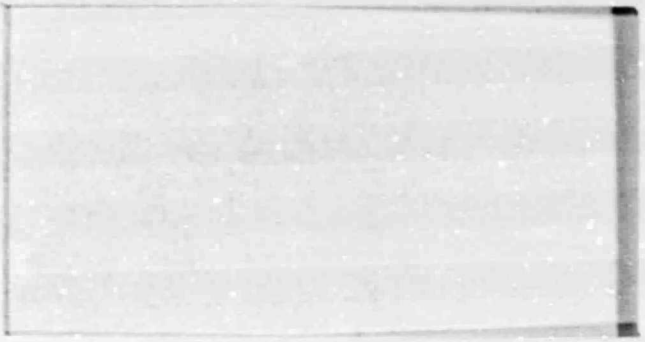

Lockheed

Missiles & Space Company, Inc.

HUNTSVILLE RESEARCH & ENGINEERING CENTER

Cummings Research Park
4800 Bradford Drive,
Huntsville, Alabama

SOLID ROCKET BOOSTER THERMAL PROTECTION SYSTEM MATERIALS DEVELOPMENT

FINAL REPORT

December 1978

Contract NAS8-31555

Prepared for National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama 35812

by

William G. Dean

APPROVED: C. Donald Andrews

C. Donald Andrews, Supervisor
Flight Technologies Section

J. S. Farrior

J.S. Farrior
Resident Director

FOREWORD

This final report presents the results of work performed by personnel of the Lockheed-Huntsville Research & Engineering Center for the Structures and Propulsion Division of NASA-Marshall Space Flight Center under Contract NAS8-31555 "Solid Rocket Booster Thermal Protection Systems Materials Development."

The NASA Contracting Officer's Representative (COR) for this contract was Dr. Kenneth E. McCoy, S&E-EP44. The period of performance for this contract was from January 1976 to November 1978.

The Lockheed-Huntsville Project Engineer for this contract was Mr. William G. Dean.

CONTENTS

1. INTRODUCTION AND SUMMARY

Since January 1976 Lockheed-Huntsville has been involved in the development of the Thermal Protection System materials for the Space Shuttle Solid Rocket Booster. Specific work performed includes:

- Thermal Analyses
- Model Design
- Model Fabrication
- Test Planning
- Models/Materials Testing
- Test Facility Operation Support
- Data Reduction
- Data Analysis
- Data Application
- TPS Design/Recommendations

Details of this work have been documented and published in various technical and monthly progress reports as the work progressed. The purpose of this Final Report is to assemble, for reference purposes, a summary of the work accomplished.

This is presented in three sections:

- Bibliography of reports published
- List of design drawings made under this contract
- Complete run log of all tests conducted in the NASA-MSFC Hot Gas Test Facility.

2. BIBLIOGRAPHY OF REPORTS PUBLISHED

The following technical reports were published under this contract:

1. Connor, L.E., "Qualification and Verification of MSA-1 TPS Material for Combined Environments," LMSC-HREC TN D568377, July 1978.
2. Connor, L.E., "Qualification and Verification of SRB Aft Skirt Curtain," LMSC-HREC TN D568409, August 1978.
3. Connor, L.E., "Qualification and Verification of the SRB Instrument Islands," LMSC-HREC TN D568410, August 1978.
4. Dean, W.G., "Qualification/Verification of SRB/Aft Skirt TPS for on-Pad Abort Environments," LMSC-HREC TN D568380, August 1978.
5. Karu, Z.S., and L.E. Connor, "Analytical Thermal Analysis of Instrumentation Islands of the Space Shuttle Solid Rocket Booster," LMSC-HREC TN D568325, May 1978.
6. Karu, Z.S., "Design of SRB Aft Attach Ring Cork Thermal Protection System," LMSC-HREC TM D568384, August 1978.
7. Karu, Z.S., "Thermal Analysis of Exposed Electrical Cables Between the Flanges of the SRB Aft Attach Ring," LMSC-HREC TN D568369, July 1978.
8. Karu, Z.S., and W.G. Dean, "SRB Materials Test and Evaluation in NASA-MSFC Hot Gas Facility, NASA-Ames 3.5 ft HWT, and AEDC Tunnel C," LMSC-HREC TM D597497, November 1977.
9. Wojciechowski, C.J., "Thermal Protection System Analysis of the Space Shuttle SRB ET Attach Ring and Kick Ring," LMSC-HREC TN D568532, November 1978.

3. TECHNICAL DRAWINGS

The following is a list of technical drawings made under this contract:

R80108, Sheet 4, "Test Section MHGF," 2-9-76 — A new drawing to show complete installation at two stations in the tunnel with TPS and cryopanel.

R80156, Rev. A, "Long Foam Panel," 2-2-76 — Redrawn to show the cutaway necessary to clear the sealing angles (R80161).

R80158, Rev. C, "Adjustable Panel Support," 3-19-76 — This new design for using various combinations of TPS and substrate thicknesses was revised through "C" to update for specification changes.

R80159, Rev. C, "TPS Panel," 3-19-76 — A new design to use with R80158 with revisions for TPS thickness changes, thermocouple requirements, and number of parts required.

R80160, "MHGF, General Arrangement," 2-2-76 — A new drawing made from design concept drawing.

R80161, "TPS, Seal Angle," 2-3-76 — A new drawing to record seal angle configuration.

R80162, Sheet 1 of 2, Rev. A, 4-20-76 — "Wedge Components Tunnel C AEDC Installation and Details," — An assembly drawing showing the water cooled adaptor mounted on the existing AEDC wedge fixture.

R80162, Sheet 2 of 2, Rev. A, 4-20-76 — "Water Cooled Adaptor Tunnel C AEDC, Installation and Details," — Fabrication details of water cooled adaptor/jacket.

R80163, Rev. A, 4-20-76 — "TPS Panels for Water Cooled Wedge Tunnel C, AEDC, Details," — Substrate and TPS thickness and hole pattern.

R80164, Rev. A, 4-20-76 — "TPS Adaptor Wedge-AEDC, Tunnel C Details," — Height adjustor jacks, fabrication details.

R80166, "TPS Panels for MSFC Large Radiant/Vacuum Facility (20 in. x 30 in.)," 5-17-76.

R80167, MHGF Quarter Panel Adapter for Nominal 1 in. Thick Foam Panels.

R80168, TPS Panel Substrate for Nominal 1 in. Foam Basic AEDC Wedge.

R80169, TPS Substrate for Use in Nominal 1 in. MHGF Quarter Panel Adaptor.

R80170, Calibration Panel for Water Cooled Wedge Adaptor — AEDC.

R80171, GH_2 Injection Tube — MHGF.

R80172, Thermocouple Rake for Dummy Panel/MHGF Details and Assembly.

R80808, Calibration Panel for HGF – 113 in. (Rev. version of R80800) 1-15-77.
R80809, SRB/TPS Protuberance for Tunnel C. AEDC, Model Details, 1-10-77.
R80810, Flame Holder, Combus. Cham. HGF, Ass'y. and Details, 1-12-77.
R80814, Blower Adaptor Radiant TPS Test Facility Details, 1-21-77.
R80815, Cryorad TPS Tester Radiant Heat Facility MSFC Installation, 1-26-77.
R80816, Flow Stabilizer, Low Enthalpy HGF, 2-4-77.
R80914, Thin-Skin Calibration Model, SRM Paint Test Specimen for AEDC.
R80915, Mounting Fixture, SRM Pain Test Specimen for AEDC.
R80916, SRM Paint Test Specimen.
R80917, Mounting Plate, SRM Paint Test Specimen.
R80918, Thin Skin Mounting Block Cyl. Protub. Model HGF, 3-21-77.
R90919, Cylindrical Core SRB/TPS Protuberance, 3-21-77.
R80920, Substrate for 0.25 in. SRB/TPS Cyl. Protub. Test at AEDC, 3-22-77.
R80921, Cover and Base Plate SRB/TPS Cyl. Protub. Test at AEDC, 3-22-77.
R80922, HGF Adaptor and Holder for SRB/TPS Cyl. Protub. Model, 4-25-77.
R80923, HGF Small Side Window Adaptor, 4-27-77.
R80924, Support Plate, 10 ft Tank, 7-26-77.
R80925, Clamp Plate, 7-26-77.
R80926, Hot Board Segment, 7-27-77.
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R80929, HGF and AEDC SRB Kick Ring TPS Substrate Model, 8-5-77.
R81254, Curtain Test Program Test Model Layout, 7-18-78.
R81255, Curtain Test Program Calibration Test Plate, 7-18-74.
R81256, Curtain Test Program Specimen Test Plate, 7-18-78.
R81257, HGF Window Replacement Glass (Large Window), 7-26-78.
R81258, HGF Window Replacement Glass (Small Window), 7-26-78.
R81286, Bottom Rails, Hot Gas Facility, 10-19-78.
R81321, Phenolic Glass TPS Holder for SRB Attach Ring Tests, 10-16-78.
R80805, Mods of 1/4 in. HGF-TPS Panel Substrate, 11/17/76.
R80806, Mods of 1/8 in. HGF-TPS Panel Substrate, 11/24/76.
R80807, AEDC Wedge Panel Support, 12/14/76

4. NASA-MSFC HOT GAS TEST FACILITY RUN LOG

The following tables present a complete run log of all runs made in the NASA-MSFC Hot Gas Test Facility designed, developed and fabricated by Lockheed-Huntsville.

Table 1

RUN LOG/SUMMARY FOR NASA/MHGF

Test No.	Date	θ (sec)	P_c (psia)	P_c (Backup) (psia)	Air Supply Pressure (psig)	H_2 Venturi Supply Pressure (psig)
086	5-10-76	2	113.7	113.2	602	496.6
099	5-21-76	10	114.0	114.7	596	500.6
100	5-21-76	10	112.0	110.7	602	498.5
101	5-25-76	10	114.3	115.1	599	505.2
102	5-25-76	10	114.2	116.0	602	509.6
103	5-26-76	10	113.8	114.6	596	498.5
104	↓	10	114.4	115.5	602	503
105		10	113.9	114.?	597	497.5
106		10	125.3	125.6	600	604
107		10	136.7	137.8	602	741.7
108		Cutoff by Igniter P_c High				850
112	6-2-76	10	113.3	113.2	581	501.8
113	6-2-76	9	147.1	147.3	582	850.2
114	6-2-76	9	134.6	134.9	601	735.4
115	6-3-76	4	130.5	130.8	599	736.4
116		4	129.6	130.0	599	735.7
117		3	129.7	129.7	602	735.9
118		4	129.3	129.9	600	736.0
119		4	129.1	129.7	600	735.0
120		4	129.2	129.9	601	735.9
121		4	129.6	130.3	600	735.2
122		4	130.4	131.0	600	735.7
123	↓	4	130.9	131.4	601	734.5
124	6-4-76	TC in Copper – Run No Good				
125		10	111.4	112.1	602	499.2
126		4	108.7	109.1	599	498.0
127		4	108.8	109.2	600	498.9
128		4	108.6	109.1	599	498.5
129		4	108.6	109.1	600	498.9
130		4	108.8	109.2	600	496.8
131		4	108.6	108.9	601	498.4
132		4	108.0	108.4	599	495.7
133	↓	4	108.0	108.4	600	497.3

(Continued)

Table 1 (Continued)

Date (1976)	Test No.	Igniters P_{air} (psig)	Igniters P_{GH_2} (psig)	Igniters P_c (psia)	Main P_{air} (psig)	Main P_{GH_2} (psig)	Main $\dot{M}_{air}$ (lbm/sec)	Main $\dot{M}_{GH_2}$ (lbm/sec)	O/F	Main P_c (psia)	Main T_c, Top (F)	Main T_c, Bot (F)	Main θ (sec)	Remarks
					— Injector GH_2 tubes replaced; panel rakes introduced; nozzle total pressure tubes installed —									
7-12	134				600	498								
	135				600	498								GN_2 purge left on. Did not light.
	136	605	755	150	600	735								GN_2 purge turned off before firing command. Still did not light.
	137	605	755	152	600	605				134	1834		4	Chamber rake and panel rake data taken.
	138	605	755	160	600	850				112	Lost		4	
7-13	139	605	755	133	600	605				145	Lost		4	
7-14	140	605	755	128	600	605				110	1329	529	8	Chamber rake, out; nozzle total pressure, out; inserted TC to read $T_{c\ bottom}$
7-15	141	605	755	122	600	605				110	1610	1371	8	No chamber rake. Installed 0.5 in. x 0.065 wall mixing tube 1 in. from face — it came out.
	142	605	755	160	600	735				101	39	95	8	No chamber rake. Installed 7/8 in. diam. mixing rod 1 in. from face.
	143	605	755	140	600	605				143	1561	1190	8	No chamber rake. Installed 7/8 in. diam. mixing rod 1 in. from face.
	144	605	755	160	600	735				121	1005	644	8	No chamber rake. Installed 7/8 in. diam. mixing rod 3 in. from face.
	145	605	755	142	600	605				144	1339	843	8	No chamber rake. Installed 7/8 in. diam. mixing rod 3 in. from face.
7-16	146	605	755	135	600	605				121	1014	403	8	No chamber rake. Installed 7/8 in. diam. mixing rod 5 in. from face.
	147	605	755	162	600	735				91	35	63	4	No chamber rake. Installed 9/16 in. diam. mixing rod 1/8 in. from face.
	148				600	850				132	1645	752	4	No chamber rake. Installed 9/16 in. diam. mixing rod 1/8 in. from face.
	149	605	755	169	600	800								Cut-off on P_c high after 1.5 sec.
	150	605	755	150	600	605				142	2325	900	4	No chamber rake. Installed 9/16 in. diam. mixing rod 1/8 in. from face.
										124	963	747	8	No chamber rake. Installed 7/8 in. diam. mixing rod 2 in. from face.
					— Inspected injector and found 20 GH_2 tubes blocked; corrected problem; made a lateral rake —									
7-30	151	605	755	111	600	498				81	47	47	8	Installed lateral rake. Did not burn. P_c seemed higher for cold flow.
	152	605	755	113	600	605				85	46	45	8	
	153	605	755	148	600	735				132	1000	920	8	Lateral data taken.
	154	605	755	145	530	735				131	1218	1024	8	Lateral data taken.

Table 1 (Continued)

Date (1976)	Test No.	Igniters P_{air} (psig)	Igniters P_{GH_2} (psig)	Igniters P_c (psia)	Main P_{air} (psig)	Main P_{GH_2} (psig)	Main $\dot{M}_{air}$ (lbm/sec)	Main $\dot{M}_{GH_2}$ (lbm/sec)	Main O/F	Main P_c (psia)	Main T_c, Top (F)	Main T_c, Bot (F)	θ (sec)	Remarks
														Run 151 P_c hinted that we were perhaps flowing more air than we thought.
														Started looking into the oxidizer valve opening problems and decided to calibrate it using chamber pressure obtained in cold flow runs and backing out the air $\dot{M}$ from $\dot{m} = \frac{P_c A_t g_c}{C^*}$ where $C^* = \frac{\sqrt{RT_c \gamma}}{\Gamma}$, $\Gamma = \gamma \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{2(\gamma-1)}}$ (Bailey Report)
8-3	155	–	–		590	–				71.9	37	44		Blowdown 1: Air side pop-off valve opened downstream of the oxidizer valve – P > 250.
	156	–	–		590	–				75.6	32	38		Blowdown 2: Same as Run 155
	157	–	–		400	–				50	32	39		Blowdown 3
	158	–	–		590	–				70	29	35		Blowdown 4
	159	–	–		480					59	29	34		Blowdown 5
	160	475	654	95	480	498	29.2	.192	152	57	106	98		Flame holder installed. Did not light. Cut-off on low chamber P_c at ~ 1 sec.
	161	605	755	117	480	605	29.2	.234	125	98	1005	–	8	Flame holder at 2.75 in. from face. Chamber rake installed.
	162	605	755	142	480	735	29.2	.281	104	126	1598	–	8	
	163	605	755	146	480	800	29.2	.305	95.8	133	1760	–	8	
8-5	164	605	755	143	480	735	29.2	.281	104	130	1555	–	6	Flame holder at 1.25 in. from face. Chamber rake in.
	165	605	755	125	400	612	24.6	.236	104	107	1521	–	6	Flame holder at 1.25 in. from face. Lost ~ 5 TC on chamber rake and about 3 on panel rakes.
	166													Flame holder out. No chamber rake. Cutoff.
	167	605	755	120	460	628	27.8	.242	115	97	1172	Lost	6	
	168	605	755	130	460	695	27.8	.265	104	110	1460	–	6	
8-9	169	605	755	136	460	695	27.8	.265	104	118	1464	1305	6	Flame holder at 2.75 in. from face. No chamber rake. Replaced bottom TC.
	170	605	755	125	400	612	24.6	.236	104	104	1454	1303	6	Flame holder at 2.75 in. from face. No chamber rake.
	171	605	755	138	480	735	29.2	.281	104	.25	1488	1219	6	Flame holder at 3.75 in. from face. No chamber rake.
	172	605	755	133	460	695	27.8	.265	104	119	1463	1204	6	
	173	605	755	125	400	612	24.6	.236	104	105	1448	1186	6	
	174	605	755	118	355	545	22.1	.212	104	94	1442	1187	6	
8-10	175	700	995	286	460	695	27.8	.265	104	119	1491	1240	6	Flame holder at 3.75 in. and installed high P_c igniters on side. Igniter, O/F = 17.5.

Table 1 (Continued)

Date (1976)	Test No.	Igniters P_{air} (psig)	Igniters P_{GH_2} (psig)	Igniters P_c (psia)	Main P_{air} (psig)	Main P_{GH_2} (psig)	Main $\dot{M}_{air}$ (lbm/sec)	Main $\dot{M}_{GH_2}$ (lbm/sec)	Main O/F	Main P_c (psia)	Main T_c, Top (F)	Main T_c, Bot (F)	Main θ (sec)	Remarks
8-12	176	842	10[illegible]	316*/339	400	612	24.6	.236	104	108	1515	–	6	Flame holder at 3.75 in.; high P_c igniters, new chamber rake at 6.37 from east side and 6.75 from face; igniter O/F = 20
↓	177	842	1052	318/341	355	545	22.1	.212	104	97	14[illegible]	–	6	
↓	178	842	1052	316/340	355	545	22.1	.212	104	91	1537	–	6	Flame holder out; high P_c igniters, new chamber rake at 6.37 from east side and 6.75 from face; igniter O/F = 20
↓	179	842	1052	321/344	355	722	22.1	.276	80	111	2050	–	6	
8-17	180	842	1050	122/119	355	545	22.1	.212	104	40	62	60	6	Igniters moved on top of chamber. No flame holder, chamber rake in; cut-off on low chamber P_c – igniters did not light
↓	181	842	1052	120/117	355	545	22.1	.212	104	41	62	61	6	
↓	182	605	755	216/216	355	545	22.1	.212	104	94	1577	–	6	High P_c igniters – on top; chamber rake; no flame holder/ west igniter did not light.
↓	183	842	1052	313/339	355	545	22.1	.212	104	91	1476	–	6	High P_c igniters – on top; chamber rake; no flame holder
↓	184	842	1052	317/343	355	545	22.1	.212	104	96	1660	–	6	High P_c igniters – on top; chamber rake; no flame holder, add vertical tube mixer.
↓	185	842	1052	316/343	400	612	24.6	.236	104	108	1660	–	6	High P_c igniters – on top; chamber rake; no flame holder, add vertical tube mixer.
↓	186	842	1052	319/346	355	545	22.1	.212	104	99.7	1505	–	5	High P_c igniters – on top; chamber rake; flame holder in, mixer out.
↓	187	842	1052	320/348	400	612	24.6	.236	104	110	1465	–	3	High P_c igniters – on top; chamber rake; flame holder in, mixer out; cut-off on high igniter P_c at ~ 3.5 sec.

*Indicates two P_c measurements.

Table 1 (Continued)

Date	Test No.	Igniters			Main									Remarks
		P_{air} (psig)	P_{GH_2} (psig)	P_c (psia)	P_{air} (psig)	P_{CH_2} (psig)	$\dot{m}_{air}$ (lbm/sec)	$\dot{m}_{GH_2}$ (lbm/sec)	O/F	P_c (psia)	$T_{c,top}$ (F)	$T_{c,top}$ (F)	θ (sec)	
8-30-76	188	793	990	133/322	355	545	22.1	.212	104	95	1522/1568	–	4/13	High P_c igniters on top; chamber rake in; New Inconel flame holder in; east igniter, no lite – F.H. came out
	189	793	990	145/150	355	545	22.1	.212	104					High P_c igniters on top; no rake, no flame holder; both igniters no lite – cut off on main P_c loss
	190	793	990	145/150	355	545	22.1	.212	104					Repeat of Run 189; both igniters did not light – cut off on main P_c low
9-2-76	191	842	1052	(Igniters did not fire)										
	192	497	1052	E-100 / W-195	355	545	22.1	.212	104	92				Plan for $O/F/_{ign}$ = ~ 12; west igniter lit; east did not.
	193	646	1367	E-135 / W-260	355	639	22.1	.246	90	108				Plan for $O/F/_{ign}$ = ~ 12: west igniter lit; east did not.
	194	950	1367	–	355	722	22.1	.276	80	–				Plan for O/F = 26 (neither lit), could only go to 950
9-7-76	195	605	755	40/100										Igniter stems with larger throat used to give low igniter P_c: east igniter did not light; no burn.
	196	605	755	100/50										Switched igniter cables after checking sparks; now west igniter did not light. no burn because main valve did not open.
9-8-76	197	605	755	128/130	355	722	22.1	.276	80	108	2155	–	20	Changed west side igniter cable; it worked!
	198	605	755		400	810	24.6	.308	80				20	Burnt panel rake TC wires due to plume exhaust at the back of the duct.
9-16-76	199	605	755		355	662	22.1	.254	87			–	10	New Inconel flame holder; no chamber rake; no ceramic beads on panel rakes. Panel rake TCs were not hooked right.
	200	605	755		355	662	22.1	.254	87	107	1785	–	10	Same as 199; reactivated all pressure pickups and added two totals to top wall and one total on each panel.
	201	605	755		400	741	24.6	.283	87	119.3	1323?	–	10	
	202	605	755		460	844	27.8	.320	87	136	1386?	–	10	
	203	605	755		480	890	29.2	.336	87	143	1826	–	10	
9-21-76	204	842	1052	323/345	355	662	22.1	.254	87	10.7	Bad	–	10	Switched back to high P_c igniters to study their influence by comparing with Run 200. New flame holder still in.

Table 1 (Continued)

Date	Test No.	Igniters			Main									Remarks
		P_{air} (psig)	P_{GH_2} (psig)	P_c (psia)	P_{air} (psig)	P_{GH_2} (psig)	$\dot{m}_{air}$ (lbm/sec)	$\dot{m}_{GH_2}$ (lbm/sec)	O/F	P_c (psia)	$T_{c,top}$ (F)	$T_{c,top}$ (F	θ (sec)	
9-21-76	205	–	–		360	–				42.7	25	–		Blowdown 1
	206	–	–		406	–				47.	20	–		Blowdown 2
	207	–	–		457	–				52.75	17	–		Blowdown 3
	208	–	–		508	–				57.9	16	–		Blowdown 4
	209	–	–		559	–				63.1	16	–		Blowdown 5
	210	–	–		610	–				68.6	16	–		Blowdown 6
	211	842	1052	319/342	355	545	22.1	.212	104	93.5	1369	–	20	Run conditions same as Run 204 except increased O/F to 104 to compare with 186 and 188.
9-24-76	212	842	1052		355	662	22.1	.254	87	107	1814	–	10	Start of calibration runs; moved calibration panel in position 1 and panel rake in position 4.
	213	842	1052		355	662	22.1	.254	87	105	1786	–	10	Same as 212 to check for repeatability.
	214	842	1052		355	545	22.1	.212	104	90	1369	–	10	Increased O/F, decreased P_c; flow did not start at this low P_c
	215	842	1052		355	545	22.1	.212	104	90	1362	–	10	Same as 214.
10-4-76	216	842	1052	321/153	355	662	22.1	.254	87	105	1804	–	5	West igniter did not light and P_c profile on strip chart was unsteady.
	217	842	1052	323/154	355	662	22.1	.254	87	105	1787	–	5	West igniter did not light and P_c profile on strip chart was unsteady.
	218	842	1052	314/152	355	662	22.1	.254	87	105	1792	–	5	West igniter still did not light, but P_c trace was more or less steady; considered as good run.
	219	842	1052	164/340	460	844	27.8	.320	87	132	1790	–	5	East igniter did not light, but run is good!
10-8-76	220	842	1052						104					Installed second throat section in back of duct; west igniter did not light.
	221	842	1052						104					West igniter did not light.
	222	842	1052		355	545	22.1	.212	104	91.3				Flow failed to start.
	223	842	1052		460	844	27.8	.320	87	135				Flow failed to start.
	224	842	1052		460	844	27.8	.320	87	133.4				Removed second throat assembly and made a check run (repeat of run 219)
11-3-76	225	842	1052		460	844	27.8	.320	87	133.0	1795	–	5	Calibration panel in position 2; west igniter did not light. Upper wall pressures didn't repeat, probably due to sitting too long (moisutre?).
	226	–	–		307					37.0	21			Blowdown to get more points on m versus supply pressure curve.

Table I (Continued)

Date	Test No.	Igniters			Main									Remarks
		P_{air} (psig)	P_{GH_2} (psig)	P_c (psia)	P_{air} (psig)	P_{GH_2} (psig)	$\dot{m}_{air}$ (lbm/sec)	$\dot{m}_{GH_2}$ (lbm/sec)	O/F	P_c (psia)	$T_{c,top}$ (F)	$T_{c,bot}$ (F)	θ (sec)	
11-3-76	227	–	–		204					25.3	18			Blowdown to get more points on $\dot{m}$ versus supply pressure curve.
	228	–	–		101					15.3	13			Blowdown to get more points in $\dot{m}$ versus supply pressure curve.
	229	842	1052		460	844	27.8	.320	87	132.8	1782	–	5	Calibration panel in position 2; west igniter did not light. Upper wall pressures repeated well with run 224.
	230	842	1052		280	595	18.4	.320	80	91	2002	–	5	Calibration panel in position 2; west igniter did not light. Tried O/F = 80 (like run 197).
11-4-76	231	842	1052		460	844	27.8	.320	87	132	1784	–	5	Calibration panel in position 3; west igniter did not light.
	232	842	1052		460	844	27.8	.320	87	132	1770	–	5	Calibration panel in position 3; west igniter did not light. Repeat run. Repeated runs 231, 229.
	233	842	1052		280	595	18.4	.230	80	87	2179	–	5	Calibration panel in position 3; west igniter did not not light. Set pressure falling due to regulator problems.
	234	842	1052		460	844	27.8	.320	87	132	1806	–	5	Calibration panel in position 3; west igniter did not light. Repeated well.
	235	842	1052		280	595	18.4	.230	80	91	2005	–	5	Calibration panel in position 3; west igniter did not light. This run repeated well with yesterday's run 230.
11-5-76	236	842	1052		460	844	27.8	.320	87	132	1757	–	5	Calibration panel in position 4; west igniter did not light.
	237	842	1052		460	844	27.8	.320	87	133	1731	–	5	Calibration panel in position 4; west igniter did not light. Repeat run; repeated 236 well.
	238	842	1052		280	595	18.4	.230	80	92	1970	–	5	Calibration panel in position 4; west igniter did not light.
	239	842	1052		460	844	27.8	.320	87	136	1755	–	60	Calibration panel in position 4; west igniter did not light. Repeated with run 236.

Table 1 (Continued)

Run No	Date	Panel/ Model No.	Substrate Thickness (in.)	Description	Panel No.	Substrate Thickness (in.)	Description	Panel No.	Substrate Thickness (in.)	Description
240	11-12-76	1	1/8	PD 200 w DC 92007	2	1/8	PD 200 w DC 92007	3	1/8	PD 200 w DC 92007
241	11-19-76	4	1/8	PD 200 w DC 92007	5	1/8	PD 200 w DC 92007	6	1/8	PD 200 w DC 92007
242	12-01-76	7	1/8	PD 200 w RTV 147	8	1/8	PD 200 w RTV 147	9	1/8	PD 200 w RTV 147
243	12-03-76	27	1/8	MXSA w T6109	30	1/8	MXSA w T6109	31	1/8	MXSA w T6109
244	12-08-76	28	1/8	MXSA Bare	26	1/8	MXSA w T6109	29	1/8	MXSA Bare
245	01-07-77	32	1/8	MXSA w T6109	33	1/8	MXSA w T6109	34	1/8	MXSA T6109
			1/4			1/4			1/4	
246	01-13-77	35	1/8	MXSA w T6109	36	1/8	MXSA w T6109	37	1/4	PD 200 w RTV 560 & DC 92007
			1/4			1/4			1/4	
247	01-19-77	12	1/8	DC 36548 Bare	15	1/8	DC 36548 Bare	16	1/8	DC 36548 Bare
248	01-27-77	17	1/8	DC 36548 Bare	18	1/8	DC 36548 Bare	21	1/8	DC 36548 Bare
249	03-02-77	Flow stablizer wedge run. Stabilizer at X = 35 in. δ = 5 deg; θ = 10 sec								
250		Flow stabilizer wedge run. Stablizer at X = 33 in. δ = 5 deg; θ = 60 sec								
251		Stabilizer at X = 33 in. δ = 7 deg; θ = 60 sec								
252	03-04-77	Moved stabilizer to X = 53 in. δ = 5 deg; θ = 60 sec								
253		Repeat of run 252								
254		Repeat of run 252								
255	04-07-77	Cylindrical Protuberance Calibration Run, θ = 30 sec								
256		Acoustic Data Run; Transducer in Position 4, θ = 10 sec								
257		Position 3 Calibration Run, θ = 60 sec								
258	04-14-77	42	1/8	1/16 MSA-1 Bare, M*	49	1/8	1/8 MSA-1 Bare, M*	50	1/8	1/8 MSA-1 Bare, M*
259	04-14-77	44	1/8	↓	51	1/8	↓	52	1/8	1/8 MSA-1 Bare, M*
260	04-18-77	41	1/8		121	1/4		114	1/8	1/4 MSA-1 Bare, M*
261	04-18-77	43	1/8		122	1/4		115	1/8	1/4 MSA-1 Bare, M*

Calibration Runs With Flow Stabilizer Installed.

Table 1 (Continued)

Run No.	Date	Panel/ Model No.	Substrate Thickness (in.)	Description	Panel No.	Substrate Thickness (in.)	Description	Panel No.	Substrate Thickness (in.)	Description
262	4-21-77	46	1/4	↓	123	1/4	↓	152	1/4	↓
263	4-21-77	47	1/4	↓	124	1/4	↓	154	1/4	↓
264	4-26-77	45	1/4	↓	167	1/4	1/4 MSA-1 Bare, M*	157	1/8	↓
265	4-26-77	48	1/4	↓	146	1/8	1/4 MSA-1 Bare, M*	160	1/4	↓
266	4-29-77	133	1/8	1/16 MSA-1 w T6109	131	1/8	1/8 MSA-1 w T6109	145	1/8	1/4 MSA-1 w T6109
267	4-29-77	134	1/8	1/16 MSA-1 w T6109	148	1/8	↓	147	1/8	↓
268	5-12-77	170	1/8	1/8 MSA-1 w T6109	174	1/8	↓	165	1/8	↓
269	5-12-77	163	1/8	1/4 MSA-1 Bare, M*	168	1/8	1/4 MSA-1 Bare, M*	169	1/8	1/4 MSA-1 Bare, M*
270	5-19-77	Cylindrical Protuberance Calibration on Cal Plate in Position 1 - Bottom								
271	5-19-77	Repeat of Run 270								
272	5-20-77	Cylindrical Protuberance Calibration on Cal Plate in Position 4 - Bottom								
273	5-20-77	Repeat of Run 272								
274	5-24-77	Cy-3	1/4 SS	1/4 MSA-1, Bare, M, Cyl. TPS Protuberance in Position 1 - Top — θ = 5 sec						
275	↓	Cy-2	1/4 SS	θ = 3 sec						
276	↓	Cy-1	1/4 SS	θ = 3 sec						

*Machined

Table 1 (Continued)

Run No.	Date	Panel/ Model No.	Substrate Thickness (in.)	Description	Panel No.	Substrate Thickness (in.)	Description	Panel No.	Substrate Thickness (in.)	Description
277	5-26-77	Cy-5	1/4 SS	1/4 Cork Cyl. TPS Protuberance in Position 1 - Top — θ = 3 sec						
278		Cy-6	1/4 SS	— θ = 1 sec						
279			1/4 SS	— θ = 5 sec						
280		Cy-7	1/4 SS	— θ = 7 sec						
281		Cy-8	1/4 SS	— θ = 13.32 sec						
282	6-1-77	Systems Tunnel Calibration in Position 1 - Bottom — P_c = 127 psia								
283		Repeat of Run 282								
284		Systems Tunnel Calibration in Position 1 - Bottom — P_c = 98 psia								
285		Repeat of Run 284								
286	6-3-77	Cylindrical Protuberance Calibration in 30 deg Slant Configuration in Position 4 - Bottom — P_c = 127 psia								
287		Repeat of Run 286								
288		Cylindrical Protuberance Calibration in 30 deg Slant Configuration in Position 4 - Bottom — P_c = 98 psia								
289		Repeat of Run 288								
290	6-14-77	Cy-9	1/4 SS	1/4 Cork Cyl. TPS Protuberance in Slanted Configuration in Position 4 - Bottom; P_c = 98 psia; θ = 15 sec						
291		Cy-10	1/4 SS	θ = 25 sec						
292		Cy-11	1/4 SS	θ = 30 sec						
293		Cy-12	1/4 SS	θ = 25 sec						
294	6-20-77	Cy-13	1/4 SS	3/16 Cork Cyl. TPS Protuberance in Slanted Configuration in Position 4 - Bottom; P_c = 98 psia; θ = 20 sec						
295		Cy-14	1/4 SS	P_c = 127 psia; θ = 15 sec						
296		Cy-15	1/4 SS	1/8 Cork Cyl. TPS Protuberance in Slanted Configuration in Position 4 - Bottom; P_c = 98 psia; θ = 15 sec						
297		Cy-16	1/4 SS	P_c = 127 psia; θ = 10 sec						

Table 1 (Continued)

Run No.	Date	Panel/ Model No.	Substrate Thickness (in.)	Description	P_c (psia)	Run Time, θ (sec)	Remarks
298	6-29-77	Cy-17	1/4 SS	1/4 MSA-1, Bare, M. Cyl. TPS Protuberance in Slanted Configuration in Position 4 - Bottom	98	18.74	Cut run at bondline temperature of 230 F
299	↓	Cy-18	1/4 SS	↓	98	12.15	Cut run at bondline temperature of 210 F
300		Cy-19	1/4 SS		127	6.7	Middle TC on LE at bondline started to rise fast. Cut at 340 F
301		Cy-20	1/4 SS		98	12.33	Cut run at bondline temperature of 220 F
302	7-1-77	Kick Ring Calibration in Position 1 - Bottom			98	4.0	$\dot{Q}$ range comparable to flight values
303	↓	Repeat of Run 302			98	4.0	↓
304		Kick Ring Calibration			127	4.0	
305		Repeat of Run 304			127	4.0	
306	7-6-77	Cylindrical Protuberance Calibration in 30° Slant Configuration in Position 1 - Bottom; Flush Mounted			98	4.0	$\dot{Q}$ range not acceptable
307	↓	Repeat of Run 306			98	4.0	↓
308		Cylindrical Protuberance Calibration in 30° Slant Configuration in Position 1 - Bottom; Flush Mounted			127	4.0	
309		Repeat of Run 308			127	4.0	
310	7-8-77	Attach Ring Calibration in Position 1 - Bottom			98	4.0	$\dot{Q}$ range comparable to flight values
311	↓	Repeat of Run 310			98	4.0	
312		Attach Ring Calibration in Position 1 - Bottom			127	4.0	
313		Repeat of Run 312			127	4.0	
314	7-12-77	Cylindrical Protuberance Calibration in 30° Slant Configuration Recessed 1 1/4 - in. in Position 1			–	–	GH_2 igniter valve did not work
315	7-12-77				–	–	GH_2 igniter valve did not work
316	7-13-77				127	4.0	$\dot{Q}$ range acceptable
317	↓				98	4.0	$\dot{Q}$ range a little too high not acceptable
318					127	4.0	$\dot{Q}$ range acceptable/run without flow stabilizer

Table 1 (Continued)

Run No.	Date	Panel Model No.	Substrate Thickness (in.)	Description	P_c (psia)	Run Time θ (sec)	Remarks
319	7-14-77	Cy-21	1/4 SS	1/4 MSA-1, Bare, M, Cyl. TPS Protuberance in Slanted Configuration in Recessed Position 1	127	20.0	Obtained burn through in the high $\dot{Q}$ area
320	7-14-77	Cy-22	1/4 SS		127	14.9	Barely burned through
321	7-15-77	Cy-23	1/4 SS		127	10.0	A little less than half TPS thickness left over
322	7-15-77	Cy-24	1/4 SS		127	8.0	About half TPS left over
323	7-18-77	Cy-25	1/4 SS	1/4 Cork Cyl. TPS Protuberance in Slanted Configuration in Recessed Position 1	127	20.0	Obtained slight burn through on top but only ~ 4 deg change in bondline temperature
324	7-18-77	Cy-26	1/4 SS		127	15.0	Barely burned through
325	7-19-77	Cy-27	1/4 SS		127	10.0	About half TPS left over
326	7-19-77	Cy-28	1/4 SS		127	5.0	No change in bondline temperature.

Run No.	Date	Air Supply Pressure (psig)	H_2 Supply Pressure (psig)	Acoustic dB Level			P_c (psia)	Run Time θ (sec)	Remarks
				Pos. 1	Pos. 2	Pos. 3			
327	7-21-77	410	–	NA	NA	163	44	15	
328	↓	560	–	↓	↓	167	58	15	
329	↓	500	–	↓	↓	166	[illegible]2	15	
330	↓	540	–	↓	↓	166.5	56.6	10	
331	↓	200	–	↓	↓	162.5	27.8	15	
332	↓	354	662	164-184 Variable	175	168	98	10	
333	↓	460	844	Bad	Bad	177	127	15	Transducers went out in Pos. 1 and 2.

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Table 1 (Continued)

Run No.	Date	Panel/ Model No.	Substrate Thickness (in.)	Panel Description	Panel/ Model No.	Substrate Thickness (in.)	Panel Description	Panel/ Model No.	Substrate Thickness (in.)	Panel Description	P_c psia	θ sec
334	8-2-77	1	1/8	1/8 MSA as Sprayed	4	1/8	1/4 MSA as Sprayed	6	1/4	1/4 MSA as Sprayed	127	39.7
335	8-4-77	2		1/8 MSA as Sprayed	5		1/4 MSA as Sprayed	7		1/4 MSA as Sprayed		37.5
336	8-8-77	101		1/8 MSA Split Panel	106		1/4 MSA Split Panel	107		1/4 MSA Split Panel		23.3
337	8-10-77	103		1/8 MSA Split Panel	158		1/4 MSA Split Panel	108		1/4 MSA Split Panel		27.4
338	8-11-77	171		1/8 MSA Closeout Study	164		1/4 MSA Closeout Study	110		1/4 MSA Close Study		27.7
339	8-15-77	173		↓	166		↓	111		↓		20.0
340	8-16-77	109	1/4	1/4 MSA as Sprayed	112	1/4	1/4 MSA as Sprayed	113	1/8	1/8 MSA as Sprayed		25.0

Run No.	Date	Panel/ Model No.	Substrate Thickness (in.)	Description	P_c (psia)	Run Time θ (deg)	Remarks
341	8-22-77	2	1/8	1/4 MSA as Sprayed on Systems Tunnel and Base Plate	127	15	Very uniform char layer. No localized erosion. Substrate temps stayed within 100 F
342	8-24-77	1				25	Performed just about the same as one above. One TC read 104 F on the front face.
343	8-26-77	3				45	Let the sample run until the substrate temperature reached 200 F
344	8-30-77	4				30	The substrate temperature reached 200 F in only 30 sec. TPS on bottom plate on left side of entire model debonded and came off during shutdown.

Table 1 (Continued)

Run No.	Date	Panel/ Model No.	Substrate Thickness	Description	P_e (psia)	Run Time θ (deg)	Remarks
345	9-1-77	9	1/8	1/4 MSA as Sprayed on Kick Ring and Base Plate	127	20.0	Substrate TCS bad so no control over run time. Ran full 20 sec. No TPS left on front face and top. TPS probably lifted off from top of ring.
346	9-6-77	11				1.17	Run cut off due to timer problem
347	9-6-77	11				1.28	↓
348	9-12-77	11				4.24	Cut run at front lip temperature of 300 F. Lost all TPS on front lip and partly on top of model
349	9-13-77	10				12.0	Lost some TPS front face, all on lip and partly on top. Lip temperature reached 635 F.
350	9-15-77	EH 4394 3		1/4 MSA as Sprayed on Attach Ring and Base Plate		10.0	Lost all TPS on front, under lip, on and above front lip. Substrate temperatures as high as 500 F.
351	9-16-77	AP6		1/4 P-50 Cork Bonded on Attach Ring. No Base Plate.		20.0	Seemed to do better than the MSA Attach Ring, but had the same problem on the high heating lip surface
352	9-20-77	AP8				20.0	↓
			Acoustic dB Level				
			Position 1	Position 2	Position 3		
353	9-22-77		No Data	No Data	No Data	127	10.0	Amplifier gain set too high on all three transducers.
354	↓		No Data	No Data	174		10.0	Amplifier overdrive in Pos. 1; Broken connector in Pos. 2.
355	9-26-77		No Data	No Data	174		10.0	Amplifier went bad in Pos. 1; Bad transducer in Pos. 2.
356			172	173	No Transducer		10.0	Changed amplifier in Pos. 1; Transferred transducer from Pos. 3 to Pos. 2.
357	↓		172	173	↓	↓	10.0	Repeat run 356
358	10-6-77		1/4	3/16 Cork P-50 Panels in Positions 1, 2 and 3 respectively with Acoustics Transducers Installed in Middle of Each	127	50.4	Obtained burn-through toward the end of third panel. No acoustics data from Pos. 1 or 2. Position 3 acoustics same as before.
359	10-11-77	KR1	1/8 on Front Lip	1/2 Cork P-50 on Kick Ring 3/16 Cork P-50 on Base Plate		27.4	Severe erosion on forward lip and top. Cut run at substrate temperature of 300 F.
360	10-13-77	KR2	↓	1/2 ESM Material on Kick Ring 3/16 Cork P-50 on Base Plate		6.9	↓
361	10-17-77	ARF-1	1/8	1/2 Cork P-50 on Attach Ring with Fairing. 1/4 Cork on Base Plate		55.0	O/F varied from 87 down to 65 gradually causing the total temperature to rise by about 500 F. Obtained burnthrough toward the top of the fairing – cut run at substrate temp. of 300 F. Flame holder and windows Damaged.
362	10-19-77	ST-2	1/8	1/2 Cork P-50 on Front Face of Systems Tunnel; 1/4 Cork on Rest of Model. No Base Plate		60.0	Substrate temperature rise maximum 55 F.
363	10-20-77	KR 5	1/8 on Front Lip	0.10 Thick Epoxy Glass on Kick Ring. No Base Plate		19.64	Cut-off run at substrate temp. of 300 F.

Table 1 (Continued)

Run No.	Date	Panel/ Model No.	Substrate Thickness	Description	P_c (psia)	Run Time @ deg	Remarks
364	10-27-77	KR7	1/8 on Front Lip	B-Stage Cork on Form Filled Kick Ring with 3/16" Cork on Base Plate	127	60.0	The foamed area was completely ablated and the front lip of the kick ring was exposed.
365	11-8-77	ARF-2	1/8 on Front Lip	1/2" Cork P-50 on Attach Ring with Fairing. 3/16 on Base Plate		51.6	Model looked good. Substrate temperatures did not rise more than 5 deg.
366	11-10-77	KR4	1/8 on Front Lip	Approx. 1/4" Phenolic E-Glass on Kick Ring. No Base Plate. Not post cured.		20.3	Cut run at front lip temp. of 300 F. Temperatures rose faster than expected.
367							
368	Did not light. Igniter problem						
369							
370	11-15-77	ST1	1/8	1/2" P-50 Cork on Front Face of Systems Tunnel Mounted at 5 deg Yaw. No TPS on Base Plate.	127	60.0	Looked good. Maximum substrate temperatures were 136 F
371	11-15-77	KR3	1/8 on Front Lip	MA25S Material on Kick Ring. No Base Plate.		30.0	Run for 30 sec. only. Front lip temperature reached 187 deg. Behavior similar to MSA.
372	11-22-77	Did not light. Igniter problem; low P_c cut off					
373	11-22-77	AR-1	1/8 on Front Lip	MA25s Material on Attach Ring. No Base Plate	127	25.3	Cut-off at front lip substrate temp. of 300 F. Most of TPS over lip came off.
374	12-1-77	FP-5 FP-8 FP-6	1/8	P-50 Cork Flat Panel in 3 Positions – 1/8, 3/16 and 1/4 resp.		50.0	Run full 50.0 sec as substrate temps. did not come upto a cut-off limit.
375	12-5-77	FP-4 FP-9 FP-7	1/8	P-50 Cork Flat Panels in 3 Positions – 1/8, 3/16 and 1/4 resp.		48.2	Added five TCS on each panel near ℄ at locations where $\dot{q}$ was actually measured. Cut off on TC furthest downstream at 300 F.
376	12-7-77	ARF-3	Run cut-off on main chamber P_c high.				

Table 1 (Continued)

Run No.	Date	Model No.	Model Description	Run Time (sec)	P_c (psia)	Remarks
377	12-14-77	KR-9	1/4" Phenolic Glass S-Glass	20	128	Little or no substrate temperature rise. No measurable recession.
378	12-19-77	3 B-Stage Cork Panels	Pos. No. 1: 1/8 Cork, 1/8 Substrate Pos. No. 2: 1/8 Cork, 1/8 Substrate Pos. No. 3: 1/4 Cork, 1/8 Substrate	60	128	B-Stage looks better than P-50
379	12-19-77	KR-8	1/4" Phenolic Glass E-Glass	20	128	Previously tested twice at AEDC @ 40 sec. Salt soaked (about 2 days). Substrate temperature only rose a few deg. Lost about 6 plys of material probably due to water inside.
380	12-14-77	KR-10	1/8" Phenolic Glass S-Glass	20	128	Substrate temperature rise: Lip = 40°F, Face = 30°F
381	1-16-78	–	–	–	–	Cutoff on high igniter P_c
382	1-16-78	–	–	–	–	Cutoff on high igniter P_c
383	1-17-78	MMC Cyl. 1	1/2" MA25S	30	95	Surface crased about 1/16 deep, looked like delaminating at 1/16 and 5/16 deep
384	1-17-78	MMC Cyl. 1	1/2" MA25S	30	128	More crazing than above, had same delaminations lost 1/16" material near top leading edge
385	1-17-78	MMC Cyl. 2	1/2" Carbon Wrap SLA	30	95	White ash on surface, carbon wrap appeared to be loose from SLA, no apparent recession frayed carbon wrap.
386	1-23-78	ET Cyl. 5	MA25-S in Position 3	60	98	Test point 3; model looked satisfactory; some surface crazing, not to substrate. May have had some delamination.
387	1-23-78	ET Cyl. 6	MA25-S in Position 3	43	127	Test point 3; cut off due to temperature rise of substrate; TPS crack may have caused high substrate temperature; plenty of material left on substrate.
388	1-23-78	ET Cyl. 8	SLA 561 with Carbon Cloth Wrap in Position 3	60	98	Test point 3; wrap debonded and came off at about 40 sec; erosion all the way to substrate.
389	1-23-78	ET Cyl. 9	SLA 561 with Carbon Cloth Wrap in Position 3	45	98	Test point 3; wrap came off at about 40 sec; had severe ablation; test terminated at preplanned time of 45 sec; not on temperature.
390	1-25-78	KR-17	V-44 Rubber	20	105	Run for 20 sec at low P_c (not a valid test)
391	1-25-78	KR-13				Cut-off on igniter P_c low
392	1-25-78	KR-13	1/8" Phenolic S-Glass on Lip, 1/2" B-Stage on Web	20	127	Some delamination on outer plies; material defective, need new stock.
393	2-1-78	AR-12	Full Scale Attach Ring, 1/8" Phenolic Glass, 3/8" B-Stage on Web, RTV on two fastener heads, MTA-3 on one fastener head.	23.8	127	Cut-off on ΔT coolant (was set at 5°, should have been 50°). No bond on TPS. Phenolic lifted from top of substrate. Determined requirement for bonding.

Table 1 (Continued)

Run No.	Date	Model No.	Model Description	Run Time (sec)	P_c (psia)	Remarks
394	2-1-78	KR-16	ESM Material on Lip, Cork on Web.	10.7	127	Manual cut-off at 300°F. All ESM gone on lip.
395	2-3-78	KR-10				Cut-off on igniter P_c low.
396	2-3-78	KR-10	1/8" Phenolic S-Glass on Lip, 3/8" B-Stage on Web. Model was First Tested in Run 380, Soaked in Salt Water and Cork Replaced.	32.09	127	Material performed full duration of test. Only two flights possible at this thickness.
397	2-3-78	Panel PV-125	1 1/8" Thick Polyuerathene Foam on 1/8" Al Substrate (Made in Tiles)	21.94	127	Panel run in position 2. Sample came out in chunks. Manual cutoff at 300°F ΔT. Looks like a good substitute for SLA-561.
398	2-13-78	ET Cyl. 3	MA25S in Position 1	30	127	Test point 2; looked satisfactory; some surface cracks only.
399	2-13-78	ET Cyl. 4	MA25S in Position 1	60	127	Test point 2; similar to test 398; no rise in substrate temperature.
400		KR-15				Cut-off
401	2-15-78	KR-15 (FS-KRC-11)	1/8" S-Glass Phenolic on Kick Ring, B-Stage on Web, MTA-3 on Three Fastener Heads.	34.6	127	Phenolic started peeling at 24 sec at corner. Manual cutoff at ΔT = 300 F. Obtained burn-through to silicone adhesive on front corner lip – only two plies remaining on center of lip. Test proves that bonding with RTV is good. May need thickness of phenolic to be greater than 1/8."
402	2-24-78	AR-MHGF-19	—	1.0		Misfire
403	2-24-78	AR-MHGF-19	0.160" Phenolic S-Glass on Lip, RTV over Fasteners, Cork over Web 3/8" RTV Bonded Only.	40.0	127	Started delaminating from outside corners on lip at 24 sec into run. 0.061" remaining on fwd lip at center. RTV on fasteners eroded away. ΔT rise at 40 sec = 257°F under lip. Fastener ΔT = 261°F RTV Bond Held Up.
404	3-7-78	AR-MHGF-14	1/8" Phenolic S-Glass on Lip, RTV over Bolts. 1/2" Cork on Web, RTV Bonded Only.	35	127	Started delaminating from outside corners on lip at 23 sec into run, RTV Bond on top RH side shows minor failure. 0.049" remaining on fwd lip. Fastener partially exposed. Lip ΔT = 296°F.
405	3-10-78	EH-43-6-1 -2 -3	"B" Stage Cork on Flat Panels in Pos. 1, 2 and 3	35.2	127	ΔT = 300°F cutoff based on T/C D on panel in pos. 3. No visual inspection of panels as of this writing.
406	3-14-78	KR-MHGF-21	0.190" Phenolic S-Glass on Lip, Top, Rear of Full Size Kick Ring. Leading Edge of Phenolic Rolled Under with 4 Simulated Fasteners on LH Side. 0.5" P50 Cork on Web and Under Side of Lip. RTV Bonded Only.	35	127	Started delaminating from outside lip corners at 23 sec into run. Fastener helped hold laminate together. 0.052 remaining on fwd lip. RTV Bond held up. ΔT rise on fwd lip = 206°F. Delamination occurred mainly on fwd lip and not as severe as runs 403, 404 and 401.
407	3-17-78	AR-MHGF-20	0.190" Phenolic S-Glass on Lip, and Over Fasteners, 0.5" Cork on Web. RTV Bond.	35	127	Started delaminating from outside lip corners 22 sec into run. Phenolic over fasteners worked fine as well as RTV Bond. 0.090 phenolic remaining on fwd lip and over fasteners. ΔT rise fwd lip = 150°F. ΔT rise fasteners = 104°F.

Table 1 (Continued)

Run No.	Date	Model No.	Model Description	Run Time (sec)	P_e (psia)	Remarks
408	4-4-78		3-B-Stage Cork Flat Panels.	60	127	Looked good T_{max} = 150 F.
409	4-6-78	KR-18	V-44 Rubber OK. Kick Ring (Old Shape Substrate).	35	101	Rubber receeded all the way to the substrate but temperature limit of 300 F was not exceeded
410	4-12-78	AR-22	Phenolic Lap and Butt Joint Model of Full-Scale Attach Ring.	35	127	Started peeling on the overlap and both sides of the butt joint. Top joint started to pell at 18.9 sec. End started to peel at 26.7 sec. Lost RTV between butt joint. Temperature limit of 300 F not exceeded. Lap joint aggravated $\dot{q}$ at joint. Lap joint redesigned for subsequent tests.
411	4-12-78	KR-23	Phenolic Lap and Butt Joint Model of Full-Scale Kick Ring.	22	127	Debonding of the entire TPS. Lost all TPS. Temperature of substrate went very high. Plys peeled rapidly one or two, at a time. (TPS did not come off as a unit.) Peeling started at 4.6 sec. Design change needed on phenolic forward lip.
412	4-20-78	AR-MHGF-24	High Silica Phenolic Glass.	22.7	127	Temperature cutoff. Material was cracked before mounting on model. Repaired w/EA-934. Bolt cover part came off; lip looked good. No delamination.
413	4-26-78	AR-MHGF-25	S-Glass Phenolic Glass 6 TCS L.E. TPS Thickness ~0.2 Metal End Caps	13	127	No delamination. Cut off due to facility water flow ΔT.
414	4-27-78	AR-MHGF-25	Same Model (Rerun)	26	Nom. 127	Didn't look as good as high silica. Temperature was < 300. Lost bolt cover.
415	4-27-78	–	KR Cal Model	5	Nom. 127	$\dot{q}$ data lower than run 416.
416	4-27-78	–	KR Cal Model	5	Nom. 127	Repeat of run 415 data did not agree.
417	4-28-78	–	AR Cal Model		Nom. 127	Data looked OK.
418	4-28-78	–	AR Cal Model		Nom. 127	Repeat of run 417 (data repeated reasonably well.
419	5-18-78	C-1	5/8 Cork Flat Panel Lightning Struck Simulated Position 3.	45.4	Nom. 127	Trying to get heat load of 1545 Btu/ft^2. Test went for full time.
420	5-18-78	C-6	1/2 Cork, Position 3.	42.7	Nom. 127	Trying to get heat load of 1545 Btu/ft^2. Manual cutoff at temperature 350 F at TC under divot.
421	5-18-78	C-10	1/4 Cork, Position 3.	22.7	Nom. 127	Went planned duration (heat load = 1405 Btu/ft^2.
422	5-18-78	M-13	1/8 MSA, Position 1.	58.5	Nom. 127	Trying to get heat load of 702 Btu/ft^2. Went for planned duration.

Table 1 (Continued)

Run No.	Date	Model No.	Model Description	Run Time (sec)	p_c^* (psia)	Remarks
423	5-23-78	AR-47	Phenolic Glass on "Full Scale" Attach Ring	17	127	Model looked real good, did not delaminate. Substrate temperature went to 127 F.
424	5-23-78	KR Cal	"Full Scale" KR Cal Model	2.5	127	Data from all 3 runs repeated. Compared to Cal Run 416 reasonably well.
425	5-23-78	KR Cal		2.5	127	
426	5-23-78	KR Cal		2.5	127	
427	6-13-78	Island-101	2 Islands Fiberite and Chopped Silica.	47	127	Ran in Pos. 3. Calorimeters read $\dot{q}_{cw}$ = 15. Fiberite and chopped silica phenolic both held up well. Bolt temperature as predicted. MTA-2 eroded as expected under this severe environment.
428	6-15-78	KR-Cal	KR Cal Model Without Spacer, Total Height of 2"	–	–	Low igniter P_c cutoff.
429	6-15-78	KR-Cal		~1.0	127	$\dot{q}$ calibration runs. The 127 psia case is a useful test condition but the 98 psia cases were unstable, – not a usable test condition.
430	6-15-78	KR-Cal		~1.0	127	
431	6-15-78	KR-Cal		~1.0	127	
432	6-15-78	KR-Cal		~1.0	98	
433	6-15-78	KR-Cal		~1.0	98	
434	6-15-78	KR-Cal		–	–	Low igniter P_c cutoff.
435	6-22-78	KR-Cal	KR Cal Model with Spacer, (3" Total Height)		–	Low igniter P_c cutoff.
436	6-22-78	KR-Cal		~1.0	127	$\dot{q}$ calibration runs – data not yet reduced.
437	6-22-78	KR-Cal		~1.0	127	
438	6-22-78	KR-Cal		~1.0	127	
439	6-22-78	KR-Cal		~1.0	98	
440	6-22-78	KR-Cal		~1.0	98	
441	6-22-78	KR-Cal		~1.0	98	
442	7-12-78	KR-Cal	KR Cal Model with Spacer, (3 3/4" Total Weight).	~1.0	127	$\dot{q}$ calibration runs – data not good because holes in dummy panel mounting plate were left open. Need to rerun.
443	7-12-78	KR-Cal		~1.0	127	
444	7-12-78	KR-Cal		~1.0	127	
445	7-12-78	KR-Cal		~1.0	98	
446	Misfire	KR-Cal		–	–	
447	7-12-78	KR-Cal		~1.0	98	
448	7-12-78	KR-Cal		~1.0	98	
449	7-13-78	Island No. 2	Island Model Fiberite and Chopped Silica.	–	–	Misfire
450	7-13-78	Island No.2	Island Model Fiberite and Chopped Silica	33	127	Chopped silica looked good. $\dot{q}$ to island calorimeter = 35 (Other calorimeter bad.) Manual cutoff due to one thermocouple going high.
451	7-13-78	FSAR. No.83	Phenolic Glass TPS Fastener Model	17.1	127	Fasteners looked good. MTA-2 held up well.

*Nominal P_c values.

Table 1 (Continued)

Run No.	Date	Model No.	Model Description	Run Time (sec)	P_c^* (psia)	Remarks
452	7-27-78	Island-103	Castable Island	3.8	127	Combustor coolant ΔT cutoff.
453	7-27-78	Island-103	Same as Run 452 (Test of Castable Island Material)	47	127	Castable material looked good. Did not recede excessively. Temperatures were within limits.
454	7-31-78		IEA on Attach Ring			
455	↓		Cal Model		127	
456			↓			
457					98	
458						
459						
460	8-1-78	MTA-1-001	Closeout Panel Verification 1/8" MSA/MTA-1	33	127	Planned 52 sec. Got coolant ΔT cutoff
461	8-2-78	MTA-2-001	Closeout 5/8" Sheet Cork/ MTA-2	59.9	127	Downstream fasteners uncovered. GH_2 set pressure started dropping at 25 sec and dropped from 844 psia to 750 psia at end of test.
462	8-3-78	MTA-1-007	Closeout Verification 1/8" MSA/MTA-1	57	127	Went full duration.
463	8-7-78	MTA-2-002	Closeout Verification Panel, 1/8" Sheet Cork/MTA-2	30	127	Test time reduced because of overtest of MTA-2-001
464	8-8-78	Configuration 1	Fastener Cal Model (2' High x 8' Wide)	1.0	127	
465	↓	↓				
467						
468	8-9-78	Configuration 2	Fastener Calibration Model (2" High x 5" Wide)	1.0	127	Now reducing data. Looks OK.
470	↓	↓				
471	8-10-78	Configuration 3	Forward Face of KR and at R (5" High x 8" Wide)	1.0	127	471, 472, misfired
472	↓	↓	↓			
473						
474						
475						
476	8-10-78	APO-5 (Position 1) APO-4 (Position 2)	Atmos. Pressure Orifice Verification Panel, 1/8" MSA per "Appendix H"	18	127	Misfire
477	8-11-78	(Same as 476)	(Same as 476)	42	127	Opened up pressure ports to vacuum at 27 seconds.

Table 1 (Continued)

Run No.	Date	Model No.	Model Description	Run Time (sec)	P_c^* (psia)	Remarks
478	8-28-78	AP06 (Pos. 1) AP03 (Pos. 2)	SRB Atmospheric Pressure Sensor Orifice Panels 3/8" MSA-1/1/8" Al Substrate	42	127	Purpose of run was to determine amount of ablating MSA that would be drawn into the orifice
479	8-30-78	(None)	5" x 8" Attach Ring SRB/TPS Phenolic, "Fast Cal." Shape, 24 Plies S-Glass	60	127	Test of SRB phenolic TPS; α = 90 deg; ΔP was too high; model lasted 6 sec; test too severe.
480	8-31-78	TAVP-002 Pos. 1	1/8" MSA-1, 1/8" Al Substrate	20	127	Test 1 of Appendix A, "Thermal Acoustic Verification." Lost strain gages at about 2 sec; lost microphone after few seconds; Jim Herring satisfied with acoustic spectrum.
		TAVP-006 (Pos. 2)	1/8" MSA-1, 1/8" Al Substrate			
		VFP-009 (Pos. 3)	5/8" Sheet Cork, 1/8" Al Substrate			
481	9-1-78	–	–	—	—	Misfires due to igniter problems.
482	↓					
483						
484	9-1-78	TAVP-006 (Pos. 1)	1/8" MSA-1, 1/8" Al Substrate	8.1	127	Cutoff due to facility running out of GH_2.
		TAVP-002 (Pos. 2)	1/8" MSA-1, 1/8" Al Substrate			
		VFP-009 (Pos. 3)	5/8" Sheet Cork, 1/8" Al Substrate			
485	9-6-78	–	–	—	—	Misfires due to igniter problems; P_c too low.
489	9-7-78					
490	9-7-78	Same as Run 484	Same as Run 484	26.9	127	Fixed igniter problem (wrong, straight tube, extension had been used). Thermal acoustics verification tests. Test 2 of Appendix A now complete.
491	9-8-78	TAVP-002 (Pos. 2)	1/8" MSA-1, 1/8" Al Substrate	25	127	Test 3 of Appendix A, "Thermal Acoustics Verification."
		VFP-9 (Pos. 3)	5/8" Sheet Cork, 1/8" Al Substrate			
492	9-11-78	–	"Fast Cal." Model, Attach Ring Shape	~1	127	α = 45 deg; calibration to get reduced $\dot{q}$ and pressure.
493	↓					
494						
495	9-11-78	–	–	—	—	Misfire.
496	9-12-78	–	"Fast Cal." Model, Attach Ring Shape	~1	127	α = 30 deg; calibration runs to get reduced $\dot{q}$ and pressure.
497	↓					
498						
499	9-14-78	TAVP-006 (Pos. 2)	1/8" MSA-1, 1/8" Al Substrate	25	127	Test 4 of Appendix A, "Thermal Acoustics Verification."
		VFP 10 (Pos. 3)	5/8" Sheet Cork, 1/8" Al Substrate			
500	9-15-78	–	"Fast Cal." Model, Attach Ring Shape	~1	127	α = 37 deg; calibration runs to "home-in" on desired $\dot{q}$ and pressure.
501						
502						

Table 1 (Concluded)

Run No.	Date	Model No.	Model Description	Run Time (sec)	P_c^{α} (psia)	Remarks
503	9-18-78	–	"Fast Cal." Model, Attach Ring Shape	~1	127	α = 41 deg, calibration runs were made to "home-in" on $\dot{q}$ and pressure.
504	↓					
505						
506	9-19-78	–	–	—	—	Misfire.
507	9-19-78	MHGF-A1	5" x 8" x 2" Attach Ring Phenolic TPS, 24 Layers S-Glass	4.6	127	Phenolic with pressure and acoustics loads at 500 F, α = 41 deg.
508	9-19-78	Same as Run 507		6.0	127	
509	9-19-78	Same as Run 507	Same as Run 507	6.0	127	Model held up for three tests even with high backface temperatures.
510	–	–	–	—	—	Misfire.
511	9-20-78	MHGF-A2	5" x 8" x 2" Attach Ring Phenolic	9.6	127	α = 41 deg, had pressure leakage problem; phenolic held up well for flight heat load and pressure difference.
512	9-20-78	Same as Run 511	Same as Run 511	7	127	
513	9-25-78	MHGF-A3	5" x 8" x 2" Attach Ring, 5/8" Cork over Phenolic	13.6	127	α = 41 deg, had leakage problem; heating from backside; problem with cork eroding under top cover lip. Run cut due to high backface temperature.
514	9-26-78	MHGF-A2	Same as Run 511	49.2	127	α = 41 deg, rerun of phenolic part of run 511 without leading edge protector, cavity pressure good for 35 sec; model did not fail, ΔP = 24-27 psi.
515	9-27-78	–	"Fast Cal." Model, Attach Ring Shape Raised Position	~1	127	α = 41 deg, calibration runs with model raised on struts to get lower ΔP.
516	↓					
517						
518	9-28-78	MHGF-A4 (AEDC-2)	Phenolic TPS, Attach Ring Shape	60	127	Model lasted about 50 sec; α = 41 deg, elevated; lost cavity pressure measurement.
519	9-29-78	MHGF-A5	Composite, 3 Silica Glass Plies, 18 S-Glass Plies	35.5	127	α = 41 deg, elevated; repeat to get run 518 ΔP measurement, cavity pressure = 5 psia; ΔP = 30 across phenolic. Phenolic looked good. Cut off at T. B. F. = 500 F.
520	10-5-78	MHGF-A6	Refurbished Model A3 Plus Seal	35	127	Seal test, RTV-560; backface temperature held; pressure held constant. Seal did not leak, but eroded on front.
521	10-13-78	TAVP-008 (Pos. 1)	1/4" MSA-1, 1/8" Al Substrate	25	127	Bolts were left out of front of right-hand hold-down rail and panels lifted when flow started, causing damage to cryopanel, insulation, rails, adaptors and TPS panels. Facility will have to be refurbished.
		TAVP-006 (Pos. 2)	1/8" MSA-1, 1/8" Al Substrate			
		VFP-10 (Pos. 3)	5/8" Cork, 1/8" Al Substrate			