



TPS REQUIREMENTS ON GH_2 P/L FAIRING

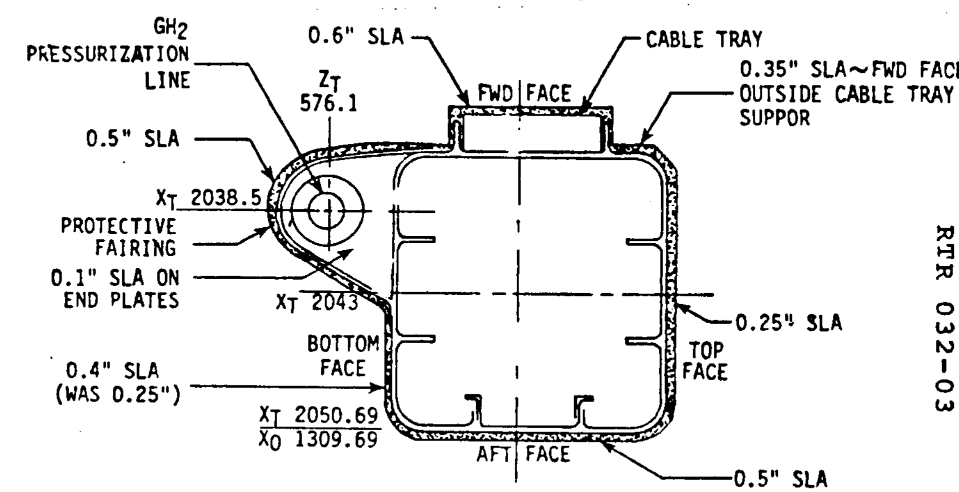


Fig. 12 TPS Requirements on LH_2 Tank Protuberances

Section 4.0

RTLS TRAJECTORY AND THERMAL ENVIRONMENTS

Thermal environments for 163 points on the ET were defined by RI for an RTLS abort event. The environments are based on a 1σ dispersed trajectory in the presence of December winds launched from the Western Test Range. A RTLS trajectory profile is shown in Figure 7 and this abort situation usually results from one or two engine failures prior to the AOA/RTLS mode boundary. The altitude and velocity profiles for the RTLS trajectory for which thermal environments were generated are shown in Figure 13. The angle of attack depicting the somersault maneuver is shown in Figure 14. Table 9 compares the RTLS environments with the current design. Table 10 gives those body points that the RTLS environment exceeds the current design.

TABLE 9 COMPARISON OF RTLS ABORT ENVIRONMENTS WITH DESIGN

BODY POINT	IVBC-3 DESIGN QMAX* BTU/FT^2SEC	IVBC-3 DESIGN QLOAD BTU/FT^2	RTLS QMAX* BTU/FT^2SEC	RTLS QLOAD BTU/FT^2
200	11.9861	1105.29	--------	-------
202	1.9178	186.49	--------	-------
352	5.5930	501.09	--------	-------
560	10.7587	996.39	--------	-------
601	13.2632	752.05	--------	-------
650	9.2881	583.01	--------	-------
690	13.2632	752.05	--------	-------
738	4.7599	594.95	--------	-------
752	14.6614	1546.67	--------	-------
772	10.3283	1124.01	--------	-------
785	12.8056	774.63	--------	-------
788	9.2881	582.88	--------	-------
790	6.7795	798.92	--------	-------
791	1.0885	139.52	--------	-------
900	10.2223	722.24	--------	-------
911	5.0948	336.01	--------	-------
934	2.9959	230.55	--------	-------
955	3.5227	238.13	--------	-------
961	8.9552	605.95	--------	-------
963	6.9168	470.83	--------	-------
966	7.5674	431.80	--------	-------
968	3.1025	175.80	--------	-------
979	1.8574	118.31	--------	-------
980	1.8574	118.29	--------	-------
981	3.3466	201.43	--------	-------
982	3.3466	201.43	--------	-------
985	3.3466	201.43	--------	-------
986	1.8574	118.31	--------	-------
988	1.8574	118.31	--------	-------
991	3.3466	201.43	--------	-------
992	3.3466	201.43	--------	-------
995	3.3466	201.43	--------	-------
1002	20.3152	953.57	--------	-------
1005	20.2903	889.42	--------	-------
1007	20.0050	887.35	--------	-------
1009	19.7165	876.91	--------	-------
1011	19.3634	856.51	--------	-------
1012	11.8056	512.22	--------	-------
1021	5.2570	311.50	--------	-------
1023	7.7127	352.47	--------	-------
1025	9.3500	520.88	--------	-------
1026	5.5034	258.54	--------	-------

* Denotes those RTLS environments that are higher than design

TABLE 9 (Continued)

1028	5.9769	271.98	--------	-------
1032	8.8893	486.58	--------	-------
1041	3.2799	203.30	--------	-------
1043	7.8249	330.98	--------	-------
1046	13.2432	501.43	--------	-------
1047	3.7986	214.82	--------	-------
1049	5.6808	250.37	--------	-------
1050	4.6298	267.86	--------	-------
1054	6.4907	311.72	--------	-------
1100	4.6449	321.61	--------	-------
1101	7.0773	410.79	--------	-------
1105	5.3011	371.13	--------	-------
1107	3.7606	286.90	--------	-------
1108	5.5479	369.12	--------	-------
1110	4.7774	337.10	--------	-------
1115	6.7241	418.60	--------	-------
1122	6.3227	354.73	--------	-------
1205	8.8673	541.86	--------	-------
1206	6.3970	272.10	--------	-------
1207	6.6042	273.57	--------	-------
1211	7.9886	423.23	--------	-------
1300	12.5759	533.82	--------	-------
1303	13.8119	597.82	--------	-------
1305	12.5461	533.03	--------	-------
1306	12.7491	537.96	--------	-------
1307	9.7794	517.89	--------	-------
1309	9.7996	516.99	--------	-------
1401	2.6327	214.85	--------	-------
1404	4.7280	385.97	--------	-------
1406	5.3891	305.32	--------	-------
1409	3.0738	225.94	--------	-------
1414	3.5098	222.37	--------	-------
1500	11.6515	754.32	--------	-------
1504	6.2126	425.90	--------	-------
1510	9.4285	722.58	--------	-------
1514	4.0545	337.42	--------	-------
1520	13.6306	855.27	--------	-------
1524	5.8613	395.01	--------	-------
1530	12.5057	777.33	--------	-------
1534	5.3820	358.93	--------	-------
1540	15.0868	775.62	--------	-------
1544	6.4867	357.84	--------	-------
1550	15.2381	806.82	--------	-------
1554	6.5524	371.28	--------	-------
1560	8.7596	540.48	--------	-------
1561	7.0224	445.05	--------	-------
1564	3.7659	255.66	--------	-------
1580	11.1071	700.67	--------	-------

TABLE 9 (Continued)

1581	9.9727	678.71	--------	-------
1584	4.7745	327.67	--------	-------
1600	10.3002	581.09	--------	-------
1601	8.2315	479.00	--------	-------
1604	5.4959	331.40	--------	-------
1620	10.6494	566.33	--------	-------
1621	8.5206	467.83	--------	-------
1624	4.5834	267.88	--------	-------
1704	5.2689	320.67	--------	-------
1705	9.6526	444.05	--------	-------
1712	4.6923	422.40	--------	-------
1713	6.1444	383.91	--------	-------
1715	5.0889	324.07	--------	-------
1716	3.6271	234.50	--------	-------
1738	2.7756	173.44	--------	-------
1746	3.2242	193.18	--------	-------
5009	3.1137	294.89	--------	-------
5010	4.7390	337.70	--------	-------
5015	7.2291	477.27	--------	-------
5018	3.3277	262.69	--------	-------
5045	8.7939	595.75	--------	-------
5048	2.9121	229.99	--------	-------
5054	12.3349	842.43	--------	-------
5068	5.7622	369.20	--------	-------
5079	2.3563	168.85	--------	-------
5099	3.4096	296.06	--------	-------
5105	9.4316	573.63	--------	-------
5108	2.1660	186.92	--------	-------
5114	11.4784	601.27	--------	-------
5128	6.8340	491.03	--------	-------
5137	3.5145	247.90	--------	-------
5158	7.4537	481.96	--------	-------
5165	3.2727	224.47	--------	-------
5174	8.9379	565.41	--------	-------
5234	7.7092	427.05	--------	-------
5282	2.4192	182.81	--------	-------
5294	6.8930	402.10	--------	-------
5302	2.3356	181.39	--------	-------
5311	13.1139	676.42	--------	-------
5321	1.2065	116.10	--------	-------
5322	3.2044	222.69	--------	-------
5351	7.8796	436.16	--------	-------
5352	3.3114	231.22	--------	-------
5354	9.1520	477.34	--------	-------
5362	3.4074	233.26	--------	-------
5382	3.8540	251.31	--------	-------
5397	1.0796	100.27	--------	-------
5398	2.5982	196.88	--------	-------

TABLE 9 (Continued)

5401	2.3390	190.85	--------	-------
5402	4.1183	295.14	--------	-------
5414	9.4678	490.62	--------	-------
5416	3.9415	251.49	--------	-------
5417	2.3021	185.06	--------	-------
5418	1.3811	117.08	--------	-------
5421	2.9761	245.64	--------	-------
5422	5.3291	309.35	--------	-------
5424	4.6692	274.39	--------	-------
5431	2.9099	272.47	--------	-------
5432	1.9393	152.00	--------	-------
5434	4.0610	244.50	--------	-------
5482	3.1186	209.44	--------	-------
5484	3.7791	243.17	--------	-------
5551	4.5582	316.73	--------	-------
5552	3.3718	230.66	--------	-------
5621	2.2751	172.59	--------	-------
5622	2.3026	194.54	--------	-------
5692	2.0290	161.94	--------	-------
5694	2.2264	175.31	--------	-------
5761	2.1402	216.81	--------	-------
5762	1.7193	161.79	--------	-------
5832	2.7397	186.47	--------	-------
5834	3.5642	215.65	--------	-------
5901	2.4489	188.61	--------	-------
5902	3.6677	222.85	--------	-------
5922	4.1253	284.25	--------	-------
5924	5.6213	319.58	--------	-------
6286	5.0914	313.09	--------	-------
6301	5.2355	316.06	--------	-------
6331	3.8938	253.61	--------	-------
6367	2.8304	169.96	--------	-------
6368	2.3227	155.44	--------	-------
6369	3.4079	192.99	--------	-------
6394	1.3310	119.88	--------	-------
6395	4.4168	248.67	--------	-------
6407	3.3904	207.96	--------	-------
6408	3.9711	251.01	--------	-------
6409	3.8943	258.88	--------	-------
6410	2.5097	201.62	--------	-------
6413	2.1900	175.18	--------	-------
6424	4.7167	266.82	--------	-------
6427	2.0934	197.67	--------	-------
6429	4.7169	321.77	--------	-------
6489	4.8541	271.67	--------	-------
6555	1.6536	118.94	--------	-------
6587	1.2334	149.40	--------	-------
6588	1.5852	172.21	--------	-------

TABLE 9 (Continued)

6589	2.2391	210.98	--------	-------
6590	2.6358	241.73	--------	-------
6593	3.1799	270.10	--------	-------
6594	1.0921	139.18	--------	-------
6595	1.1856	140.66	--------	-------
6596	1.1852	137.58	--------	-------
6597	0.9377	118.84	--------	-------
6603	2.6022	213.71	--------	-------
6606	3.0619	239.45	--------	-------
6614	2.4712	147.90	--------	-------
6617	3.3945	197.29	--------	-------
6632	1.5604	140.60	--------	-------
6633	2.1952	166.37	--------	-------
6634	2.6979	194.86	--------	-------
6637	3.8140	260.03	--------	-------
6638	1.1130	112.34	--------	-------
6639	1.0339	114.54	--------	-------
6640	0.9853	111.83	--------	-------
6699	3.3196	195.70	--------	-------
6909	2.4677	189.42	--------	-------
6929	11.1376	569.80	--------	-------
7000	5.6790	715.63	4.6794	491.17
7280	--------	--------	1.4887	150.33
7285	--------	--------	4.5412	286.31
7300	1.8592	137.14	1.4568	149.60*
7301	1.8095	136.64	--------	-------
7302	2.0009	147.60	--------	-------
7304	2.0047	142.89	--------	-------
7305	9.4492	465.26	9.3031	475.07*
7306	1.6123	113.93	--------	-------
7307	1.5837	107.75	--------	-------
7309	1.9542	130.66	--------	-------
7320	1.6895	131.06	2.6892*	200.87*
7325	9.8855	530.18	11.6996*	534.15*
7329	2.0765	124.39	--------	-------
7350	1.7217	133.28	1.5352	167.42*
7354	5.8988	321.72	--------	-------
7355	16.5352	809.86	12.8174	647.48
7359	2.0586	123.44	--------	-------
7360	1.8918	139.75	2.2703*	191.75*
7365	11.7609	510.29	10.8235	545.92*
7369	2.0457	121.96	--------	-------
7380	2.3921	158.67	2.8984*	248.07*
7381	2.6313	175.23	--------	-------
7385	1.3132	123.37	3.6326*	251.06*
7386	2.0997	156.56	--------	-------
7387	2.6249	168.96	--------	-------
7400	2.8532	189.33	5.3234*	354.38*

TABLE 9 (Continued)

7401	2.9413	200.39	--------	-------
7404	1.8153	147.82	--------	-------
7405	1.3063	123.64	3.4109*	238.4*
7406	1.4886	128.28	--------	-------
7409	2.1022	124.21	--------	-------
7420	6.7762	417.40	7.3907*	493.95*
7421	3.7673	245.20	--------	-------
7422	4.4232	231.83	--------	-------
7424	1.6386	137.49	--------	-------
7425	1.2994	123.68	1.9872*	188.71*
7426	1.5215	129.32	--------	-------
7427	2.4755	162.68	--------	-------
7429	2.2483	129.94	--------	-------
7430	8.3623	447.20	9.0502*	584.80*
7431	4.3528	260.13	--------	-------
7432	6.2504	296.62	--------	-------
7434	1.5490	134.47	--------	-------
7435	1.2953	124.10	1.9804*	187.72*
7436	1.5009	129.08	--------	-------
7437	2.2180	156.85	--------	-------
7439	2.2412	129.20	--------	-------
7440	6.4681	406.41	6.2646	415.95*
7441	3.3310	240.47	--------	-------
7442	2.4138	176.20	--------	-------
7444	1.1386	104.52	--------	-------
7445	1.0698	102.51	1.2271*	118.94*
7446	1.1890	107.05	--------	-------
7447	1.2262	108.75	--------	-------
7449	1.0997	101.92	--------	-------
7450	4.2550	312.87	3.9334	301.98
7451	2.8877	232.20	--------	-------
7452	2.1619	163.69	--------	-------
7455	1.0594	98.03	1.2214*	116.54*
7457	1.7389	128.30	--------	-------
7459	1.7229	112.20	--------	-------
7470	2.8524	208.69	3.0553*	214.86*
7475	1.6619	124.03	1.2150	114.22
7479	1.8443	111.59	--------	-------
7480	3.6497	219.19	3.3677	216.85
7485	1.6555	123.37	1.3243	118.00
7489	1.8811	112.93	--------	-------
7520	3.5323	204.72	2.6740	201.10
7525	1.6410	121.50	1.4321	120.38
7529	1.9142	112.40	--------	-------
7550	2.0181	155.44	2.3311*	179.22*
7551	1.3111	127.42	--------	-------
7552	1.7642	134.44	--------	-------
7554	1.2292	100.42	--------	-------

TABLE 9 (Continued)

7555	1.6290	120.39	1.7537*	133.65*
7556	1.1367	95.18	--------	-------
7557	1.1367	95.30	--------	-------
7559	1.3765	105.84	--------	-------
7590	--------	--------	2.0375	170.99
7595	--------	--------	2.1025	142.65
7620	2.6663	186.56	2.0615	171.22
7625	2.4676	147.00	2.0354	140.67
7629	1.9983	112.47	--------	-------
7660	--------	--------	1.8790	155.32
7665	--------	--------	1.8858	138.64
7690	2.0361	154.34	1.3997	129.79
7691	1.6981	126.44	--------	-------
7692	1.4404	122.60	--------	-------
7694	1.5040	117.05	--------	-------
7695	2.0441	137.32	1.7577	137.32
7696	1.1431	96.70	--------	-------
7697	1.2038	97.60	--------	-------
7699	1.8440	119.85	--------	-------
7760	1.3395	126.52	1.2621	119.49
7761	1.1525	106.56	--------	-------
7762	1.4323	110.52	--------	-------
7764	1.8726	125.63	--------	-------
7765	--------	--------	1.6941	139.42
7766	1.2166	98.57	--------	-------
7767	1.6074	103.35	--------	-------
7769	1.7254	113.58	--------	-------
7830	2.4858	163.94	1.7856	151.96
7831	1.8678	133.47	--------	-------
7832	1.8882	140.88	--------	-------
7834	4.2387	203.91	--------	-------
7835	3.1482	164.24	1.9556	153.11
7836	1.3565	110.82	--------	-------
7837	1.3791	107.55	--------	-------
7839	1.3499	99.97	--------	-------
7850	2.7733	189.09	1.9421	161.80
7852	2.5031	189.44	--------	-------
7855	1.9850	147.65	2.0640*	157.75*
7859	1.5344	95.80	--------	-------
7870	--------	--------	2.5364	200.34
7875	--------	--------	3.6441	206.67
7900	--------	--------	3.4180	271.67
7905	--------	--------	5.4250	269.59
7920	8.7343	432.64	6.7170	405.09
7921	6.0297	281.27	--------	-------
7922	2.6783	190.20	--------	-------
7925	4.1902	214.60	8.8415*	382.45*
7929	1.4087	95.08	--------	-------

TABLE 9 (Continued)

7930	4.7682	252.95	4.2824	291.46*
7931	4.2399	192.57	--------	-------
7935	6.5820	242.44	6.2229	315.56*
7937	2.1639	143.05	--------	-------
7939	1.2341	93.86	--------	-------
50101	4.4152	300.17	--------	-------
50102	4.4152	300.17	--------	-------
50103	4.4152	300.17	--------	-------
50104	4.0615	277.01	--------	-------
50106	3.4876	239.43	--------	-------
50107	2.6488	184.51	--------	-------
50108	2.9260	215.64	--------	-------
50109	3.0427	223.92	--------	-------
50111	2.0480	153.37	--------	-------
50301	6.0717	411.79	--------	-------
50302	6.0717	411.79	--------	-------
50303	6.0717	411.79	--------	-------
50304	5.5854	381.62	--------	-------
50306	4.8569	336.42	--------	-------
50307	3.5820	257.32	--------	-------
50308	5.1890	342.04	--------	-------
50309	5.4998	361.39	--------	-------
50311	4.1508	277.42	--------	-------
50501	5.4842	396.44	--------	-------
50502	5.3191	385.84	--------	-------
50503	5.3191	385.84	--------	-------
50504	5.0449	368.22	--------	-------
50506	4.3869	325.94	--------	-------
50507	3.1805	248.42	--------	-------
50508	4.2068	303.45	--------	-------
50509	4.5008	323.20	--------	-------
50511	2.9445	218.68	--------	-------
50801	2.8783	296.45	--------	-------
50802	2.7638	244.61	--------	-------
50803	2.7638	242.96	--------	-------
50804	2.1496	198.98	--------	-------
50806	1.5252	165.23	--------	-------
50807	1.3712	121.23	--------	-------
50808	1.7698	178.47	--------	-------
50809	2.1496	199.03	--------	-------
50811	0.9269	105.80	--------	-------
51301	3.5668	262.83	--------	-------
51302	2.7012	220.13	--------	-------
51303	2.5648	216.54	--------	-------
51304	2.3066	189.55	--------	-------
51306	1.7843	157.87	--------	-------
51307	1.1894	110.39	--------	-------
51308	2.1364	177.23	--------	-------

TABLE 9 (Continued)

51309	2.3069	189.64	--------	-------
51311	1.5710	129.89	--------	-------
51601	8.5071	513.68	--------	-------
51602	8.7104	525.52	--------	-------
51603	8.3361	503.72	--------	-------
51604	7.9108	478.95	--------	-------
51606	6.8475	417.01	--------	-------
51607	5.3589	330.30	--------	-------
51608	7.0209	436.91	--------	-------
51609	7.4063	460.22	--------	-------
51611	5.8268	364.72	--------	-------
55305	4.6692	274.36	--------	-------
55403	5.1191	385.32	--------	-------
55483	3.2436	230.55	--------	-------
55623	2.1486	175.25	--------	-------
55833	3.0996	194.53	--------	-------
55923	4.9806	326.27	--------	-------
56282	3.2140	210.60	--------	-------
56283	4.8862	276.14	--------	-------
56505	8.4533	398.99	--------	-------
56515	11.6283	573.80	--------	-------
56525	10.4298	554.25	--------	-------
56534	6.1057	401.17	--------	-------
56535	4.2065	210.69	--------	-------
56565	9.8863	493.96	--------	-------
56575	9.3886	460.85	--------	-------
60101	11.3066	1593.37	--------	-------
60109	28.4075	1900.43	--------	-------
60111	22.0050	1574.18	--------	-------
60112	18.6081	1364.96	--------	-------
60122	10.7502	1349.10	--------	-------
60130	3.8311	467.05	--------	-------
60133	14.9803	1840.32	--------	-------
60203	22.3891	1635.13	--------	-------
60209	26.1623	1669.68	--------	-------
60303	19.4641	1389.21	--------	-------
60309	22.9682	1544.29	--------	-------
60310	18.1452	1434.25	--------	-------
60319	3.0302	300.87	--------	-------
60320	16.6111	1335.79	--------	-------
60321	13.5948	1109.59	--------	-------
60322	14.4344	1124.46	--------	-------
60323	10.3290	914.35	--------	-------
60324	1.6490	178.23	--------	-------
60325	16.4869	1323.49	--------	-------
60326	1.6490	178.23	--------	-------
60327	1.6490	178.48	--------	-------
60400	9.2338	750.02	--------	-------

TABLE 9 (Continued)

60405	11.5627	875.02	--------	-------
60407	14.3378	1016.14	--------	-------
60409	12.2104	909.17	--------	-------
60411	9.3052	753.03	--------	-------
60413	9.2966	764.57	--------	-------
60418	10.5529	760.29	--------	-------
60420	30.3138	2054.71	--------	-------
60500	8.4117	706.18	--------	-------
60507	10.9148	819.72	--------	-------
60509	7.6230	648.56	--------	-------
60510	7.4458	653.83	--------	-------
60517	9.6180	734.15	--------	-------
60601	7.5440	648.82	--------	-------
60607	8.9576	698.99	--------	-------
60609	7.0014	614.65	--------	-------
60610	8.0565	670.29	--------	-------
60617	8.1878	665.16	--------	-------
60701	7.3483	628.45	--------	-------
60707	12.2738	939.97	--------	-------
60709	12.7622	940.12	--------	-------
60711	10.7803	821.62	--------	-------
60716	7.9953	626.15	--------	-------
60802	7.2203	615.38	--------	-------
60806	9.9913	747.69	--------	-------
60807	12.3241	937.47	--------	-------
60809	12.1928	931.14	--------	-------
60810	9.9455	762.03	--------	-------
60816	8.8594	706.93	--------	-------
60820	24.2447	1838.93	--------	-------
60907	8.7572	617.48	--------	-------
60909	10.5910	755.86	--------	-------
60911	9.0791	661.07	--------	-------
60915	6.2332	511.28	--------	-------
60920	20.2561	1440.64	--------	-------
61009	8.8595	641.45	--------	-------
61020	18.4014	1324.66	--------	-------
61109	6.6787	493.46	--------	-------
61111	7.3931	518.75	--------	-------
61114	3.7472	320.89	--------	-------
61120	13.9117	994.64	--------	-------
61209	5.2717	409.72	--------	-------
61220	11.2730	840.81	--------	-------
61309	4.3393	332.43	--------	-------
61311	4.3970	338.27	--------	-------
61313	2.8261	236.30	--------	-------
61409	2.9496	239.69	--------	-------
61420	7.3599	566.68	--------	-------
61509	2.5100	215.63	--------	-------

TABLE 9 (Continued)

61609	2.0963	186.08	--------	-------
61610	3.5214	263.68	--------	-------
61611	2.0176	181.38	--------	-------
61613	1.6526	147.82	--------	-------
61620	4.8487	375.37	--------	-------
61709	2.0342	150.57	--------	-------
61809	2.2513	169.59	--------	-------
61909	2.3643	191.72	--------	-------
62009	2.8849	216.52	--------	-------
62109	2.8597	215.61	--------	-------
62120	4.7753	368.44	--------	-------
70300	10.2076	1329.23	--------	-------
70350	9.6378	1147.40	--------	-------
70375	10.8676	1380.48	--------	-------
70400	4.0300	498.80	--------	-------
70450	3.5805	414.87	--------	-------
70475	4.7284	576.93	--------	-------
70500	15.2473	1434.43	10.8879	857.40
70550	12.8114	1122.06	10.8450	767.31
70563	---------	--------	10.9713	769.34
70575	13.4979	1297.62	10.9768	761.12
70588	---------	--------	10.9770	822.33
70600	18.3834	1593.51	10.5068	815.11
70650	15.4467	1250.11	10.4654	760.54
70663	---------	--------	10.5874	758.44
70675	16.2777	1435.56	10.5929	742.16
70688	---------	--------	10.5929	788.43
70700	23.2298	1863.15	7.8931	635.06
70750	19.5170	1436.51	10.2135	768.06
70763	---------	--------	10.3462	760.16
70775	20.5697	1643.09	7.9750	578.94
70788	---------	--------	7.9680	612.83
70800	19.0247	1542.72	9.9304	732.05
70850	15.9836	1217.82	9.8911	706.14
70863	---------	--------	10.0072	704.78
70875	16.8465	1379.36	10.0123	693.11
70888	---------	--------	10.0123	714.87
70900	8.9700	817.29	6.9464	534.10
70950	8.8877	825.50	8.9879*	636.73
70956	8.8269	816.89	9.0711*	639.76
70963	8.9562	845.58	9.1197*	639.68
70969	8.9882	849.12	9.1362*	643.30
70975	8.9970	846.84	7.0290	503.13
70981	8.8710	807.99	7.0293	510.77
70988	9.0096	829.80	7.0223	519.13
70994	8.9337	816.92	6.9442	525.49
71000	6.5956	594.46	7.4307*	556.02
71050	6.7588	598.03	7.3513*	521.03

TABLE 9 (Continued)

71056	6.7846	597.70	7.5194*	528.81
71063	6.8923	604.43	7.6506*	534.22
71069	7.8825	681.17	7.7332	540.43
71075	7.9321	683.40	7.7673	536.58
71081	6.9527	606.68	7.7548*	545.83
71088	6.8045	599.88	7.6945*	553.08
71094	6.6925	594.96	7.5843*	558.78
71100	5.9490	532.88	6.0814*	464.62
71150	6.3037	539.76	5.9916	433.29
71156	---------	--------	6.1841	442.17
71163	---------	--------	6.3417	448.99
71169	---------	--------	6.4467	455.21
71175	6.1279	557.20	6.4915*	461.72
71181	---------	--------	6.4745	474.57
71188	---------	--------	6.3970	477.82
71194	---------	--------	6.2611	470.65
71200	5.6881	486.45	5.6657	444.11
71250	6.0008	521.77	5.5411	406.97
71256	---------	--------	5.7718	415.94
71263	5.6318	512.37	6.1104*	434.84
71269	---------	--------	6.2237	441.63
71275	5.9114	514.44	6.0942*	430.42
71281	---------	--------	6.0756	442.93
71288	5.8889	509.04	5.9930*	448.26
71294	---------	--------	5.8514	449.10
71300	4.9744	410.40	4.3129	352.38
71350	4.4942	399.27	4.3841	326.53
71356	4.0232	366.78	4.5524*	336.01
71363	4.0266	362.00	4.6966*	344.90
71369	4.1255	358.21	4.7994*	352.90
71375	4.9494	440.73	4.6898	345.73
71381	4.2376	361.90	4.6731*	359.48
71388	4.2718	369.59	4.5974*	365.32
71394	4.3502	376.87	4.4715*	359.23
71400	3.2248	280.84	2.9130	261.38
71450	3.3797	265.67	2.8442	227.31
71456	2.8558	252.00	2.9989*	235.00
71463	2.8332	246.64	3.1378*	241.53
71469	2.8885	241.86	3.2370*	247.12*
71475	3.7140	311.83	3.2813	249.89
71481	3.0079	248.74	3.2637*	262.46*
71488	3.0533	258.20	3.1867*	271.10*
71494	3.1452	266.57	3.0625	270.66*
71500	2.1567	208.73	1.9681	200.80
71550	2.3962	180.44	1.9586	167.49
71556	1.9077	170.61	2.0302*	172.00*
71563	1.8930	167.84	2.1156*	176.10*
71569	1.8948	165.08	2.1899*	179.59*

TABLE 9 (Continued)

71575	2.4714	210.78	2.2244	182.19
71581	1.9658	167.99	2.2114*	194.02*
71588	2.0298	175.26	2.1537*	204.34*
71594	2.0952	183.04	2.0646	205.90*
71600	1.7580	159.98	2.9450*	78.62*
71650	1.6562	148.52	1.6699*	152.42*
71656	---------	--------	1.7336	153.92
71663	---------	--------	1.7707	154.93
71669	---------	--------	1.8049	155.52
71675	1.9713	172.56	1.8220	156.96
71681	---------	--------	1.8124	168.04
71688	---------	--------	1.7793	178.95
71694	---------	--------	1.7337	183.42
71700	2.0958	160.65	1.3934	171.62*
71750	2.2080	164.06	1.5934	150.51
71756	2.2080	162.82	1.6304	150.24
71763	2.2080	161.57	1.6609	148.81
71769	2.2080	160.16	1.6874	147.23
71775	2.5848	192.39	1.5788	132.70
71781	1.9222	139.26	1.5693	144.48*
71788	1.9222	144.71	1.5283	164.72*
71794	2.0502	153.31	1.4778	174.92*
71800	2.1548	168.71	1.3266	170.99*
71850	2.1830	161.51	1.5369	146.45
71856	---------	--------	1.5724	146.00
71863	---------	--------	1.6020	144.23
71869	---------	--------	1.6275	142.40
71875	2.5559	191.72	1.5030	127.32
71881	---------	--------	1.4939	138.98
71888	---------	--------	1.4550	161.05
71894	---------	--------	1.4068	173.10
80000	10.9675	927.15	--------	-------
80002	6.8657	678.15	--------	-------
80003	6.8657	678.15	--------	-------
80004	10.9675	933.02	--------	-------
80005	13.3808	745.75	--------	-------
80008	1.8574	118.31	--------	-------
80009	1.8574	118.31	--------	-------
80010	5.5723	354.61	--------	-------
80011	13.2632	750.68	--------	-------
80012	3.3466	201.43	--------	-------
80013	13.2632	752.05	--------	-------
80016	13.2632	750.68	--------	-------
80017	3.3466	201.43	--------	-------
80018	13.2632	752.05	--------	-------
80034	17.6351	1170.47	--------	-------
80035	11.7436	819.51	--------	-------
80037	17.1422	850.25	--------	-------

TABLE 9 (Concluded)

80043	10.2195	553.77	--------	-------
80045	8.4141	552.96	--------	-------
80049	10.7021	677.93	--------	-------
80053	8.5643	569.01	--------	-------
80057	10.7407	603.93	--------	-------
80110	26.5149	1381.24	--------	-------
80115	26.2902	1819.94	--------	-------
80119	9.1746	715.52	--------	-------
80123	4.7555	383.94	--------	-------
80127	8.4141	552.64	--------	-------
80131	10.2050	641.58	--------	-------
80135	8.3559	521.40	--------	-------
80137	6.7476	456.09	--------	-------
80143	9.9036	545.81	--------	-------
80147	4.5945	323.55	--------	-------
80148	1.8477	146.39	--------	-------
80150	4.6757	338.43	--------	-------
80151	1.8166	145.94	--------	-------
80153	4.3331	307.86	--------	-------
80154	2.3542	179.22	--------	-------
80156	3.6340	265.07	--------	-------
80157	2.6057	189.00	--------	-------
80158	2.6267	191.85	--------	-------
80162	7.5190	411.30	--------	-------
80163	5.0159	290.11	--------	-------
80164	5.0159	290.11	--------	-------
80165	4.6291	348.22	--------	-------
80166	1.7804	142.23	--------	-------
80167	1.6099	141.16	--------	-------
80168	4.0456	293.70	--------	-------
80169	1.6698	139.50	--------	-------
80174	20.2177	964.05	--------	-------
80175	8.8866	528.68	--------	-------
81609	5.6139	398.39	--------	-------
81809	2.5982	197.17	--------	-------
82094	14.2882	984.31	--------	-------
82194	11.1273	832.22	--------	-------
82294	7.8978	631.57	--------	-------
82394	7.4053	560.29	--------	-------
82494	5.4729	406.38	--------	-------
82594	3.5812	277.69	--------	-------
82666	3.4164	249.54	--------	-------
82694	2.7256	219.66	--------	-------
82994	15.2396	1150.49	--------	-------
82999	2.3408	172.33	--------	-------
83000	13.2632	750.80	--------	-------
83001	13.2632	750.80	--------	-------
83002	9.2881	581.83	--------	-------

TABLE 10 SUMMARY OF RTLS ENVIRONMENT EXCEEDANCES OVER DESIGN

BODY POINT	IVBC-3 DESIGN QMAX BTU/FT2SEC	IVBC-3 DESIGN QLOAD BTU/FT2	RTLS QMAX BTU/FT2SEC	RTLS QLOAD BTU/FT2
7300	1.8592	137.14	1.4568	149.60*
7305	9.4492	465.26	9.3031	475.07*
7320	1.6895	131.06	2.6892*	200.87*
7325	9.8855	530.18	11.6996*	534.15*
7350	1.7217	133.28	1.5352	167.42*
7360	1.8918	139.75	2.2703*	191.75*
7365	11.7609	510.29	10.8235	545.92*
7380	2.3921	158.67	2.8984*	248.07*
7385	1.3132	123.37	3.6326*	251.06*
7400	2.8532	189.33	5.3234*	354.38*
7405	1.3063	123.64	3.4109*	238.47*
7420	6.7762	417.40	7.3907*	493.95*
7425	1.2994	123.68	1.9872*	188.71*
7430	8.3623	447.20	9.0502*	584.80*
7435	1.2953	124.10	1.9804*	187.72*
7440	6.4681	406.41	6.2646	415.95*
7445	1.0698	102.51	1.2271*	118.94*
7455	1.0594	98.03	1.2214*	116.54*
7470	2.8524	208.69	3.0553*	214.86*
7550	2.0181	155.44	2.3311*	179.22*
7555	1.6290	120.39	1.7537*	133.65*
7855	1.9850	147.65	2.0640*	157.75*
7925	4.1902	214.60	8.8415*	382.45*
7930	4.7682	252.95	4.2824	291.46*
7935	6.5820	242.44	6.2229	315.56*
70950	16.4869	1323.49	8.9879*	636.73
70956	8.8269	816.89	9.0711*	639.76
70963	8.9562	845.58	9.1197*	639.68
70969	8.9882	849.12	9.1362*	643.30
71000	6.5956	594.46	7.4307*	556.02
71050	6.7588	598.03	7.3513*	521.03
71056	6.7846	597.70	7.5194*	528.81
71063	6.8923	604.43	7.6506*	534.22
71081	6.9527	606.68	7.7548*	545.83
71088	6.8045	599.88	7.6945*	553.08
71094	6.6925	594.96	7.5843*	558.78
71100	5.9490	532.88	6.0814*	464.62
71175	6.1279	557.20	6.4915*	461.72
71263	5.6318	512.37	6.1104*	434.84
71275	5.9114	514.44	6.0942*	430.42
71288	5.8889	509.04	5.9930*	448.26
71356	4.0232	366.78	4.5524*	336.01
71363	4.0266	362.00	4.6966*	344.90
71369	4.1255	358.21	4.7994*	352.90

TABLE 10 (Concluded)

71381	4.2376	361.90	4.6731*	359.48
71388	4.2718	369.59	4.5974*	365.32
71394	4.3502	376.87	4.4715*	359.23
71456	2.8558	252.00	2.9989*	235.00
71463	2.8332	246.64	3.1378*	241.53
71469	2.8885	241.86	3.2370*	247.12*
71481	3.0079	248.74	3.2637*	262.46*
71488	3.0533	258.20	3.1867*	271.10*
71494	3.1452	266.57	3.0625	270.66*
71556	1.9077	170.61	2.0302*	172.00*
71563	1.8930	167.84	2.1156*	176.10*
71569	1.8948	165.08	2.1899*	179.59*
71581	1.9658	167.99	2.2114*	194.02*
71588	2.0298	175.26	2.1537*	204.34*
71594	2.0952	183.04	2.0646	205.90*
71600	1.7580	159.98	2.9450*	278.62*
71650	1.6562	148.52	1.6699*	152.42*
71700	2.0958	160.65	1.3934	171.62*
71781	1.9222	139.26	1.5693	144.48*
71788	1.9222	144.71	1.5283	164.72*
71794	2.0502	153.31	1.4778	174.92*
71800	2.1548	168.71	1.3266	170.99*

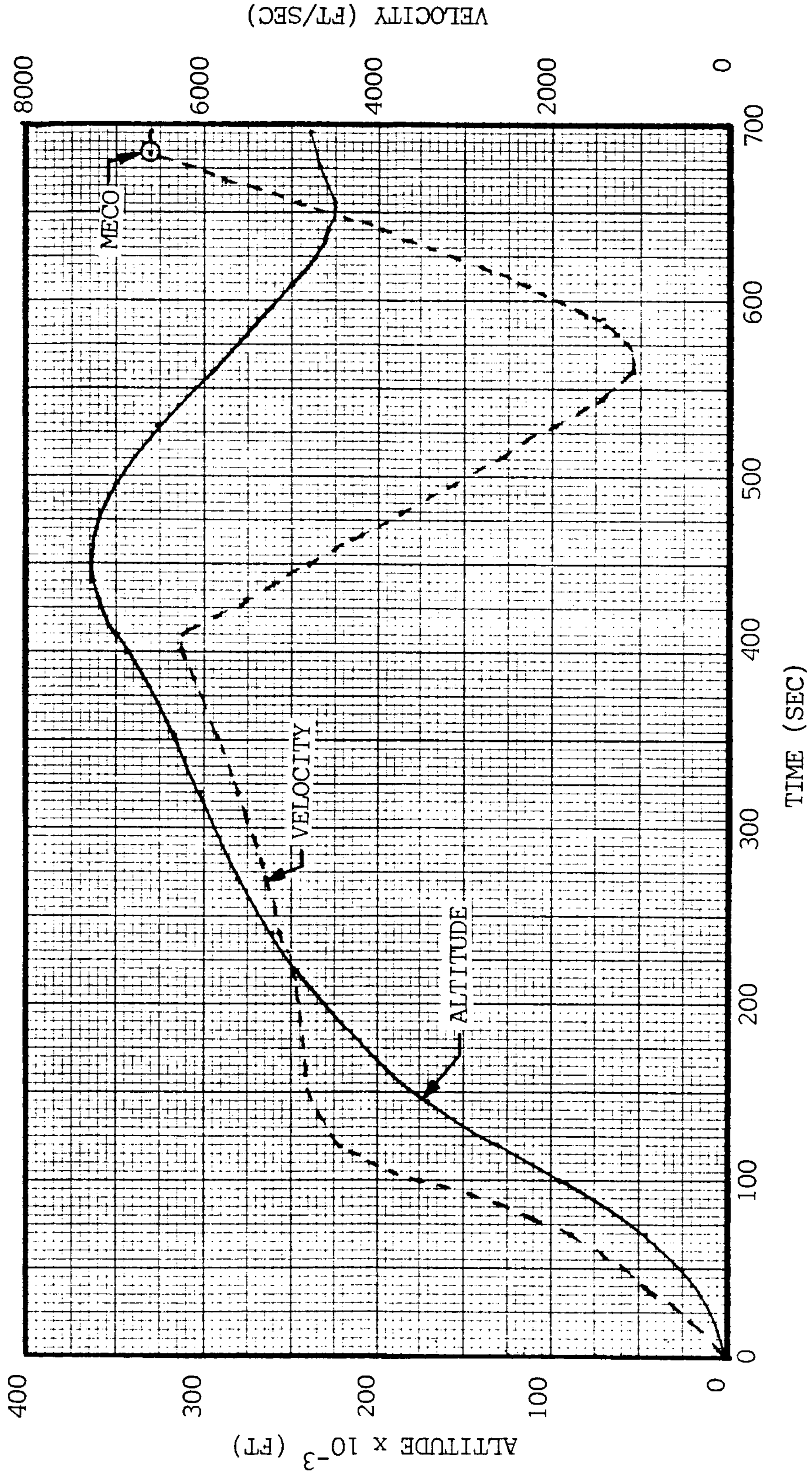


Fig. 13 RTLS Trajectory - Altitude and Velocity as a Function of Time

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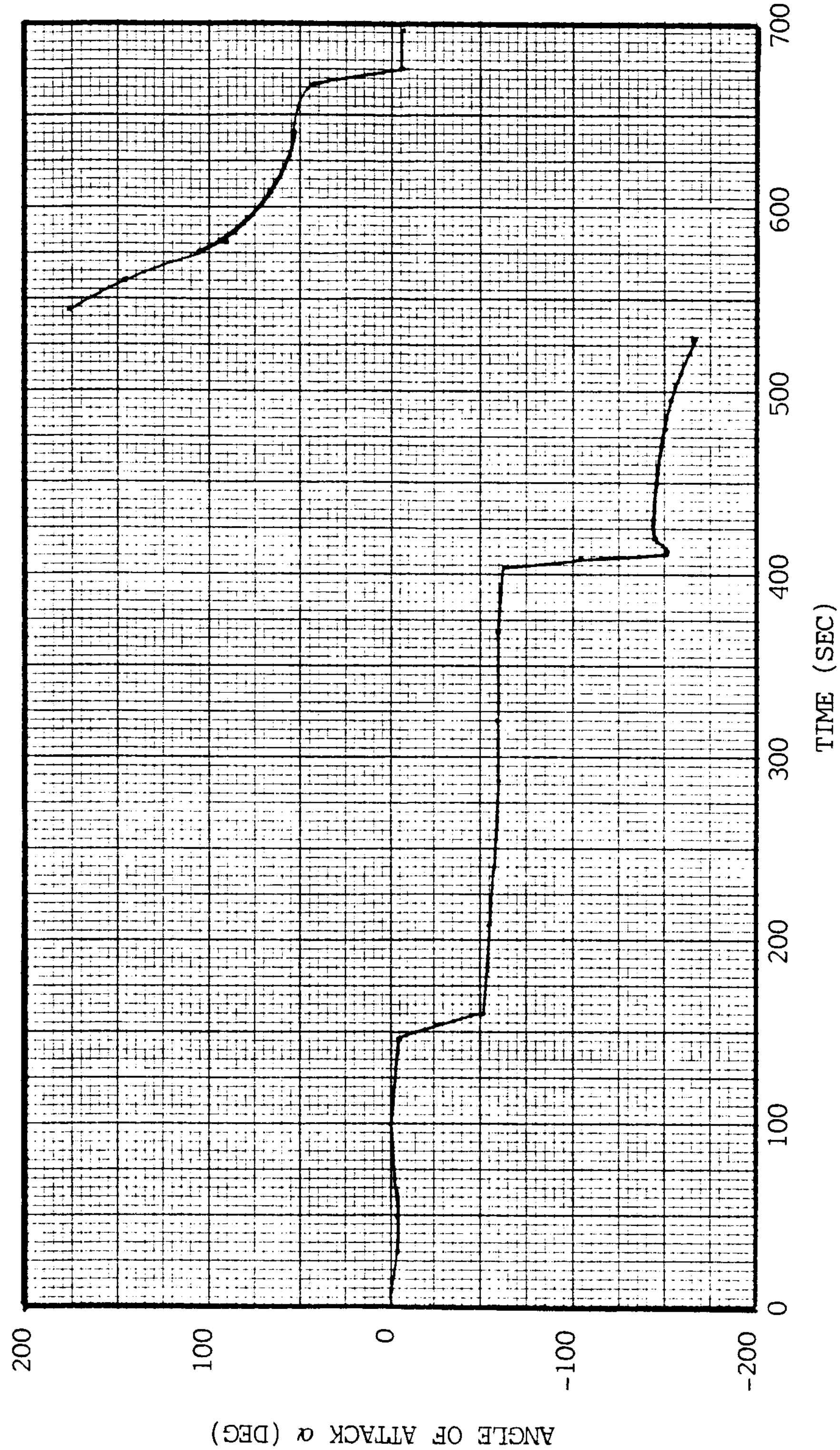

Fig. 14 Angle of Attack as a Function of Time for RTLS Trajectory

Section 5.0

TAL THERMAL ENVIRONMENTS

One of the abort modes that is currently getting much attention and study is the one referred to as Trans Abort Landing (TAL). A TAL trajectory is essentially ballistic with the launch configuration not getting to orbit conditions. The Orbiter/ET configuration flies downrange and after MECO the Orbiter separates and lands on a runway long enough to accomodate a safe landing. Four TAL environments for 96 body points were received from RI in September 1986 and are identified as follows:

(1) DAKAR - EARLY

(2) DAKAR - LATE

(3) MORON - EARLY

(4) MORAN - LATE

These environments are compared with design in Table 11. Those body points for which TAL environments exceed design are identified in Table 12. The exceedances are not, however, considered significant.

TABLE 11 COMPARISON OF TAL ENVIRONMENTS WITH DESIGN

	IVBC-3 DESIGN		DAKAR EARLY TAL		DAKAR LATE TAL		MORUN EARLY TAL	
BODY POINT	QMAX (BTU/FT^{2}SEC)	QLOAD (BTU/FT^2)	QMAX (BTU/FT^{2}SEC)	QLOAD (BTU/FT^2)	QMAX (BTU/FT^{2}SEC)	QLOAD (BTU/FT^2)	QMAX (BTU/FT^{2}SEC)	QLOAD (BTU/FT^2)
200	11.9861	1105.29	--------	--------	--------	--------	--------	--------
202	1.9178	186.49	--------	--------	--------	--------	--------	--------
352	5.5930	501.09	--------	--------	--------	--------	--------	--------
560	10.7587	996.39	--------	--------	--------	--------	--------	--------
601	13.2632	752.05	--------	--------	--------	--------	--------	--------
650	9.2881	583.01	--------	--------	--------	--------	--------	--------
690	13.2632	752.05	--------	--------	--------	--------	--------	--------
738	4.7599	594.95	--------	--------	--------	--------	--------	--------
752	14.6614	1546.67	--------	--------	--------	--------	--------	--------
772	10.3283	1124.01	--------	--------	--------	--------	--------	--------
785	12.8056	774.63	--------	--------	--------	--------	--------	--------
788	9.2881	582.88	--------	--------	--------	--------	--------	--------
790	6.7795	798.92	--------	--------	--------	--------	--------	--------
791	1.0885	139.52	--------	--------	--------	--------	--------	--------
900	10.2223	722.24	--------	--------	--------	--------	--------	--------
911	5.0948	336.01	--------	--------	--------	--------	--------	--------
934	2.9959	230.55	--------	--------	--------	--------	--------	--------
955	3.5227	238.13	--------	--------	--------	--------	--------	--------
961	8.9552	605.95	--------	--------	--------	--------	--------	--------
963	6.9168	470.83	--------	--------	--------	--------	--------	--------
966	7.5674	431.80	--------	--------	--------	--------	--------	--------
968	3.1025	175.80	--------	--------	--------	--------	--------	--------
979	1.8574	118.31	--------	--------	--------	--------	--------	--------
980	1.8574	118.29	--------	--------	--------	--------	--------	--------
981	3.3466	201.43	--------	--------	--------	--------	--------	--------
982	3.3466	201.43	--------	--------	--------	--------	--------	--------
985	3.3466	201.43	--------	--------	--------	--------	--------	--------
986	1.8574	118.31	--------	--------	--------	--------	--------	--------
988	1.8574	118.31	--------	--------	--------	--------	--------	--------
991	3.3466	201.43	--------	--------	--------	--------	--------	--------
992	3.3466	201.43	--------	--------	--------	--------	--------	--------
995	3.3466	201.43	--------	--------	--------	--------	--------	--------
1002	20.3152	953.57	--------	--------	--------	--------	--------	--------
1005	20.2903	889.42	--------	--------	--------	--------	--------	--------
1007	20.0050	887.35	--------	--------	--------	--------	--------	--------

TABLE 11 (Continued)

1009	19.7165	876.91	--------	--------	--------	--------	--------	--------
1011	19.3634	856.51	--------	--------	--------	--------	--------	--------
1012	11.8056	512.22	--------	--------	--------	--------	--------	--------
1021	5.2570	311.50	--------	--------	--------	--------	--------	--------
1023	7.7127	352.47	--------	--------	--------	--------	--------	--------
1025	9.3500	520.88	--------	--------	--------	--------	--------	--------
1026	5.5034	258.54	--------	--------	--------	--------	--------	--------
1028	5.9769	271.98	--------	--------	--------	--------	--------	--------
1032	8.8893	486.58	--------	--------	--------	--------	--------	--------
1041	3.2799	203.30	--------	--------	--------	--------	--------	--------
1043	7.8249	330.98	--------	--------	--------	--------	--------	--------
1046	13.2432	501.43	--------	--------	--------	--------	--------	--------
1047	3.7986	214.82	--------	--------	--------	--------	--------	--------
1049	5.6808	250.37	--------	--------	--------	--------	--------	--------
1050	4.6298	267.86	--------	--------	--------	--------	--------	--------
1054	6.4907	311.72	--------	--------	--------	--------	--------	--------
1100	4.6449	321.61	--------	--------	--------	--------	--------	--------
1101	7.0773	410.79	--------	--------	--------	--------	--------	--------
1105	5.3011	371.13	--------	--------	--------	--------	--------	--------
1107	3.7606	286.90	--------	--------	--------	--------	--------	--------
1108	5.5479	369.12	--------	--------	--------	--------	--------	--------
1110	4.7774	337.10	--------	--------	--------	--------	--------	--------
1115	6.7241	418.60	--------	--------	--------	--------	--------	--------
1122	6.3227	354.73	--------	--------	--------	--------	--------	--------
1205	8.8673	541.86	--------	--------	--------	--------	--------	--------
1206	6.3970	272.10	--------	--------	--------	--------	--------	--------
1207	6.6042	273.57	--------	--------	--------	--------	--------	--------
1211	7.9886	423.23	--------	--------	--------	--------	--------	--------
1300	12.5759	533.82	--------	--------	--------	--------	--------	--------
1303	13.8119	597.82	--------	--------	--------	--------	--------	--------
1305	12.5461	533.03	--------	--------	--------	--------	--------	--------
1306	12.7491	537.96	--------	--------	--------	--------	--------	--------
1307	9.7794	517.89	--------	--------	--------	--------	--------	--------
1309	9.7996	516.99	--------	--------	--------	--------	--------	--------
1401	2.6327	214.85	--------	--------	--------	--------	--------	--------
1404	4.7280	385.97	--------	--------	--------	--------	--------	--------

TABLE 11 (Continued)

1406	5.3891	305.32	--------	--------	--------	--------	--------	--------
1409	3.0738	225.94	--------	--------	--------	--------	--------	--------
1414	3.5098	222.37	--------	--------	--------	--------	--------	--------
1500	11.6515	754.32	--------	--------	--------	--------	--------	--------
1504	6.2126	425.90	--------	--------	--------	--------	--------	--------
1510	9.4285	722.58	--------	--------	--------	--------	--------	--------
1514	4.0545	337.42	--------	--------	--------	--------	--------	--------
1520	13.6306	855.27	--------	--------	--------	--------	--------	--------
1524	5.8613	395.01	--------	--------	--------	--------	--------	--------
1530	12.5057	777.33	--------	--------	--------	--------	--------	--------
1534	5.3820	358.93	--------	--------	--------	--------	--------	--------
1540	15.0868	775.62	--------	--------	--------	--------	--------	--------
1544	6.4867	357.84	--------	--------	--------	--------	--------	--------
1550	15.2381	806.82	--------	--------	--------	--------	--------	--------
1554	6.5524	371.28	--------	--------	--------	--------	--------	--------
1560	8.7596	540.48	--------	--------	--------	--------	--------	--------
1561	7.0224	445.05	--------	--------	--------	--------	--------	--------
1564	3.7659	255.66	--------	--------	--------	--------	--------	--------
1580	11.1071	700.67	--------	--------	--------	--------	--------	--------
1581	9.9727	678.71	--------	--------	--------	--------	--------	--------
1584	4.7745	327.67	--------	--------	--------	--------	--------	--------
1600	10.3002	581.09	--------	--------	--------	--------	--------	--------
1601	8.2315	479.00	--------	--------	--------	--------	--------	--------
1604	5.4959	331.40	--------	--------	--------	--------	--------	--------
1620	10.6494	566.33	--------	--------	--------	--------	--------	--------
1621	8.5206	467.83	--------	--------	--------	--------	--------	--------
1624	4.5834	267.88	--------	--------	--------	--------	--------	--------
1704	5.2689	320.67	--------	--------	--------	--------	--------	--------
1705	9.6526	444.05	6.2594	338.69	6.2594	323.78	6.2594	325.91
1712	4.6923	422.40	--------	--------	--------	--------	--------	--------
1713	6.1444	383.91	--------	--------	--------	--------	--------	--------
1715	5.0889	324.07	--------	--------	--------	--------	--------	--------
1716	3.6271	234.50	--------	--------	--------	--------	--------	--------
1738	2.7756	173.44	--------	--------	--------	--------	--------	--------
1746	3.2242	193.18	--------	--------	--------	--------	--------	--------
5009	3.1137	294.89	--------	--------	--------	--------	--------	--------

TABLE 11 (Continued)

5010	4.7390	337.70	--------	--------	--------	--------	--------	--------
5015	7.2291	477.27	--------	--------	--------	--------	--------	--------
5018	3.3277	262.69	--------	--------	--------	--------	--------	--------
5045	8.7939	595.75	--------	--------	--------	--------	--------	--------
5048	2.9121	229.99	--------	--------	--------	--------	--------	--------
5054	12.3349	842.43	--------	--------	--------	--------	--------	--------
5068	5.7622	369.20	--------	--------	--------	--------	--------	--------
5079	2.3563	168.85	--------	--------	--------	--------	--------	--------
5099	3.4096	296.06	--------	--------	--------	--------	--------	--------
5105	9.4316	573.63	--------	--------	--------	--------	--------	--------
5108	2.1660	186.92	--------	--------	--------	--------	--------	--------
5114	11.4784	601.27	--------	--------	--------	--------	--------	--------
5128	6.8340	491.03	--------	--------	--------	--------	--------	--------
5137	3.5145	247.90	--------	--------	--------	--------	--------	--------
5158	7.4537	481.96	--------	--------	--------	--------	--------	--------
5165	3.2727	224.47	--------	--------	--------	--------	--------	--------
5173	-------	-------	2.6802	201.92	2.6802	196.87	2.6802	197.56
5174	8.9379	565.41	--------	--------	--------	--------	--------	--------
5177	-------	-------	4.6169	308.75	4.6169	300.15	4.6169	301.18
5178	-------	-------	2.8924	221.53	2.8924	211.49	2.8924	212.43
5179	-------	-------	1.8057	171.47	1.8057	165.41	1.8057	165.05
5180	-------	-------	1.1198	120.37	1.1198	117.46	1.1198	117.14
5181	-------	-------	1.2504	134.59	1.2504	130.15	1.2504	129.80
5234	7.7092	427.05	--------	--------	--------	--------	--------	--------
5282	2.4192	182.81	--------	--------	--------	--------	--------	--------
5294	6.8930	402.10	--------	--------	--------	--------	--------	--------
5302	2.3356	181.39	--------	--------	--------	--------	--------	--------
5311	13.1139	676.42	--------	--------	--------	--------	--------	--------
5321	1.2065	116.10	--------	--------	--------	--------	--------	--------
5322	3.2044	222.69	--------	--------	--------	--------	--------	--------
5351	7.8796	436.16	--------	--------	--------	--------	--------	--------
5352	3.3114	231.22	--------	--------	--------	--------	--------	--------
5354	9.1520	477.34	--------	--------	--------	--------	--------	--------
5362	3.4074	233.26	--------	--------	--------	--------	--------	--------
5382	3.8540	251.31	--------	--------	--------	--------	--------	--------
5397	1.0796	100.27	--------	--------	--------	--------	--------	--------
5398	2.5982	196.88	--------	--------	--------	--------	--------	--------

TABLE 11 (Continued)

5401	2.3390	190.85	--------	--------	--------	--------	--------	--------
5402	4.1183	295.14	--------	--------	--------	--------	--------	--------
5414	9.4678	490.62	--------	--------	--------	--------	--------	--------
5416	3.9415	251.49	--------	--------	--------	--------	--------	--------
5417	2.3021	185.06	--------	--------	--------	--------	--------	--------
5418	1.3811	117.08	--------	--------	--------	--------	--------	--------
5421	2.9761	245.64	--------	--------	--------	--------	--------	--------
5422	5.3291	309.35	--------	--------	--------	--------	--------	--------
5424	4.6692	274.39	--------	--------	--------	--------	--------	--------
5431	2.9099	272.47	--------	--------	--------	--------	--------	--------
5432	1.9393	152.00	--------	--------	--------	--------	--------	--------
5434	4.0610	244.50	--------	--------	--------	--------	--------	--------
5482	3.1186	209.44	--------	--------	--------	--------	--------	--------
5484	3.7791	243.17	--------	--------	--------	--------	--------	--------
5551	4.5582	316.73	--------	--------	--------	--------	--------	--------
5552	3.3718	230.66	--------	--------	--------	--------	--------	--------
5621	2.2751	172.59	--------	--------	--------	--------	--------	--------
5622	2.3026	194.54	--------	--------	--------	--------	--------	--------
5692	2.0290	161.94	--------	--------	--------	--------	--------	--------
5694	2.2264	175.31	--------	--------	--------	--------	--------	--------
5761	2.1402	216.81	--------	--------	--------	--------	--------	--------
5762	1.7193	161.79	--------	--------	--------	--------	--------	--------
5832	2.7397	186.47	--------	--------	--------	--------	--------	--------
5834	3.5642	215.65	--------	--------	--------	--------	--------	--------
5901	2.4489	188.61	--------	--------	--------	--------	--------	--------
5902	3.6677	222.85	--------	--------	--------	--------	--------	--------
5922	4.1253	284.25	--------	--------	--------	--------	--------	--------
5924	5.6213	319.58	--------	--------	--------	--------	--------	--------
6286	5.0914	313.09	--------	--------	--------	--------	--------	--------
6301	5.2355	316.06	--------	--------	--------	--------	--------	--------
6331	3.8938	253.61	--------	--------	--------	--------	--------	--------
6367	2.8304	169.96	--------	--------	--------	--------	--------	--------
6368	2.3227	155.44	--------	--------	--------	--------	--------	--------
6369	3.4079	192.99	--------	--------	--------	--------	--------	--------
6394	1.3310	119.88	--------	--------	--------	--------	--------	--------
6395	4.4168	248.67	--------	--------	--------	--------	--------	--------
6407	3.3904	207.96	--------	--------	--------	--------	--------	--------

TABLE 11 (Continued)

6408	3.9711	251.01	--------	--------	--------	--------	--------	--------
6409	3.8943	258.88	--------	--------	--------	--------	--------	--------
6410	2.5097	201.62	--------	--------	--------	--------	--------	--------
6413	2.1900	175.18	--------	--------	--------	--------	--------	--------
6424	4.7167	266.82	--------	--------	--------	--------	--------	--------
6427	2.0934	197.67	--------	--------	--------	--------	--------	--------
6429	4.7169	321.77	--------	--------	--------	--------	--------	--------
6435	-------	-------	3.5873	221.75	3.5873	219.68	3.5873	218.89
6489	4.8541	271.67	--------	--------	--------	--------	--------	--------
6555	1.6536	118.94	0.9123	108.95	0.9123	106.20	0.9123	106.15
6587	1.2334	149.40	--------	--------	--------	--------	--------	--------
6588	1.5852	172.21	--------	--------	--------	--------	--------	--------
6589	2.2391	210.98	--------	--------	--------	--------	--------	--------
6590	2.6358	241.73	--------	--------	--------	--------	--------	--------
6593	3.1799	270.10	--------	--------	--------	--------	--------	--------
6594	1.0921	139.18	--------	--------	--------	--------	--------	--------
6595	1.1856	140.66	--------	--------	--------	--------	--------	--------
6596	1.1852	137.58	--------	--------	--------	--------	--------	--------
6597	0.9377	118.84	--------	--------	--------	--------	--------	--------
6603	2.6022	213.71	--------	--------	--------	--------	--------	--------
6606	3.0619	239.45	--------	--------	--------	--------	--------	--------
6614	2.4712	147.90	--------	--------	--------	--------	--------	--------
6617	3.3945	197.29	--------	--------	--------	--------	--------	--------
6632	1.5604	140.60	--------	--------	--------	--------	--------	--------
6633	2.1952	166.37	--------	--------	--------	--------	--------	--------
6634	2.6979	194.86	--------	--------	--------	--------	--------	--------
6637	3.8140	260.03	--------	--------	--------	--------	--------	--------
6638	1.1130	112.34	--------	--------	--------	--------	--------	--------
6639	1.0339	114.54	--------	--------	--------	--------	--------	--------
6640	0.9853	111.83	--------	--------	--------	--------	--------	--------
6699	3.3196	195.70	--------	--------	--------	--------	--------	--------
6909	2.4677	189.42	--------	--------	--------	--------	--------	--------
6925	-------	-------	2.2523	153.24	2.2523	151.46	2.2523	151.96
6929	11.1376	569.80	--------	--------	--------	--------	--------	--------
7000	5.6790	715.63	3.9036	546.71	3.9036	585.05	3.9036	566.49
7300	1.8592	137.14	--------	--------	--------	--------	--------	--------
7301	1.8095	136.64	--------	--------	--------	--------	--------	--------
7302	2.0009	147.60	--------	--------	--------	--------	--------	--------

TABLE 11 (Continued)

7304	2.0047	142.89	--------	--------	--------	--------	--------	--------
7305	9.4492	465.26	5.1349	293.65	5.1349	295.22	5.1349	295.91
7306	1.6123	113.93	--------	--------	--------	--------	--------	--------
7307	1.5837	107.75	--------	--------	--------	--------	--------	--------
7309	1.9542	130.66	--------	--------	--------	--------	--------	--------
7320	1.6895	131.06	--------	--------	--------	--------	--------	--------
7325	9.8855	530.18	--------	--------	--------	--------	--------	--------
7329	2.0765	124.39	--------	--------	--------	--------	--------	--------
7350	1.7217	133.28	--------	--------	--------	--------	--------	--------
7354	5.8988	321.72	4.3436	248.32	4.3436	248.25	4.3436	249.37
7355	16.5352	809.86	--------	--------	--------	--------	--------	--------
7359	2.0586	123.44	--------	--------	--------	--------	--------	--------
7360	1.8918	139.75	--------	--------	--------	--------	--------	--------
7365	11.7609	510.29	--------	--------	--------	--------	--------	--------
7369	2.0457	121.96	--------	--------	--------	--------	--------	--------
7380	2.3921	158.67	--------	--------	--------	--------	--------	--------
7381	2.6313	175.23	--------	--------	--------	--------	--------	--------
7385	1.3132	123.37	--------	--------	--------	--------	--------	--------
7386	2.0997	156.56	--------	--------	--------	--------	--------	--------
7387	2.6249	168.96	--------	--------	--------	--------	--------	--------
7400	2.8532	189.33	--------	--------	--------	--------	--------	--------
7401	2.9413	200.39	--------	--------	--------	--------	--------	--------
7404	1.8153	147.82	--------	--------	--------	--------	--------	--------
7405	1.3063	123.64	--------	--------	--------	--------	--------	--------
7406	1.4886	128.28	--------	--------	--------	--------	--------	--------
7409	2.1022	124.21	--------	--------	--------	--------	--------	--------
7420	6.7762	417.40	--------	--------	--------	--------	--------	--------
7421	3.7673	245.20	--------	--------	--------	--------	--------	--------
7422	4.4232	231.83	--------	--------	--------	--------	--------	--------
7424	1.6386	137.49	--------	--------	--------	--------	--------	--------
7425	1.2994	123.68	--------	--------	--------	--------	--------	--------
7426	1.5215	129.32	--------	--------	--------	--------	--------	--------
7427	2.4755	162.68	--------	--------	--------	--------	--------	--------
7429	2.2483	129.94	--------	--------	--------	--------	--------	--------
7430	8.3623	447.20	4.9872	329.45	4.9872	320.20	4.9872	316.92
7431	4.3528	260.13	--------	--------	--------	--------	--------	--------
7432	6.2504	296.62	--------	--------	--------	--------	--------	--------
7434	1.5490	134.47	--------	--------	--------	--------	--------	--------

TABLE 11 (Continued)

7435	1.2953	124.10	--------	--------	--------	--------	--------	--------
7436	1.5009	129.08	--------	--------	--------	--------	--------	--------
7437	2.2180	156.85	--------	--------	--------	--------	--------	--------
7439	2.2412	129.20	1.6520	117.82	1.6520	121.24	1.6520	118.41
7440	6.4681	406.41	--------	--------	--------	--------	--------	--------
7441	3.3310	240.47	--------	--------	--------	--------	--------	--------
7442	2.4138	176.20	--------	--------	--------	--------	--------	--------
7444	1.1386	104.52	--------	--------	--------	--------	--------	--------
7445	1.0698	102.51	--------	--------	--------	--------	--------	--------
7446	1.1890	107.05	--------	--------	--------	--------	--------	--------
7447	1.2262	108.75	--------	--------	--------	--------	--------	--------
7449	1.0997	101.92	--------	--------	--------	--------	--------	--------
7450	4.2550	312.87	2.2585	212.40	2.2585	206.20	2.2585	210.98
7451	2.8877	232.20	1.9065	189.24	1.9065	180.84	1.9065	179.26
7452	2.1619	163.69	1.3941	130.27	1.3941	134.41	1.3941	123.50
7454	--------	--------	0.9339	97.55	0.9339	97.55	0.9339	98.45
7455	1.0594	98.03	0.9339	91.28	0.9339	91.58	0.9339	92.18
7456	--------	--------	1.2586	108.74	1.2586	110.88	1.2586	105.81
7457	1.7389	128.30	1.4313	122.81	1.4313	125.37	1.4313	117.76
7459	1.7229	112.20	1.4468	115.65*	1.4468	118.96*	1.4468	116.23*
7470	2.8524	208.69	--------	--------	--------	--------	--------	--------
7475	1.6619	124.03	--------	--------	--------	--------	--------	--------
7479	1.8443	111.59	--------	--------	--------	--------	--------	--------
7480	3.6497	219.19	--------	--------	--------	--------	--------	--------
7485	1.6555	123.37	--------	--------	--------	--------	--------	--------
7489	1.8811	112.93	--------	--------	--------	--------	--------	--------
7520	3.5323	204.72	--------	--------	--------	--------	--------	--------
7525	1.6410	121.50	--------	--------	--------	--------	--------	--------
7529	1.9142	112.40	--------	--------	--------	--------	--------	--------
7550	2.0181	155.44	1.4982	142.40	1.4982	139.12	1.4982	139.80
7551	1.3111	127.42	1.7830*	147.20*	1.7830*	140.54*	1.7830*	138.36*
7552	1.7642	134.44	1.2435	121.10	1.2435	118.20	1.2435	119.49
7554	1.2292	100.42	0.9524	92.45	0.9524	92.07	0.9524	93.74
7555	1.6290	120.39	1.0440	92.13	1.0440	92.50	1.0440	92.94
7556	1.1367	95.18	0.9957	93.27	0.9957	94.70	0.9957	90.39
7557	1.1367	95.30	1.0045	98.01*	1.0045	100.55*	1.0045	93.62
7559	1.3765	105.84	1.1863	108.70*	1.1863	111.72*	1.1863	109.19*
7620	2.6663	186.56	--------	--------	--------	--------	--------	--------

TABLE 11 (Continued)

7625	2.4676	147.00	--------	--------	--------	--------	--------	--------
7629	1.9983	112.47	--------	--------	--------	--------	--------	--------
7690	2.0361	154.34	--------	--------	--------	--------	--------	--------
7691	1.6981	126.44	--------	--------	--------	--------	--------	--------
7692	1.4404	122.60	--------	--------	--------	--------	--------	--------
7694	1.5040	117.05	--------	--------	--------	--------	--------	--------
7695	2.0441	137.32	--------	--------	--------	--------	--------	--------
7696	1.1431	96.70	--------	--------	--------	--------	--------	--------
7697	1.2038	97.60	--------	--------	--------	--------	--------	--------
7699	1.8440	119.85	--------	--------	--------	--------	--------	--------
7760	1.3395	126.52	--------	--------	--------	--------	--------	--------
7761	1.1525	106.56	--------	--------	--------	--------	--------	--------
7762	1.4323	110.52	--------	--------	--------	--------	--------	--------
7764	1.8726	125.63	--------	--------	--------	--------	--------	--------
7766	1.2166	98.57	--------	--------	--------	--------	--------	--------
7767	1.6074	103.35	--------	--------	--------	--------	--------	--------
7769	1.7254	113.58	--------	--------	--------	--------	--------	--------
7830	2.4858	163.94	--------	--------	--------	--------	--------	--------
7831	1.8678	133.47	--------	--------	--------	--------	--------	--------
7832	1.8882	140.88	--------	--------	--------	--------	--------	--------
7834	4.2387	203.91	--------	--------	--------	--------	--------	--------
7835	3.1482	164.24	--------	--------	--------	--------	--------	--------
7836	1.3565	110.82	--------	--------	--------	--------	--------	--------
7837	1.3791	107.55	--------	--------	--------	--------	--------	--------
7839	1.3499	99.97	--------	--------	--------	--------	--------	--------
7850	2.7733	189.09	--------	--------	--------	--------	--------	--------
7852	2.5031	189.44	--------	--------	--------	--------	--------	--------
7855	1.9850	147.65	--------	--------	--------	--------	--------	--------
7859	1.5344	95.80	--------	--------	--------	--------	--------	--------
7920	8.7343	432.64	4.6283	324.62	4.6283	303.13	4.6283	290.35
7921	6.0297	281.27	3.8005	218.69	3.8005	211.68	3.8005	212.44
7922	2.6783	190.20	1.4085	128.75	1.4085	126.25	1.4085	127.91
7924	-------	-------	2.7835	173.45	2.7835	176.76	2.7835	175.35
7925	4.1902	214.60	3.7277	204.83	3.7277	205.88	3.7277	206.07
7926	-------	-------	1.1678	105.83	1.1678	132.65	1.1678	104.21
7927	-------	-------	1.0961	101.53	1.0961	124.43	1.0961	98.54
7929	1.4087	95.08	1.1534	98.57*	1.1534	101.45*	1.1534	98.31*

TABLE 11 (Continued)

7930	4.7682	252.95	3.9224	204.11	3.9224	195.98	3.9224	194.95
7931	4.2399	192.57	2.5843	155.27	2.5843	149.73	2.5843	149.54
7935	6.5820	242.44	5.2521	234.80	5.2521	235.90	5.2521	235.69
7937	2.1639	143.05	1.2170	114.73	1.2170	119.93	1.2170	121.21
7939	1.2341	93.86	0.9493	98.06*	0.9493	100.92*	0.9493	97.80*
50101	4.4152	300.17	--------	--------	--------	--------	--------	--------
50102	4.4152	300.17	--------	--------	--------	--------	--------	--------
50103	4.4152	300.17	--------	--------	--------	--------	--------	--------
50104	4.0615	277.01	--------	--------	--------	--------	--------	--------
50106	3.4876	239.43	--------	--------	--------	--------	--------	--------
50107	2.6488	184.51	--------	--------	--------	--------	--------	--------
50108	2.9260	215.64	--------	--------	--------	--------	--------	--------
50109	3.0427	223.92	--------	--------	--------	--------	--------	--------
50111	2.0480	153.37	--------	--------	--------	--------	--------	--------
50301	6.0717	411.79	4.4249	317.22	4.4249	313.30	4.4249	311.59
50302	6.0717	411.79	--------	--------	--------	--------	--------	--------
50303	6.0717	411.79	--------	--------	--------	--------	--------	--------
50304	5.5854	381.62	--------	--------	--------	--------	--------	--------
50306	4.8569	336.42	--------	--------	--------	--------	--------	--------
50307	3.5820	257.32	--------	--------	--------	--------	--------	--------
50308	5.1890	342.04	--------	--------	--------	--------	--------	--------
50309	5.4998	361.39	--------	--------	--------	--------	--------	--------
50311	4.1508	277.42	--------	--------	--------	--------	--------	--------
50501	5.4842	396.44	--------	--------	--------	--------	--------	--------
50502	5.3191	385.84	--------	--------	--------	--------	--------	--------
50503	5.3191	385.84	--------	--------	--------	--------	--------	--------
50504	5.0449	368.22	--------	--------	--------	--------	--------	--------
50506	4.3869	325.94	--------	--------	--------	--------	--------	--------
50507	3.1805	248.42	--------	--------	--------	--------	--------	--------
50508	4.2068	303.45	--------	--------	--------	--------	--------	--------
50509	4.5008	323.20	--------	--------	--------	--------	--------	--------
50511	2.9445	218.68	--------	--------	--------	--------	--------	--------
50801	2.8783	296.45	--------	--------	--------	--------	--------	--------
50802	2.7638	244.61	--------	--------	--------	--------	--------	--------
50803	2.7638	242.96	--------	--------	--------	--------	--------	--------
50804	2.1496	198.98	--------	--------	--------	--------	--------	--------

TABLE 11 (Continued)

50806	1.5252	165.23	--------	--------	--------	--------	--------	--------
50807	1.3712	121.23	--------	--------	--------	--------	--------	--------
50808	1.7698	178.47	--------	--------	--------	--------	--------	--------
50809	2.1496	199.03	--------	--------	--------	--------	--------	--------
50811	0.9269	105.80	--------	--------	--------	--------	--------	--------
51301	3.5668	262.83	--------	--------	--------	--------	--------	--------
51302	2.7012	220.13	--------	--------	--------	--------	--------	--------
51303	2.5648	216.54	--------	--------	--------	--------	--------	--------
51304	2.3066	189.55	--------	--------	--------	--------	--------	--------
51306	1.7843	157.87	--------	--------	--------	--------	--------	--------
51307	1.1894	110.39	--------	--------	--------	--------	--------	--------
51308	2.1364	177.23	--------	--------	--------	--------	--------	--------
51309	2.3069	189.64	1.8682	159.79	1.8682	153.36	1.8682	153.55
51311	1.5710	129.89	--------	--------	--------	--------	--------	--------
51601	8.5071	513.68	--------	--------	--------	--------	--------	--------
51602	8.7104	525.52	--------	--------	--------	--------	--------	--------
51603	8.3361	503.72	--------	--------	--------	--------	--------	--------
51604	7.9108	478.95	--------	--------	--------	--------	--------	--------
51606	6.8475	417.01	--------	--------	--------	--------	--------	--------
51607	5.3589	330.30	--------	--------	--------	--------	--------	--------
51608	7.0209	436.91	--------	--------	--------	--------	--------	--------
51609	7.4063	460.22	--------	--------	--------	--------	--------	--------
51611	5.8268	364.72	--------	--------	--------	--------	--------	--------
55305	4.6692	274.36	--------	--------	--------	--------	--------	--------
55403	5.1191	385.32	--------	--------	--------	--------	--------	--------
55483	3.2436	230.55	--------	--------	--------	--------	--------	--------
55623	2.1486	175.25	--------	--------	--------	--------	--------	--------
55833	3.0996	194.53	--------	--------	--------	--------	--------	--------
55923	4.9806	326.27	--------	--------	--------	--------	--------	--------
56282	3.2140	210.60	--------	--------	--------	--------	--------	--------
56283	4.8862	276.14	--------	--------	--------	--------	--------	--------
56505	8.4533	398.99	--------	--------	--------	--------	--------	--------
56515	11.6283	573.80	--------	--------	--------	--------	--------	--------
56525	10.4298	554.25	--------	--------	--------	--------	--------	--------
56534	6.1057	401.17	--------	--------	--------	--------	--------	--------
56535	4.2065	210.69	--------	--------	--------	--------	--------	--------
56565	9.8863	493.96	--------	--------	--------	--------	--------	--------

TABLE 11 (Continued)

56575	9.3886	460.85	--------	--------	--------	--------	--------	--------
60101	11.3066	1593.37	--------	--------	--------	--------	--------	--------
60109	28.4075	1900.43	--------	--------	--------	--------	--------	--------
60111	22.0050	1574.18	--------	--------	--------	--------	--------	--------
60112	18.6081	1364.96	--------	--------	--------	--------	--------	--------
60122	10.7502	1349.10	--------	--------	--------	--------	--------	--------
60130	3.8311	467.05	--------	--------	--------	--------	--------	--------
60133	14.9803	1840.32	--------	--------	--------	--------	--------	--------
60203	22.3891	1635.13	--------	--------	--------	--------	--------	--------
60209	26.1623	1669.68	--------	--------	--------	--------	--------	--------
60303	19.4641	1389.21	--------	--------	--------	--------	--------	--------
60309	22.9682	1544.29	--------	--------	--------	--------	--------	--------
60310	18.1452	1434.25	--------	--------	--------	--------	--------	--------
60319	3.0302	300.87	--------	--------	--------	--------	--------	--------
60320	16.6111	1335.79	--------	--------	--------	--------	--------	--------
60321	13.5948	1109.59	--------	--------	--------	--------	--------	--------
60322	14.4344	1124.46	--------	--------	--------	--------	--------	--------
60323	10.3290	914.35	--------	--------	--------	--------	--------	--------
60324	1.6490	178.23	--------	--------	--------	--------	--------	--------
60325	16.4869	1323.49	--------	--------	--------	--------	--------	--------
60326	1.6490	178.23	--------	--------	--------	--------	--------	--------
60327	1.6490	178.48	--------	--------	--------	--------	--------	--------
60400	9.2338	750.02	--------	--------	--------	--------	--------	--------
60405	11.5627	875.02	--------	--------	--------	--------	--------	--------
60407	14.3378	1016.14	7.0504	439.44	7.0504	457.58	7.0504	457.24
60409	12.2104	909.17	6.8414	433.56	6.8414	448.26	6.8414	448.50
60411	9.3052	753.03	--------	--------	--------	--------	--------	--------
60413	9.2966	764.57	6.2940	405.75	6.2940	414.20	6.2940	417.34
60418	10.5529	760.29	6.0381	404.50	6.0381	413.57	6.0381	420.49
60420	30.3138	2054.71	--------	--------	--------	--------	--------	--------
60500	8.4117	706.18	--------	--------	--------	--------	--------	--------
60507	10.9148	819.72	--------	--------	--------	--------	--------	--------
60509	7.6230	648.56	--------	--------	--------	--------	--------	--------
60510	7.4458	653.83	--------	--------	--------	--------	--------	--------
60517	9.6180	734.15	--------	--------	--------	--------	--------	--------
60601	7.5440	648.82	--------	--------	--------	--------	--------	--------

TABLE 11 (Continued)

60606	-------	-------	4.1750	301.77	4.1750	309.73	4.1750	310.08
60607	8.9576	698.99	--------	--------	--------	--------	--------	--------
60609	7.0014	614.65	--------	--------	--------	--------	--------	--------
60610	8.0565	670.29	--------	--------	--------	--------	--------	--------
60614	-------	-------	3.8806	289.30	3.8806	291.97	3.8806	294.96
60617	8.1878	665.16	4.8446	342.28	4.8446	348.11	4.8446	354.28
60701	7.3483	628.45	--------	--------	--------	--------	--------	--------
60707	12.2738	939.97	--------	--------	--------	--------	--------	--------
60709	12.7622	940.12	--------	--------	--------	--------	--------	--------
60711	10.7803	821.62	--------	--------	--------	--------	--------	--------
60716	7.9953	626.15	--------	--------	--------	--------	--------	--------
60802	7.2203	615.38	--------	--------	--------	--------	--------	--------
60806	9.9913	747.69	--------	--------	--------	--------	--------	--------
60807	12.3241	937.47	--------	--------	--------	--------	--------	--------
60809	12.1928	931.14	7.3283	458.96	7.3283	474.91	7.3283	474.32
60810	9.9455	762.03	--------	--------	--------	--------	--------	--------
60816	8.8594	706.93	--------	--------	--------	--------	--------	--------
60820	24.2447	1838.93	--------	--------	--------	--------	--------	--------
60907	8.7572	617.48	4.9071	334.37	4.9071	339.55	4.9071	339.33
60909	10.5910	755.86	5.9317	392.89	5.9317	407.72	5.9317	405.86
60911	9.0791	661.07	--------	--------	--------	--------	--------	--------
60915	6.2332	511.28	3.9742	289.19	3.9742	294.02	3.9742	296.68
60920	20.2561	1440.64	--------	--------	--------	--------	--------	--------
61009	8.8595	641.45	--------	--------	--------	--------	--------	--------
61020	18.4014	1324.66	--------	--------	--------	--------	--------	--------
61109	6.6787	493.46	--------	--------	--------	--------	--------	--------
61111	7.3931	518.75	--------	--------	--------	--------	--------	--------
61114	3.7472	320.89	--------	--------	--------	--------	--------	--------
61120	13.9117	994.64	--------	--------	--------	--------	--------	--------
61207	-------	-------	2.3422	193.12	2.3422	191.96	2.3422	191.73
61209	5.2717	409.72	3.2534	240.79	3.2534	243.85	3.2534	242.65
61213	-------	-------	2.3445	192.67	2.3445	191.60	2.3445	192.52
61220	11.2730	840.81	--------	--------	--------	--------	--------	--------
61309	4.3393	332.43	--------	--------	--------	--------	--------	--------
61311	4.3970	338.27	--------	--------	--------	--------	--------	--------
61313	2.8261	236.30	--------	--------	--------	--------	--------	--------
61409	2.9496	239.69	--------	--------	--------	--------	--------	--------

TABLE 11 (Continued)

61420	7.3599	566.68	--------	--------	--------	--------	--------	--------
61509	2.5100	215.63	--------	--------	--------	--------	--------	--------
61609	2.0963	186.08	--------	--------	--------	--------	--------	--------
61610	3.5214	263.68	--------	--------	--------	--------	--------	--------
61611	2.0176	181.38	--------	--------	--------	--------	--------	--------
61613	1.6526	147.82	--------	--------	--------	--------	--------	--------
61620	4.8487	375.37	--------	--------	--------	--------	--------	--------
61709	2.0342	150.57	--------	--------	--------	--------	--------	--------
61809	2.2513	169.59	--------	--------	--------	--------	--------	--------
61909	2.3643	191.72	--------	--------	--------	--------	--------	--------
62009	2.8849	216.52	--------	--------	--------	--------	--------	--------
62109	2.8597	215.61	--------	--------	--------	--------	--------	--------
62120	4.7753	368.44	--------	--------	--------	--------	--------	--------
70300	10.2076	1329.23	--------	--------	--------	--------	--------	--------
70350	9.6378	1147.40	--------	--------	--------	--------	--------	--------
70375	10.8676	1380.48	--------	--------	--------	--------	--------	--------
70400	4.0300	498.80	--------	--------	--------	--------	--------	--------
70450	3.5805	414.87	--------	--------	--------	--------	--------	--------
70475	4.7284	576.93	--------	--------	--------	--------	--------	--------
70500	15.2473	1434.43	--------	--------	--------	--------	--------	--------
70550	12.8114	1122.06	--------	--------	--------	--------	--------	--------
70575	13.4979	1297.62	--------	--------	--------	--------	--------	--------
70600	18.3834	1593.51	--------	--------	--------	--------	--------	--------
70650	15.4467	1250.11	--------	--------	--------	--------	--------	--------
70675	16.2777	1435.56	--------	--------	--------	--------	--------	--------
70700	23.2298	1863.15	--------	--------	--------	--------	--------	--------
70750	19.5170	1436.51	--------	--------	--------	--------	--------	--------
70775	20.5697	1643.09	--------	--------	--------	--------	--------	--------
70800	19.0247	1542.72	--------	--------	--------	--------	--------	--------
70850	15.9836	1217.82	--------	--------	--------	--------	--------	--------
70875	16.8465	1379.36	--------	--------	--------	--------	--------	--------
70900	8.9700	817.29	5.9023	402.21	5.9023	429.47	5.9023	427.35
70950	8.8877	825.50	5.9656	468.78	5.9656	506.26	5.9656	485.08
70956	8.8269	816.89	5.9551	462.58	5.9551	499.06	5.9551	469.42
70963	8.9562	845.58	5.9565	452.38	5.9565	485.86	5.9565	454.01
70969	8.9882	849.12	5.9439	439.49	5.9439	468.67	5.9439	441.17
70975	8.9970	846.84	5.9275	423.52	5.9275	448.22	5.9275	428.53

TABLE 11 (Continued)

70981	8.8710	807.99	5.8974	412.87	5.8974	434.93	5.8974	423.08
70988	9.0096	829.80	5.9023	413.98	5.9023	435.29	5.9023	428.70
70994	8.9337	816.92	5.8919	404.32	5.8919	431.37	5.8919	427.80
71000	6.5956	594.46	4.4057	308.88	4.4057	319.26	4.4057	319.08
71050	6.7588	598.03	4.5434	352.78	4.5434	370.76	4.5434	357.82
71056	6.7846	597.70	4.6004	352.51	4.6004	370.20	4.6004	350.99
71063	6.8923	604.43	4.6989	349.05	4.6989	365.23	4.6989	344.86
71069	7.8825	681.17	4.7637	345.96	4.7637	359.50	4.7637	342.72
71075	7.9321	683.40	4.7513	339.21	4.7513	349.52	4.7513	338.87
71081	6.9527	606.68	4.6594	328.19	4.6594	336.13	4.6594	331.21
71088	6.8045	599.88	4.5509	319.71	4.5509	326.64	4.5509	324.95
71094	6.6925	594.96	4.4463	312.59	4.4463	321.53	4.4463	321.12
71100	5.9490	532.88	---------	---------	---------	---------	---------	---------
71150	6.3037	539.76	---------	---------	---------	---------	---------	---------
71175	6.1279	557.20	---------	---------	---------	---------	---------	---------
71200	5.6881	486.45	3.6443	265.92	3.6443	271.68	3.6443	271.94
71250	6.0008	521.77	3.8093	299.34	3.8093	312.21	3.8093	302.62
71256	---------	---------	3.7401	291.21	3.7401	303.37	3.7401	288.71
71263	5.6318	512.37	3.6959	283.39	3.6959	294.07	3.6959	278.80
71269	---------	---------	3.7592	281.97	3.7592	290.68	3.7592	278.98
71275	5.9114	514.44	3.6397	271.05	3.6397	276.44	3.6397	270.15
71281	---------	---------	3.6268	267.88	3.6268	271.67	3.6268	269.86
71288	5.8889	509.04	3.6477	268.10	3.6477	271.29	3.6477	271.65
71294	---------	---------	3.6244	266.87	3.6244	270.44	3.6244	271.11
71300	4.9744	410.40	---------	---------	---------	---------	---------	---------
71350	4.4942	399.27	---------	---------	---------	---------	---------	---------
71356	4.0232	366.78	---------	---------	---------	---------	---------	---------
71363	4.0266	362.00	---------	---------	---------	---------	---------	---------
71369	4.1255	358.21	---------	---------	---------	---------	---------	---------
71375	4.9494	440.73	---------	---------	---------	---------	---------	---------
71381	4.2376	361.90	---------	---------	---------	---------	---------	---------
71388	4.2718	369.59	---------	---------	---------	---------	---------	---------
71394	4.3502	376.87	---------	---------	---------	---------	---------	---------
71400	3.2248	280.84	2.1947	184.38	2.1947	183.24	2.1947	183.67
71450	3.3797	265.67	2.2373	191.87	2.2373	197.69	2.2373	192.32
71456	2.8558	252.00	2.2557	191.41	2.2557	196.68	2.2557	187.82
71463	2.8332	246.64	2.2582	187.79	2.2582	191.87	2.2582	183.45

TABLE 11 (Continued)

71469	2.8885	241.86	2.2439	182.35	2.2439	185.52	2.2439	180.23
71475	3.7140	311.83	2.2241	179.66	2.2241	181.33	2.2241	180.06
71481	3.0079	248.74	2.2297	182.21	2.2297	182.53	2.2297	183.89
71488	3.0533	258.20	2.2319	184.70	2.2319	183.84	2.2319	185.78
71494	3.1452	266.57	2.2215	184.31	2.2215	182.94	2.2215	184.41
71500	2.1567	208.73	--------	--------	--------	--------	--------	--------
71550	2.3962	180.44	--------	--------	--------	--------	--------	--------
71556	1.9077	170.61	--------	--------	--------	--------	--------	--------
71563	1.8930	167.84	--------	--------	--------	--------	--------	--------
71569	1.8948	165.08	--------	--------	--------	--------	--------	--------
71575	2.4714	210.78	--------	--------	--------	--------	--------	--------
71581	1.9658	167.99	--------	--------	--------	--------	--------	--------
71588	2.0298	175.26	--------	--------	--------	--------	--------	--------
71594	2.0952	183.04	--------	--------	--------	--------	--------	--------
71600	1.7580	159.98	--------	--------	--------	--------	--------	--------
71650	1.6562	148.52	--------	--------	--------	--------	--------	--------
71675	1.9713	172.56	--------	--------	--------	--------	--------	--------
71700	2.0958	160.65	--------	--------	--------	--------	--------	--------
71750	2.2080	164.06	--------	--------	--------	--------	--------	--------
71756	2.2080	162.82	--------	--------	--------	--------	--------	--------
71763	2.2080	161.57	--------	--------	--------	--------	--------	--------
71769	2.2080	160.16	--------	--------	--------	--------	--------	--------
71775	2.5848	192.39	--------	--------	--------	--------	--------	--------
71781	1.9222	139.26	--------	--------	--------	--------	--------	--------
71788	1.9222	144.71	--------	--------	--------	--------	--------	--------
71794	2.0502	153.31	--------	--------	--------	--------	--------	--------
71800	2.1548	168.71	--------	--------	--------	--------	--------	--------
71850	2.1830	161.51	--------	--------	--------	--------	--------	--------
71875	2.5559	191.72	--------	--------	--------	--------	--------	--------
80000	10.9675	927.15	--------	--------	--------	--------	--------	--------
80002	6.8657	678.15	--------	--------	--------	--------	--------	--------
80003	6.8657	678.15	--------	--------	--------	--------	--------	--------
80004	10.9675	933.02	--------	--------	--------	--------	--------	--------
80005	13.3808	745.75	--------	--------	--------	--------	--------	--------
80008	1.8574	118.31	--------	--------	--------	--------	--------	--------
80009	1.8574	118.31	--------	--------	--------	--------	--------	--------

TABLE 11 (Continued)

80010	5.5723	354.61	--------	--------	--------	--------	--------	--------
80011	13.2632	750.68	--------	--------	--------	--------	--------	--------
80012	3.3466	201.43	--------	--------	--------	--------	--------	--------
80013	13.2632	752.05	--------	--------	--------	--------	--------	--------
80016	13.2632	750.68	--------	--------	--------	--------	--------	--------
80017	3.3466	201.43	--------	--------	--------	--------	--------	--------
80018	13.2632	752.05	--------	--------	--------	--------	--------	--------
80034	17.6351	1170.47	--------	--------	--------	--------	--------	--------
80035	11.7436	819.51	--------	--------	--------	--------	--------	--------
80037	17.1422	850.25	--------	--------	--------	--------	--------	--------
80043	10.2195	553.77	--------	--------	--------	--------	--------	--------
80045	8.4141	552.96	--------	--------	--------	--------	--------	--------
80049	10.7021	677.93	--------	--------	--------	--------	--------	--------
80053	8.5643	569.01	--------	--------	--------	--------	--------	--------
80057	10.7407	603.93	--------	--------	--------	--------	--------	--------
80110	26.5149	1381.24	--------	--------	--------	--------	--------	--------
80115	26.2902	1819.94	--------	--------	--------	--------	--------	--------
80119	9.1746	715.52	--------	--------	--------	--------	--------	--------
80123	4.7555	383.94	--------	--------	--------	--------	--------	--------
80127	8.4141	552.64	--------	--------	--------	--------	--------	--------
80131	10.2050	641.58	--------	--------	--------	--------	--------	--------
80135	8.3559	521.40	--------	--------	--------	--------	--------	--------
80137	6.7476	456.09	--------	--------	--------	--------	--------	--------
80143	9.9036	545.81	--------	--------	--------	--------	--------	--------
80147	4.5945	323.55	--------	--------	--------	--------	--------	--------
80148	1.8477	146.39	--------	--------	--------	--------	--------	--------
80150	4.6757	338.43	--------	--------	--------	--------	--------	--------
80151	1.8166	145.94	--------	--------	--------	--------	--------	--------
80153	4.3331	307.86	--------	--------	--------	--------	--------	--------
80154	2.3542	179.22	--------	--------	--------	--------	--------	--------
80156	3.6340	265.07	--------	--------	--------	--------	--------	--------
80157	2.6057	189.00	--------	--------	--------	--------	--------	--------
80158	2.6267	191.85	--------	--------	--------	--------	--------	--------
80162	7.5190	411.30	--------	--------	--------	--------	--------	--------
80163	5.0159	290.11	--------	--------	--------	--------	--------	--------
80164	5.0159	290.11	--------	--------	--------	--------	--------	--------
80165	4.6291	348.22	--------	--------	--------	--------	--------	--------

TABLE 11 (Concluded)

80166	1.7804	142.23	--------	--------	--------	--------	--------	--------
80167	1.6099	141.16	--------	--------	--------	--------	--------	--------
80168	4.0456	293.70	--------	--------	--------	--------	--------	--------
80169	1.6698	139.50	--------	--------	--------	--------	--------	--------
80174	20.2177	964.05	--------	--------	--------	--------	--------	--------
80175	8.8866	528.68	--------	--------	--------	--------	--------	--------
81609	5.6139	398.39	--------	--------	--------	--------	--------	--------
81809	2.5982	197.17	--------	--------	--------	--------	--------	--------
82094	14.2882	984.31	--------	--------	--------	--------	--------	--------
82194	11.1273	832.22	--------	--------	--------	--------	--------	--------
82294	7.8978	631.57	--------	--------	--------	--------	--------	--------
82394	7.4053	560.29	--------	--------	--------	--------	--------	--------
82494	5.4729	406.38	--------	--------	--------	--------	--------	--------
82594	3.5812	277.69	--------	--------	--------	--------	--------	--------
82666	3.4164	249.54	--------	--------	--------	--------	--------	--------
82694	2.7256	219.66	--------	--------	--------	--------	--------	--------
82994	15.2396	1150.49	--------	--------	--------	--------	--------	--------
82999	2.3408	172.33	--------	--------	--------	--------	--------	--------
83000	13.2632	750.80	--------	--------	--------	--------	--------	--------
83001	13.2632	750.80	--------	--------	--------	--------	--------	--------
83002	9.2881	581.83	--------	--------	--------	--------	--------	--------

* - TAL HEAT RATES AND/OR HEAT LOADS GREATER THAN THOSE OF THE IVBC-3 DESIGN.

TABLE 12 SUMMARY OF TAL ENVIRONMENT EXCEEDANCES OVER DESIGN

	IVBC-3 DESIGN		DAKAR EARLY TAL		DAKAR LATE TAL		MORUN EARLY TAL	
BODY POINT	QMAX	QLOAD	QMAX	QLOAD	QMAX	QLOAD	QMAX	QLOAD
7459	1.7229	112.20	1.4468	115.65*	1.4468	118.96*	1.4468	116.23*
7551	1.3111	127.42	1.7830*	147.20*	1.7830*	140.54*	1.7830*	138.36*
7557	1.1367	95.30	1.0045	98.01*	1.0045	100.55*	1.0045	93.62
7559	1.3765	105.84	1.1863	108.70*	1.1863	111.72*	1.1863	109.19*
7929	1.4087	95.08	1.1534	98.57*	1.1534	101.45*	1.1534	98.31*
7939	1.2341	93.86	0.9493	98.06*	0.9493	100.92*	0.9493	97.80*

Section 6.0

CONCLUSIONS

Throughout the extent of this contract, REMTECH has developed and improved empirical math models to calculate aero dynamic heating on the ET for ascent trajectory conditions. Huge quantities of wind tunnel and flight data were analyzed and results incorporated in the calculation techniques. The REMTECH results were used to verify RI methodology and check environment outputs. In many cases the REMTECH methods were adopted by the Shuttle aerothermal community as baseline models to use for generating design thermal environments. The methodology is explained in detail in reference 5. A computer code (reference 6) was developed which provides MSFC with a tool that quickly calculates an aeroheating flight environment for any surface location on the ET body or protuberance. An interactive input routine was developed to make the input to the code simple and straight forward.

Conclusions that were drawn from the REMTECH studies that were conducted under this contract are as follows:

(1) Turbulent and laminar heating for undisturbed flow can be calculated with sufficient accuracy for design purposes using appropriate simple models for shock shape, surface pressure, and heat transfer.

(2) Accurate simulation of the flight vehicle geometry (including protuberances) must be effected in wind tunnel models to provide an acceptable data base. Protuberances and high heating regions must be densely instrumented to identify and provide sufficient data at the hot spots.

(3) The changes in trajectory with the evolution of the Shuttle system did not have as large an affect on aeroheating as suspected during the TPS development stages.

(4) The difference between aeroheating results calculated by rarefied heating methodology and laminar continuous flow methodology during second stage flight was not significant. Early in the program the second stage trajectory and MECO altitude had significant variations during shaping studies which motivated the incorporation of rarefied flow methodology into the design methodology.

(5) The scaling of h_i/h_u as a function of Mach Number from wind tunnel model to flight is appropriate for design if accurate simulation of model geometry is accomplished and the state laminar, turbulent) of the boundary layer is identical between tunnel/flight.

(6) Temperature mismatch corrections required in the reduction of the flight data were calculated using methods that were, at best, only crude approximations. The uncertainties of the temperature mismatch plus some extremely high measurements that were judged to be gage anomalies (without reliable evidence) resulted in a flight data base that required <u>too much</u> engineering judgement for application.

(7) The existing data base (wind tunnel and flight) that is used to predict RTLS and TAL environments is inadequate to produce accurate environments on and in the vicinity of protuberances (hot regions). Therefore, extreme conservatism should be used to predict environments for these cases if there is a reasonable probability that these abort flights will be flown by the Shuttle.

(8) The technical approach for simulating SOFI response to a flight environment in a wind tunnel was crude and no improved techniques evolved during the 10 years of Shuttle system development. Some of the extravagant investment in wind tunnel facility time should have been invested in research studies and instrumentation development that would have resulted in a more sophisticated simulation of SOFI response to flight environments. The equilibrium ablation temperature of SOFI was never firmly established.

Section 7.0

REFERENCES

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2. Space Shuttle IVBC-3 Aerodynamic Heating Design Environments for the External Tank Data Tape DP 4170, Delta DCR, November 1986.

3. Space Shuttle IVBC-3 Aerodynamic Heating Data Book, External Tank - Ascent, Rockwell International Report STS 84-0462, November 1984.

4. Space Shuttle External Tank Thermal Data Book (Lightweight Model), Martin Marietta Dwg. No. 80900200102, July 1982.

5. Praharaj, S.C., Engel, C.D., and Warmbrod, J.D., "Aeroheating Design Methodology for the Space Shuttle External Tank," REMTECH RTR 032-01, July 1981.

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