R-3896-11

TECHNICAL MANUAL

OPERATING INSTRUCTIONS

F-1 ROCKET ENGINE

(ROCKETDYNE)

CHANGE NOTICE

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1 APRIL 1969

CHANGE NO. 14 — 9 OCTOBER 1972

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1-36	0	Original
1-37	6	10 Feb 70
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1-39	6	10 Feb 70
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1-43 thru 1-45	8	9 Sep 70
1-46 thru 1-46A/1-46B	9	2 Dec 70
1-47 thru 1-48	9	2 Dec 70
1-48A thru 1-48B	8	9 Sep 70
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1-49	0	Original
1-50	7	28 Apr 70
1-51 thru 1-52	0	Original
1-53	8	9 Sep 70
1-54	0	Original
1-55 thru 1-56	8	9 Sep 70
1-57	6	10 Feb 70
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1-66	9	2 Dec 70
1-67	8	9 Sep 70
1-68	6	10 Feb 70
1-69	7	28 Apr 70
1-70	13	4 Apr 72
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1-73	5	9 Oct 69
1-74 thru 1-76	0	Original
1-77	9	2 Dec 70
1-78 thru 1-78A	0	Original
1-78B	9	2 Dec 70
1-78C	6	10 Feb 70
1-78D	0	Original
1-78E/1-78F	9	2 Dec 70
1-79	7	28 Apr 70
1-80	6	10 Feb 70
1-81 thru 1-82	13	4 Apr 72
1-83	6	10 Feb 70
1-84 thru 1-84A/1-84B	11	6 May 71
1-85	12	23 Aug 71
1-86	0	Original
1-87	9	2 Dec 70
1-88	0	Original
1-89 thru 1-90	6	10 Feb 70
1-91 thru 1-92A/1-92B	11	6 May 71
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1-104 thru 1-105	8	9 Sep 70
1-106	9	2 Dec 70
1-107 thru 1-108	11	6 May 71
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1-112	5	9 Oct 69
1-113 thru 1-114	0	Original
1-115	5	9 Oct 69
1-116	0	Original
1-117	5	9 Oct 69
1-118 thru 1-124	0	Original
1-125	12	23 Aug 71
1-126	11	6 May 71
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2-4 thru 2-6	0	Original
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2-27	6	10 Feb 70
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2-39	0	Original
2-40 thru 2-41	6	10 Feb 70
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2-47 thru 2-48	0	Original
2-49	7	28 Apr 70
2-50	6	10 Feb 70
2-51	0	Original
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2-54 thru 2-55/2-56	13	4 Apr 72
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3-3	1	23 Apr 69
3-4	6	10 Feb 70
3-5	8	9 Sep 70
3-6	1	23 Apr 69
3-7 thru 3-8	6	10 Feb 70
3-9	1	23 Apr 69
3-10	8	9 Sep 70
3-11 thru 3-12	1	23 Apr 69
3-13	8	9 Sep 70
3-14 thru 3-14A/3-14B	12	23 Aug 71
3-15	12	23 Aug 71
3-16	3	1 Jul 69
3-17	8	9 Sep 70
3-18 thru 3-20A/3-20B	9	2 Dec 70
3-21 thru 3-22	12	23 Aug 71
3-23 thru 3-24A/3-24B	8	9 Sep 70
3-25 thru 3-28A/3-28B	8	9 Sep 70
3-29	1	23 Apr 69
3-30	6	10 Feb 70
3-31 thru 3-32	12	23 Aug 71
3-33	5	9 Oct 69
3-34 thru 3-34A/3-34B	12	23 Aug 71
3-35	8	9 Sep 70
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Upon receipt of the second and subsequent changes to this technical manual, personnel responsible for maintaining this publication in current status will ascertain that all previous changes have been received and incorporated. Action should be taken promptly if the publication is incomplete.

This page reflects the current status of the complete manual. All pages listed must be in the manual to make this publication current and complete.

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3-59	5	9 Oct 69
3-60 thru 3-61	7	28 Apr 70
3-62	8	9 Sep 70
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3-65	9	2 Dec 70
3-66	8	9 Sep 70
3-66A/3-66B	9	2 Dec 70
3-67	9	2 Dec 70
3-68 thru 3-69	12	23 Aug 71
3-70	6	10 Feb 70
3-70A/3-70B	8	9 Sep 70
3-71	8	9 Sep 70
3-72	6	10 Feb 70
3-73 thru 3-74	8	9 Sep 70
3-74A	6	10 Feb 70
3-74B	8	9 Sep 70
3-74C thru 3-74D	12	23 Aug 71
3-75 thru 3-76B	12	23 Aug 71
3-77	9	2 Dec 70
3-78	8	9 Sep 70
3-79	9	2 Dec 70
3-80 thru 3-80A/3-80B	12	23 Aug 71
3-81 thru 3-82	9	2 Dec 70
3-83 thru 3-84	13	4 Apr 72
3-84A/3-84B	9	2 Dec 70
3-85 thru 3-87	9	2 Dec 70
3-88 thru 3-88A/3-88B	6	10 Feb 70
3-89 thru 3-90	8	9 Sep 70
3-90A/3-90B	11	6 May 71
3-91	11	6 May 71
3-92 thru 3-93	9	2 Dec 70
3-94 thru 3-96A/3-96B	12	23 Aug 71
3-97 thru 3-98	9	2 Dec 70
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3-101	9	2 Dec 70
3-102 thru 3-104A/3-104B	12	23 Aug 71
3-105	6	10 Feb 70
3-106 thru 3-106C/3-106D	13	4 Apr 72
3-107	8	9 Sep 70
3-108	9	2 Dec 70
3-109 thru 3-111	8	9 Sep 70
3-112 thru 3-113	6	10 Feb 70
3-114	13	4 Apr 72
3-114A	6	10 Feb 70
3-114B	8	9 Sep 70
3-115	6	10 Feb 70
3-116	13	4 Apr 72
3-117	3	[illegible] Jul 69
3-118	1	23 Apr 69
3-119	8	9 Sep 70
3-120 thru 3-121	1	23 Apr 69
3-122	8	9 Sep 70
3-123	1	23 Apr 69
3-124	9	2 Dec 70
3-124A thru 3-124B	7	28 Apr 70
3-124C	8	9 Sep 70
3-124D	9	2 Dec 70
3-125	7	28 Apr 70
3-126 thru 3-127	8	9 Sep 70
3-128	11	6 May 71
3-129	9	2 Dec 70
3-130	6	10 Feb 70
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3-131	14	9 Oct 72
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3-132D	8	9 Sep 70
3-133 thru 3-134	4	6 Aug 69
3-135	7	28 Apr 70
3-136 thru 3-140	4	6 Aug 69
3-141	11	6 May 71
3-142 thru 3-145	4	6 Aug 69
3-146	11	6 May 71
3-147 thru 3-148	4	6 Aug 69
3-148A	8	9 Sep 70
3-148B	7	28 Apr 70
3-149	7	28 Apr 70
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INTRODUCTION

SCOPE. This manual contains operating requirements and recommended procedures to support these requirements, for the F-1 Rocket Engine, Part Number 104001, Serial Numbers F-2029 through F-2098, designed and manufactured by Rocketdyne, a division of North American Rockwell Corporation, 6633 Canoga Avenue, Canoga Park, California 91304.

1. OUTLINE OF ENGINE OPERATING INSTRUCTIONS INFORMATION.

Operating and General Requirements.

Section I, Operating Requirements, and section II, General Requirements, provide all the specific and general requirements for the activities to be performed, acceptability criteria for these activities, limits, special constraints, safety precautions, and sequences required to satisfactorily accomplish the activities. Sections I and II represent requirements that have been agreed to by NASA, the Stage Contractor, and the Engine Contractor. Changes to these sections are Class I type changes and are subject to contractual approval. Exceptions to the requirements, limits and constraints specified in sections I and II require the approval of NASA.

Operating Procedures.

Section III outlines the procedures recommended by the Engine Contractor to satisfy the requirements of sections I and II most effectively. Where applicable, maintenance and repair type manuals are referenced to avoid duplications of existing field procedures for maintenance and repair, routine handling, and engine buildup.

2. ENGINE OPERATING INSTRUCTIONS (EOI) CONTROL AND REVISION SYSTEM.

Section I and II Control and Revision.

Changes to sections I and II of this manual are Class I by definition and require an Engineering Change Proposal (ECP), approved by NASA change order, before such changes can be incorporated into the manual. When the need for a change occurs, a Preliminary Operating Instruction Change Notice (POICN) is submitted with the engine hardware ECP or by separate ECP, as applicable, to NASA for coordination with the Stage Contractor and subsequent approval. NASA approval of the ECP and POICN authorizes release of an Operating Instruction Change Notice (OICN) to all manual holders. Revisions or changes to sections I and II will be made periodically to incorporate outstanding OICNs into the manual. When a Class I change to section I or II affects the information in section III, the section III changes will also appear on the OICN, when practicable, to ensure concurrency between all sections of the manual.

Section III Control and Revision.

Changes to section III of this manual are Class II by definition. Changes to section III that are not concurrently released with an OICN change to sections I or II, will be issued, as required, by revision, change, or if urgency demands, by a noncontractually approved OICN, to update the data or convey new methods that develop through field or factory experience. Revisions, changes, and OICNs applicable to section III will be submitted to the Resident NASA Quality Control Office for acceptance in accordance with established contractual requirements.

Index of OICN Changes.

This manual incorporates engine operating requirements for the ECPs and corresponding engine MD number, listed in figure 1, that were contractually approved as of 1 April 1969. These ECPs form the approval baseline for sections I and II. The index of OICN changes, figure 2, reflects the ECP/OICN changes that were issued after the initial release of this manual. The index of OICN changes includes the approved ECP number that authorizes the incorporation of an OICN, the related engine MD number (if applicable), the OICN number and date, and the pages affected by the change. Upon receipt of an OICN, make an appropriate reference to the OICN in the margin next to the data changed. In figure 2, enter the ECP and engine MD number (if applicable), OICN number and date, and the affected pages. File all OICNs in the Appendix to this manual.

Engine Baseline Configuration. Figure 3 represents the engine baseline configuration for requirements and procedures included in this manual. The manual is coded for engines incorporating or not incorporating, as applicable, MD configurations that are different from the baseline model.

Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.
F1-38	37	F1-62	7	F1-80	7	F1-100	7
F1-38R1		F1-64	7	F1-82	18	F1-101	8
F1-39	11	F1-65	7	F1-85	7	F1-106	7
F1-40		F1-67	10	F1-86	7	F1-108	7
F1-42	7	F1-69	7	F1-90	7	F1-124	7
F1-45	7	F1-71	9	F1-91	7	F1-129	8
F1-56	7	F1-74	7	F1-95	7	F1-129R1	
F1-57	7	F1-76	24	F1-97	7	F1-131	7
F1-59	7	F1-76R1		F1-98	20	F1-132	7
F1-60	16	F1-78	7	F1-99	14	F1-135	7

Figure 1. ECP Approval Baseline (Sheet 1 of 3)

Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.
F1-143	11	F1-236	7	F1-307	74	F1-370	106
F1-143R1		F1-241	7	F1-307R1		F1-370R1	
F1-146	1	F1-242	39	F1-308	31	F1-370R2	
F1-147	7	F1-244	7	F1-309	77,80,	F1-370R3	
F1-149	11	F1-251	7		95	F1-371	31
F1-153	7	F1-253	43	F1-310	78,80,	F1-372	100
F1-154	7	F1-254	7		95	F1-372R1	
F1-165	12	F1-255	42,45	F1-311	31,108	F1-372R2	
F1-165R1		F1-258	22	F1-311R1		F1-373	N/A
F1-166	13	F1-258R1		F1-312	96,97	F1-378	58
F1-168	8	F1-258R2		F1-312R1		F1-378R1	
F1-169	7	F1-260	54	F1-312R2		F1-378R2	
F1-172	7	F1-260R1		F1-312R3		F1-378R2	
F1-174	21	F1-260R2	155	F1-313	69	F1-379	101
F1-174R1		F1-261	122	F1-313R1		F1-379R1	
F1-176	22	F1-262	50	F1-314	31	F1-379R2	
F1-180	34	F1-263	51	F1-315	70,83	F1-380	99
F1-182	7	F1-267	49	F1-315R1		F1-381	31
F1-185	32	F1-268	59	F1-315R2		F1-391	102,103
F1-185R1		F1-268R1		F1-316	31	F1-391R1	
F1-188	7	F1-269	55	F1-317	71	F1-392	137
F1-188R1		F1-270	17	F1-319	31	F1-392R1	
F1-189	7	F1-270R1		F1-320	75	F1-392R2	
F1-191	7	F1-270R2		F1-320R1		F1-405	128
F1-192	46	F1-274	53	F1-321	31	F1-405R1	
F1-192R1		F1-276	22	F1-323	84,85,	F1-405R2	
F1-192R2		F1-277	61		86	F1-406	
F1-193	7	F1-278	64	F1-323R1		F1-407	109
F1-193R1		F1-279	21	F1-323R2		F1-407R1	
F1-194	7	F1-279R1		F1-323R3		F1-408	104
F1-195	7	F1-282	31	F1-324	72	F1-408R1	
F1-196	29	F1-283	65	F1-324R1		F1-409	105
F1-197	20	F1-283R1		F1-326	79,80,	F1-410	128
F1-198	26	F1-283R2			95	F1-410R1	
F1-198R1		F1-285	68	F1-328	76	F1-415	107
F1-202	7	F1-285R1		F1-328R1		F1-416	120
F1-206	22,66	F1-287	31	F1-331	31	F1-416R1	
F1-206R1		F1-288	31	F1-332	31	F1-417	N/A
F1-206R2		F1-289	63	F1-333	54	F1-418	N/A
F1-208	33	F1-289R1		F1-335	31	F1-418R1	
F1-208R1		F1-289R2		F1-342	30	F1-419	N/A
F1-208R2		F1-294	57	F1-343	90,91	F1-419R1	
F1-214	31	F1-294R1		F1-347	31	F1-420	
F1-214R1		F1-294R2		F1-352	31	F1-420R1	
F1-216	31	F1-303	54	F1-352R1		F1-421	N/A
F1-216R1		F1-303R1		F1-353	82	F1-421R1	
F1-217	7	F1-304	67	F1-356	88,93	F1-422	113,114
F1-226	35	F1-304R1		F1-357	89	F1-422R1	
F1-228	36	F1-305	73	F1-358	31	F1-423	119
F1-229	8	F1-305R1		F1-360	99	F1-423R1	
F1-229R1		F1-306	66	F1-361	92	F1-424	110
F1-233	38	F1-306R1		F1-362	54	F1-424R1	
F1-235	31	F1-306R2		F1-369	94	F1-426	117

Figure 1. ECP Approval Baseline (Sheet 2 of 3)

Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.
F1-426R1		F1-449	127	F1-500R1		F1-548	160
F1-427	111	F1-449R1		F1-502	148	F1-548R1	
F1-427R1		F1-452	126	F1-504	141	F1-552	170
F1-427R2		F1-452R1		F1-504R1		F1-552R1	
F1-428	87	F1-453	123	F1-505	161	F1-552R2	
F1-428R1		F1-454	118	F1-505R1		F1-568	N/A
F1-430	112	F1-454R1		F1-506	159	F1-570	N/A
F1-431	137	F1-454R2		F1-507		F1-574	N/A
F1-431R1		F1-456	124	F1-509	143	F1-578	
F1-431R2		F1-456R1		F1-510	152	F1-578R1	
F1-432	125	F1-457	136	F1-510R1		F1-579	N/A
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F1-444	139	F1-478R2		F1-526R1		F1-602	178
F1-444R1		F1-480	132	F1-530	162, 163		
F1-444R2		F1-480R1		F1-530R1			
F1-445	122	F1-482	142	F1-530R2			
F1-445R1		F1-482R1	142	F1-530R3			
F1-447	138	F1-495	144	F1-535	N/A		
F1-447R1		F1-495R1		F1-543	165		
F1-447R2		F1-498	145	F1-543R1			
F1-448	149	F1-499	137	F1-545	154		
F1-448R1		F1-499R1		F1-546	N/A		
F1-448R2		F1-500	150, 151	F1-547	169		

Figure 1. ECP Approval Baseline (Sheet 3 of 3)

ECP No.	Engine MD No.	OICN No. and Date	Affected Pages
F1-900R1	N/A	1, 24 June 1969	1-2 through 1-6, 1-43, 1-44, 1-56, 1-59, 1-67, and 2-29
F1-901R1	N/A	2, 9 October 1969	1-3, 1-10, 1-11, 1-14, 1-16, 1-17, 1-18, 1-20, 1-21, 1-22, 1-40, 1-41, 1-45, 1-47, 1-72, 1-112, 1-115, 1-117, 2-10, and 2-35
N/A	N/A	3, 1 August 1969	3-124
F1-902R1	N/A	4, 17 December 1969 and as changed by Modification No. 301 to Contract NAS8-18734	1-4, 1-7, 1-8, 1-9, 1-12, 1-13, 1-14, 1-16, 1-22, 1-27, 1-28, 1-29, 1-33, 1-34, 1-37, 1-39, 1-55, 1-56, 1-57, 1-58, 1-59, 1-62, 1-63, 1-64, 1-69, 1-78B, 1-78C, 1-79, 1-80, 1-81, 1-82, 1-83, 1-84, 1-85, 1-89, 1-90, 1-91, 1-92, 1-95, 1-96, 1-100, 1-105, 1-126, 2-1, 2-2, 2-3, 2-7, 2-14, 2-16, 2-21, 2-27, 2-29, 2-30, 2-34, 2-38, 2-40, 2-41, and 2-49
N/A	N/A	5, 24 September 1969	3-14, 3-15, 3-44, 3-85, 3-95, 3-96, 3-99, 3-100, and 3-104
F1-903	N/A	6, 11 December 1969	1-4 and 1-68
N/A	N/A	8, 3 October 1969	3-23, 3-25, 3-26, 3-27, 3-28, 3-30, 3-31, 3-33, 3-36, 3-45, 3-46, 3-47, 3-48, 3-49, 3-50, 3-51, 3-52, 3-53, and 3-131
F1-905	N/A	10, 11 December 1969	1-44 and 1-45
N/A	N/A	11, 16 October 1969	3-80 and 3-81
N/A	N/A	12, 22 October 1969	3-92, 3-94, 3-98, 3-99, 3-104, 3-106, 3-110, 3-111, 3-112, and 3-115
F1-906	N/A	13, 29 December 1969	1-2, 1-8, 1-35, 1-38, and 2-8
N/A	N/A	14, 12 November 1969	3-132 and 3-132A
F1-907	N/A	16, 25 March 1970	2-2, 2-49, and 2-53
N/A	N/A	17, 5 December 1969	3-113, 3-114, and 3-124
F1-908	N/A	19, 14 March 1970	1-2, 1-24, and 1-107
F1-909	N/A	20, 25 March 1970	1-8, 1-18, 1-22, 1-33, 1-47, 1-48B, 1-50, 1-53, 1-67, 1-69, 1-79, 2-7, and 2-13
F1-910	N/A	22, 9 April 1970	1-12, 1-13, 1-14, 1-71, 1-72, 2-10, 2-14, 2-20, and 2-29
N/A	N/A	23, 9 January 1970	3-114
N/A	N/A	24, 4 February 1970	3-124A/3-124B, 3-125, and 3-126

Figure 2. Index of OICN Changes (Sheet 1 of 3)

ECP No.	Engine MD No.	OICN No. and Date	Affected Pages
F1-912	N/A	25, 22 May 1970	1-101, 1-102, 1-104, 1-105, 2-12, and 2-13
F1-614	N/A	26, 25 June 1970	1-93, 1-94, 2-3, and 2-8
F1-913	N/A	27, 29 June 1970	1-42, 1-43, 1-44, 1-45, 1-55, 1-56, 1-58, 1-59, 1-60, 1-61, 1-62, 1-63, 1-64, 1-65, 1-67, and 2-29
F1-914	N/A	28, 29 June 1970	1-34, 1-35, 1-38, 1-45, 1-47, 1-48A, 1-48B, 1-53, and 1-67
N/A	N/A	29, 13 February 1970	3-135 and 3-149
N/A	N/A	30, 3 March 1970	3-60, 3-61, 3-132, 3-132A, and 3-132B
F1-915	N/A	31, 30 September 1970	1-4, 1-6, 1-46, 1-47, 1-48, 1-77, 1-78B, 1-78E/1-78F, 1-100, 1-106, 1-107, 1-108, 2-1, 2-2, and 2-3
F1-916	N/A	32, 30 September 1970	1-34, 1-35, 1-102, and 1-103
N/A	N/A	33, 29 April 1970	3-10, 3-13, 3-41, 3-62, 3-86, and 3-124
N/A	N/A	34, 5 May 1970	3-53, 3-54, 3-58, and 3-124
F1-917	N/A	35, 30 September 1970	1-3, 1-60, 1-61, 1-66, and 1-87
N/A	N/A	36, 18 June 1970	3-1 and 3-148A
F1-918	N/A	37, 30 September 1970	2-17
N/A	N/A	38, 8 July 1970	3-132D
F1-919	N/A	39, 6 November 1970	1-26, 1-126, and 2-30
F1-920	N/A	40, 3 February 1971	1-4, 1-5, 1-8, 1-82, 1-84, 1-84A/1-84B, 1-91, 1-92, 1-95, 1-96, 1-96A, 1-96B, 1-96C/1-96D, 1-97, 1-126, 2-45, 2-46, 2-52, 2-53, and 2-54
F1-921	N/A	41, 23 February 1971	1-5, 1-6, 1-9, 1-11, 1-12, 1-13, 1-14, 1-16, 1-18, 1-21, 1-27, 1-48C/1-48D, 1-71, 1-72, 1-107, 1-108, 1-125, 2-18, 2-19, and 2-21
N/A	N/A	42, 2 October 1970	3-124D

Figure 2. Index of OICN Changes (Sheet 2 of 3)

ECP No.	Engine MD No.	OICN No. and Date	Affected Pages
N/A	N/A	44, 9 October 1970	3-18, 3-19, 3-41, 3-42, 3-44, 3-58, 3-65, 3-67, 3-77, 3-79, 3-81, 3-82, 3-83, 3-85, 3-86, 3-87, 3-92, 3-93, 3-97, 3-98, 3-101, 3-104, 3-128, and 3-129
N/A	N/A	45, 2 November 1970	3-20, 3-67, and 3-80
N/A	N/A	46, 4 November 1970	3-84
F1-923	N/A	47, 16 August 1971	1-85 and 1-125
N/A	N/A	48, 15 February 1971	3-141
F1-924	N/A	49, 24 May 1971	1-30
F1-925	N/A	50, 20 July 1971	2-54 and 2-55/2-56
F1-928	N/A	53, 25 October 1971	2-21
N/A	N/A	54, 25 May 1971	3-74C, 3-74D, 3-94, 3-95, 3-96, 3-102, and 3-103
N/A	N/A	55, 10 June 1971	3-14, 3-15, 3-38, 3-80, and 3-80A/3-80B
F1-929	N/A	56, 15 August 1972	1-60A, 1-60B, and 2-28
N/A	N/A	57, 13 July 1971	3-14, 3-15, 3-38, 3-80, and 3-80A/3-80B
N/A	N/A	58, 4 August 1971	3-21, 3-22, 3-31, 3-34, 3-38, 3-68, 3-69, 3-75, 3-76A/3-76B, 3-80, and 3-80A/3-80B
F1-930	N/A	59, 15 August 1972	1-12, 1-13, 1-14, 1-16, 1-20, 1-21, 1-27, 1-71, 1-72, 1-72A/1-72B, 2-10, 2-13, and 2-29
F1-932	N/A	61, 6 March 1972	1-4, 1-48C/1-48D, 1-69, 2-10, and 2-55/2-56
N/A	N/A	63, 29 November 1971	3-1 and 3-155
F1-934	N/A	64, 31 March 1972	2-12, 2-13, 2-14, and 2-54
F1-935	N/A	65, 5 April 1972	1-81 and 1-82
F1-936	N/A	66, 24 May 1972	2-36A
F1-937	N/A	67, 17 October 1972	1-13, 1-14, 1-16, 1-21, 1-27, and 2-21
N/A	N/A	68, 13 June 1972	3-1, 3-2, 3-2B, 3-130A/3-130B, and 3-131

Figure 2. Index of OICN Changes (Sheet 3 of 3)

1 x 7 <u>11</u> x <u>13</u> <u>14</u> x <u>16</u> x <u>18</u> x <u>20</u> <u>22</u> x <u>24</u> x <u>26</u> x <u>29</u> x <u>31</u> <u>33</u> x <u>35</u> x <u>37</u> <u>39</u> x <u>42</u> <u>43</u> x <u>46</u> <u>47</u> x <u>49</u> <u>51</u> x <u>54</u> <u>55</u> x <u>57</u> x <u>59</u> x <u>61</u> x <u>63</u> <u>73</u> x <u>75</u> <u>79</u> x <u>87</u> <u>90</u> x <u>92</u> x <u>94</u> x <u>100</u> <u>101</u> x <u>104</u> <u>105</u> x <u>107</u> x <u>109</u> <u>110</u> x <u>113</u> x <u>115</u> x <u>117</u> <u>122</u> x <u>124</u> x <u>126</u> x <u>130</u> x <u>133</u> <u>135</u> x <u>137</u> <u>139</u> x <u>142</u> x <u>144</u> x <u>149</u> x <u>155</u> x <u>156</u> <u>158</u>

Figure 3. Engine Baseline MD Configuration

3. ABBREVIATIONS.

The following abbreviations may appear throughout this manual:

ac	alternating current
AWG	American Wire Gage
Btu	British thermal unit
C	Celsius (Centigrade)
cc	cubic centimeter
cc/m	cubic centimeters per minute
cfm	cubic feet per minute
cfs	cubic feet per second
cg	center of gravity
cpm	cycles per minute
cps	cycles per second
cu in.	cubic inch
cu ft	cubic foot
db	decibel
dc	direct current
DNA	does not apply
ECP	Engineering Change Proposal
F	Fahrenheit
ft-lb	foot-pound
ft/sec	feet per second
F_x	force, x-axis
F_y	force, y-axis
F_z	force, z-axis
g	gravitational constant
GN_2	gaseous nitrogen
GOX	gaseous oxygen
gpm	gallons per minute
gps	gallons per second
He	helium
HE	heat exchanger
in.	inch
in-lb	inch-pound
kc	kilocycle
KSC	Kennedy Space Center
lb/sec	pounds per second
LN_2	liquid nitrogen
LOX	liquid oxygen
MAF	Michoud Assembly Facility
max	maximum
min	minimum
ml	milliliter
msec	millisecond
MTF	Mississippi Test Facility
MSFC	Marshall Space Flight Center
N/A	not applicable
NPSH	net positive suction head
M_x	moment, x-axis
M_y	moment, y-axis
M_z	moment, z-axis
No.	number
nom	nominal
OICN	Operating Instruction Change Notice
Pc	chamber pressure
pH	denotes acidity and alkalinity
P/N	part number
ppm	parts per million
psia	pounds per square inch, absolute
psig	pounds per square inch, gage
R	radius or resistance
REF	reference
RJ-1	ramjet fuel
rms	root mean square
rpm	revolutions per minute
scfm	standard cubic feet per minute
scim	standard cubic inch per minute
sec	second
S/N	serial number
sq in.	square inch
sq ft	square foot
SSI	stage static instrumentation
TIS	thermal insulation set
VAB	Vehicle Assembly Building
vac	volts alternating current
vdc	volts direct current

4. DEFINITIONS.

Stage Contractor	The Boeing Company and its affiliates or subcontractors
Engine Contractor	Rocketdyne and its designated representatives, such as field engineering personnel

Customer	NASA and its designated representatives
Uninstalled engines	Engines not installed in the S-IC stage
Installed engines	Engines installed in the S-IC stage
No damage is allowable.	Defined in paragraph 2.4.3A
Engine service life	Defined in paragraph 2.5.9
Engine start	Defined in paragraph 2.5.9
Component cycle	Defined in paragraph 2.5.10
No leakage is allowable	Defined in paragraph 2.5.11
Fuzz leakage	Defined in paragraph 2.5.11
Hydraulic surface wetting	Defined in paragraph 2.5.20
Long-term storage	Defined in paragraph 2.5.11.1
Engine standby status	Defined in paragraph 2.2A.1

4A. SYMBOLS.

Symbols used in the text and on illustrations are as follows:

A change bar and an ECP number are placed adjacent to the text or illustration in sections I and II to indicate the area of
711 change made after the basic effort. The index of OICN changes (figure 2) lists the corresponding OICN numbers.

A change bar is placed adjacent to the text or illustration in section III to indicate the area of change made after the basic effort.

Used on illustrations to indicate effectivity of specific configurations.

5. ADDITIONAL DATA AND INFORMATION.

The following documents provide additional information on the F-1 rocket engine (figure 4) and F-1 ground support equipment and tooling:

R-3896-1, F-1 Rocket Engine Data Manual. This manual contains engineering data including engine description, operation, and engine system functions.

R-3896-3, F-1 Rocket Engine Maintenance and Repair Manual (Volume I). This manual contains general engine maintenance, handling, component removal and installation, and post-maintenance checkout requirements.

R-3896-3, F-1 Rocket Engine Maintenance and Repair Manual (Volume II). This manual contains component repair and testing procedures for individual engine components.

R-3896-4, F-1 Rocket Engine Illustrated Parts Breakdown Manual. This manual lists and illustrates the parts required for maintenance-level support of the F-1 rocket engine, including closures for the assembled F-1 rocket engine and its individual components and parts.

R-3896-5, F-1 Rocket Engine Ground Support Equipment Maintenance and Operation Manual (Volume I). This manual contains description, theory of operation, maintenance and checkout data, maintenance-level codes keyed to parts lists, and proof loading and pressure test requirements for delivered F-1 rocket engine ground support equipment.

R-3896-5, F-1 Rocket Engine Ground Support Equipment Maintenance and Operation Manual (Volume II). This manual contains physical and functional description, intended usage, equipment dimensions, weight, operating limitations, power and fluid requirements, a breakdown parts list, periodic maintenance and testing requirements, and other procedures for determining that the equipment and T tooling are in an operable condition.

R-3896-6, F-1 Rocket Engine Thermal Insulation and Repair Manual. This manual contains description, installation and removal procedures, and data for repair of thermal insulation for the F-1 rocket engine.

R-3896-9, F-1 Rocket Engine Transportation Manual. This manual contains procedures for preparing the F-1 rocket engine, nozzle extension, thermal insulation, and miscellaneous engine loose equipment for shipment and for shipping by truck, air, or by water. Included are recommended truck, air, and water transport checklists that may be used to verify that procedures and in-transit inspections have been performed.

R-5857, Saturn F-1 Configuration Identification & Status Report. This report provides a record of the configuration, allocation, identification, and status of delivered F-1 rocket engine and related support equipment.

R-6749, F-1 Engine Interface Document. This document is a summary and categorization of F-1 engine interface information necessary to identify established design compatibility between the engine and its mating system.

R-8842, Maintenance and Support Plan For Saturn F-1, H-1, and J-2 Rocket Engines. This plan defines the various support functions and conveys maintenance and support planning information for the Saturn engines and support equipment.

6. CONFIGURATION IDENTIFICATION.

EQUIPMENT CONFIGURATION. The MD identification symbol and the equipment model designation indicate the configuration of the equipment and distinguish it from models incorporating different changes and from basic models. A basic, unchanged configuration of the equipment has no MD identification symbol. MD identification symbols are added as changes affecting configuration are incorporated into the equipment. The MD identification symbol is stamped on the MD plate, which is mounted near the engine nameplate.

MD IDENTIFICATION SYMBOLS. On MD identification plate RD171-1022-0001, the identification symbol is a composite number representing all the changes affecting configuration (MD changes) incorporated or not incorporated into the equipment. The symbol represents a consecutively numbered series of MD changes. Any MD change or series of MD changes, not incorporated is represented by an "X." Multi-digit numbers are underlined. Two figures together represent the limits of a series of incorporated MD changes. Figure 5 illustrates how MD changes incorporated in the engine are represented by the MD identification symbol.

MD identification plates RD171-1052-0001 through -0006 have preprinted numbers from 1 through 100 on the -0001 plate, 101 through 200 on the -0002 plate, etc. Modifications that are incorporated into the equipment are represented by the letter P (production) or K (kit) stamped in the square directly to the right of the applicable number. Omission of a P or K, indicates that the MD change is not incorporated. A P or K with a bar (-) marked through the letter (P, K) indicates a MD change deleted in its entirety by the incorporation of a later MD change. Figure 5 illustrates how MD changes incorporated into the equipment are represented by the MD identification symbol.

MANUAL REFERENCE. A reference that appears in the manual may refer to a series of MD changes or to an individual MD change; for example, "MD9" refers to MD1 through MD9, but "MD9 change" refers to the individual MD change 9. This latter type of reference, illustrated in figure 5, identifies separate sets of information required by differences in configuration. When an MD reference appears in the manual, examine the MD identification symbol on the equipment to determine which set of information is applicable.

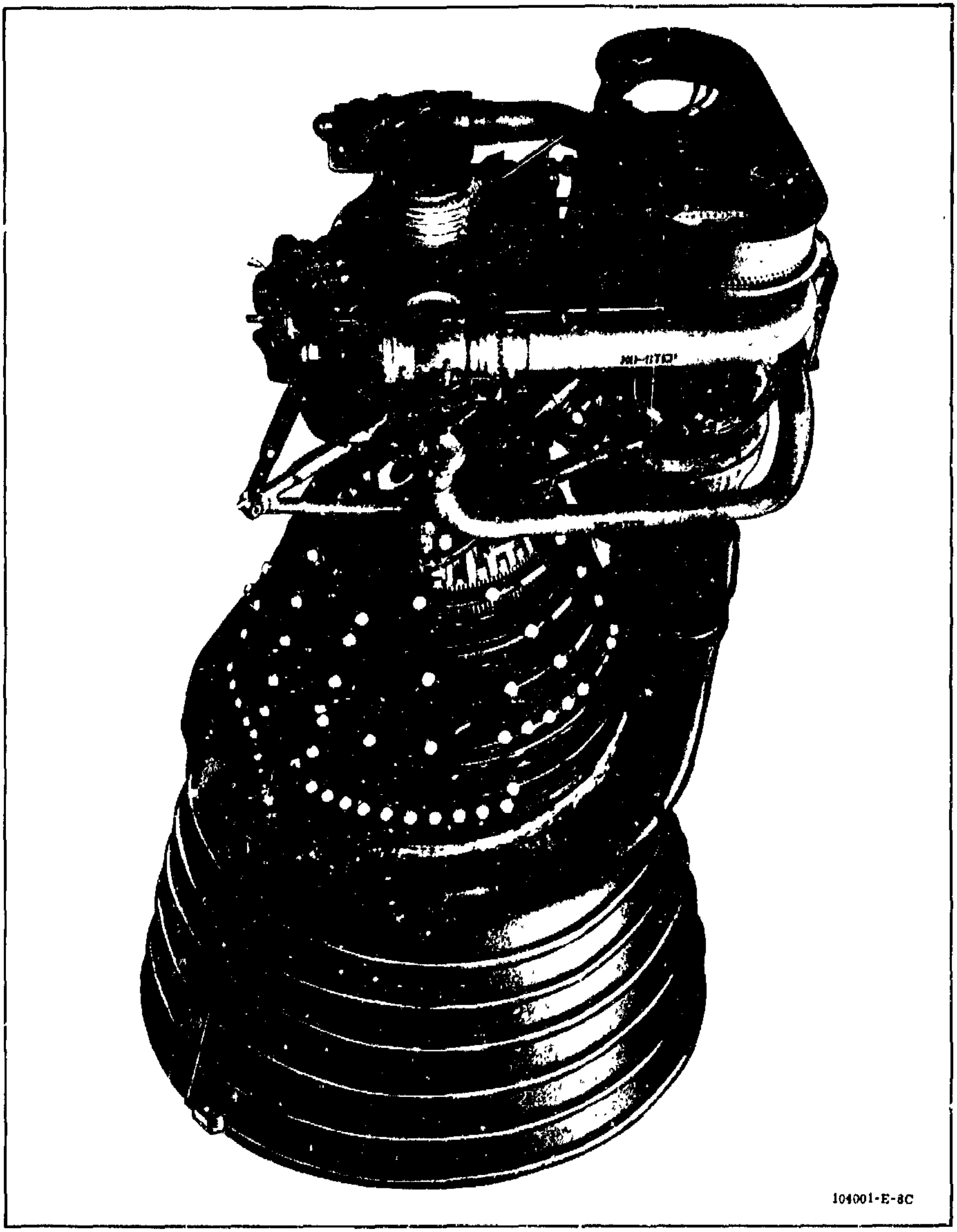

Figure 4. F-1 Rocket Engine

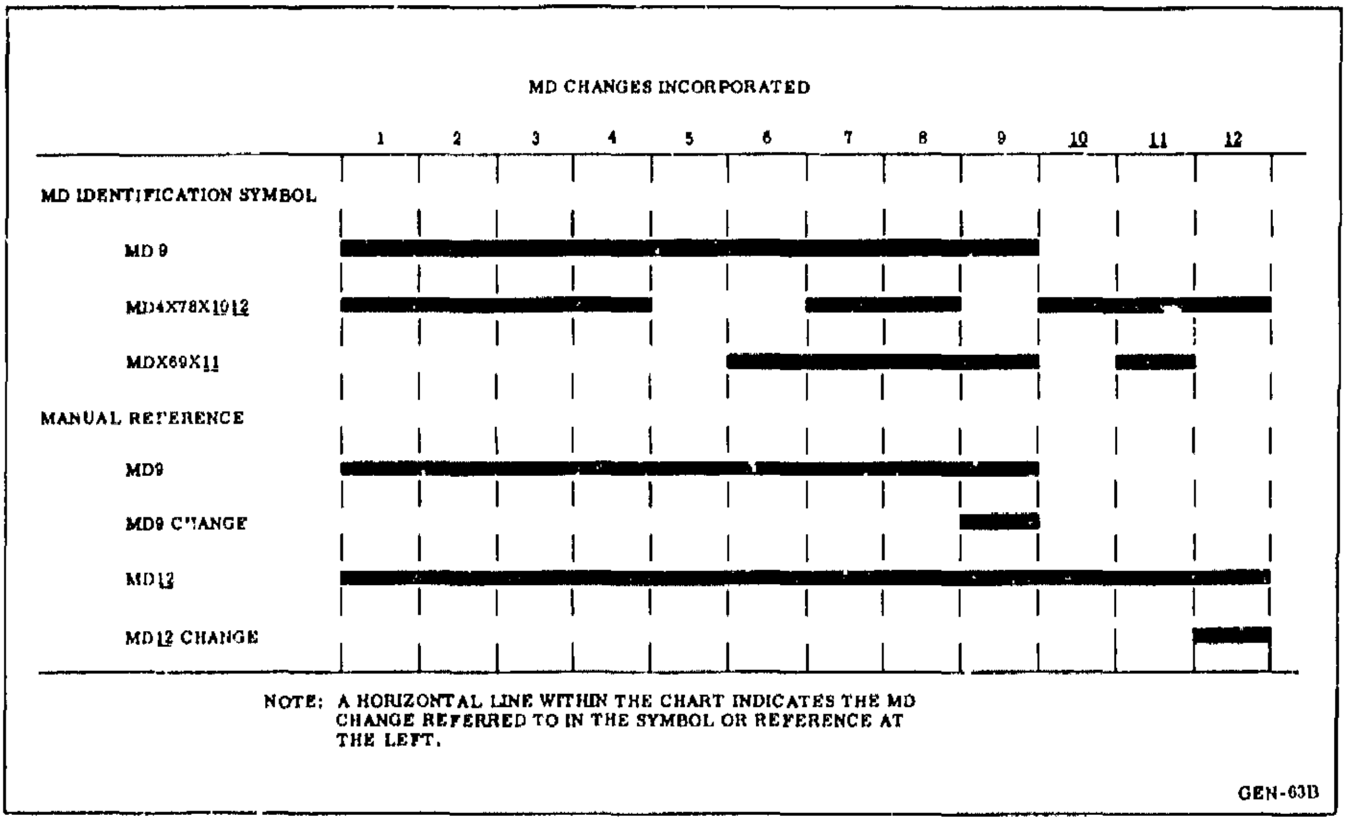

Figure 5. MD System

SECTION I

OPERATING REQUIREMENTS

SCOPE. This section outlines the scheduled and nonscheduled authorized engine activities and the requirements, limits, and constraints necessary to satisfactorily comply with these activities.

Scheduled Authorized Field Activities, figure 1-1, lists from left to right the major engine events with respect to engine status (a single engine or an engine installed in a stage). All activities for each event must be accomplished before starting the next event. Activities listed for each event may be performed in any order unless otherwise specified in the referenced activity paragraph contained in the requirements, limits, and constraints tabular presentation.

Nonscheduled Authorized Field Activities, figure 1-2, lists the activities that must be performed during nonscheduled events. The events listed across the top of this figure are grouped to reflect the location and conditions that prevailed at the time the accomplishment of a nonscheduled activity became necessary. The listed order of these events is not sequence oriented; therefore, the activities may be performed in any order unless otherwise specified in the referenced activity paragraph contained in the requirements, limits, and constraints tabular presentation. The static test and launch abort activities assume that abort was not due to engine associated problems.

Requirements, limits, and constraints are presented in tabular form immediately following figure 1-2. These activities must be accomplished during that phase of scheduled or nonscheduled engine flow specified in figures 1-1 and 1-2. During compliance with these activities, the following general requirements shall apply:

a. The safety precautions specified in section II must be complied with.

b. When the activity requires the application of a specific purge, the purge pressures and flowrates specified in section II must be applied, unless otherwise specified.

c. When a checkout activity requires pressurizing or purging a system or component, the fluid requirements specified in section II for engine checkout must be complied with.

Activity Number	Activity \ Event	SINGLE ENGINE: Receiving Inspection	SINGLE ENGINE: Checkout	SINGLE ENGINE: Storage**	SINGLE ENGINE: Installation in Stage	STAGE PRE-STATIC	STAGE PRE-STATIC: Storage**	STAGE PRE-STATIC: Shipment	STAGE STATIC TEST: Receiving Inspection	STAGE STATIC TEST: Storage	STAGE STATIC TEST: Pre-Static Checkout	STAGE STATIC TEST: Static Test Preparation	STAGE STATIC TEST: Post-Static-Test Securing	STAGE STATIC TEST: Shipment
		A	B	C	D	E	F	G	H	I	J	K	L	M
	INSPECTIONS													
1	Overall engine visual	1.1.1		1.1.2			1.1.3	1.1.4	1.1.5	1.1.3			1.1.6	1.1.4
2	Thrust chamber nozzle extension visual	1.1.7							1.1.7				1.1.8	
3	Thrust chamber tubes visual												1.1.9	
4	Thrust chamber injector contamination											1.1.10	1.1.10	
5	Thrust chamber injector damage												1.1.11	
6	Thrust chamber drain adapter torque verification												1.1.12	
6A	Engine joints closure removal verification											1.1.12A		
	ELECTRICAL TESTS													
7	Flight instrumentation system function		1.2.1								1.2.2		1.2.2	
8	Turbopump heater function		1.2.3								1.2.3			
9	Hypergol installed switch function		1.2.4								1.2.4			
10	Checkout valve timing function		1.2.5								1.2.5			
11	Engine safety circuits function										1.2.6			
12	Engine sequence verification										1.2.8			
13	Igniter test											1.2.9		
14	Inert igniter test													
15	Igniter harness test											1.2.14		
16	Vibration safety cutoff verification											1.2.12		
17	Thrust OK pressure switch function													
17A	Checkout valve engine return switch position verification											1.2.15		

* Activity requires removal and reinstallation of thermal insulation panels. Refer to section II for panel location.

** For engines stored in accordance with MSFC-STD-500, refer to paragraph 2.5.11.1 for checkout requirements after re

Figure 1-1. Scheduled Authorized Field Activities (Sheet

STAGE PRE-STATIC			STAGE STATIC TEST						STAGE POST-STATIC TEST				VEHICLE (KSC)					
	Storage**	Shipment	Receiving Inspection	Storage	Pre-Static Checkout	Static Test Preparation	Post-Static-Test Securing	Shipment	Receiving Inspection	Post-Static-Test Checkout	Storage**	Shipment	Stage Receiving Inspection	Storage	Vehicle Checkout at VAB	Countdown Demonstration Tests	Countdown Demonstration Test--Securing	Launch Preparation
E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
	1.1.3	1.1.4	1.1.5	1.1.3			1.1.6	1.1.4	1.1.4A		1.1.3	1.1.4B	1.1.5	1.1.3				
			1.1.7				1.1.8		1.1.7				1.1.7					
							1.1.9											
						1.1.10	1.1.10								1.1.10			1.1.10
							1.1.11											
							1.1.12											
						1.1.12A									1.1.12B			
					1.2.2		1.2.2			1.2.2					1.2.2	1.2.2		1.2.2
					1.2.3					1.2.3					1.2.3			
					1.2.4					1.2.4					1.2.4			
					1.2.5					1.2.5					1.2.5			
					1.2.6													1.2.7
					1.2.8										1.2.8			1.2.8
						1.2.9												1.2.9
																1.2.10		
						1.2.14				1.2.14						1.2.11*		1.2.11*
						1.2.12												
																		1.2.13
						1.2.15												1.2.15

tion panels. Refer to section II for panel location.
to paragraph 2.5.11.1 for checkout requirements after removal from storage.

Figure 1-1. Scheduled Authorized Field Activities (Sheet 1 of 5)

Activity Number	Activity / Event	SINGLE ENGINE				STAGE PRE-STATIC			STAGE STATIC TEST					
		Receiving Inspection	Checkout	Storage**	Installation in Stage		Storage**	Shipment	Receiving Inspection	Storage	Pre-Static Checkout	Static Test Preparation	Post-Static-Test Securing	Shipment
		A	B	C	D	E	F	G	H	I	J	K	L	M
	LEAK AND FUNCTION TESTS													
18	Turbopump torque function		1.3.1								1.3.1		1.3.1	
19	Thrust OK pressure switch leak and function		1.3.3								1.3.3			
20	LOX dome and gas generator LOX injector purge leak and function		1.3.4								1.3.5A			
21	LOX pump seal purge leak and function		1.3.6								1.3.7			
22	Cocoon purge leak and function													
23	Heat exchanger helium system leak		1.3.10								1.3.12			
24	Heat exchanger LOX system leak		1.3.14								1.3.16			
25	Hydraulic system leak and function		1.3.19								1.3.19		1.3.19A	
26	Ignition monitor valve diaphragm leak		1.3.20											
27	Hypergol manifold leak and function		1.3.21											
28	Ignition monitor valve interflow function		1.3.22								1.3.22			
29	Ignition monitor valve shuttle pressure function		1.3.23											
30	Valve timing function		1.3.24								1.3.25			
31	Fuel feed system leak		1.3.26								1.3.28			
32	LOX feed system leak		1.3.30								1.3.32			
33	Exhaust system leak		1.3.35											
34	Turbopump bearing coolant system leak and function		1.3.38											

** For engines stored in accordance with MSFC-STD-500, refer to paragraph 2.5.11.1 for checkout requirements after remov

Figure 1-1. Scheduled Authorized Field Activities (Sheet 2 o

GE TATIC		STAGE STATIC TEST						STAGE POST-STATIC TEST				VEHICLE (KSC)						
	Shipment	Receiving Inspection	Storage	Pre-Static Checkout	Static Test Preparation	Post-Static-Test Securing	Shipment	Receiving Inspection	Post-Static-Test Checkout	Storage**	Shipment	Stage Receiving Inspection	Storage	Vehicle Checkout at VAB	Countdown Demonstration Tests	Countdown Demonstration Test--Securing	Launch Preparation	900
F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	
				1.3.1		1.3.1			1.3.1					1.3.1				
				1.3.3					1.3.3					1.3.3				
				1.3.5A					1.3.5					1.3.5A				900
				1.3.7					1.3.6					1.3.3				
									1.3.8					1.3.9				
				1.3.12					1.3.13					1.3.11				
				1.3.16					1.3.17					1.3.15				900
				1.3.19		1.3.19A			1.3.19B					1.3.19				901
									1.3.20					1.3.20				
									1.3.21					1.3.21				
				1.3.22					1.3.22					1.3.22				
									1.3.23					1.3.23				
				1.3.25					1.3.25					1.3.25				
				1.3.28					1.3.29					1.3.29				900
				1.3.32					1.3.33					1.3.33				
									1.3.36					1.3.35A				917
									1.3.38					1.3.38				

graph 2.5.11.1 for checkout requirements after removal from storage.

1-1. Scheduled Authorized Field Activities (Sheet 2 of 5)

	Activity Number	Activity \ Event	SINGLE ENGINE: Receiving Inspection	SINGLE ENGINE: Checkout	SINGLE ENGINE: Storage**	SINGLE ENGINE: Installation in Stage	STAGE PRE-STATIC	STAGE PRE-STATIC: Storage**	STAGE PRE-STATIC: Shipment	STAGE STATIC TEST: Receiving Inspection	STAGE STATIC TEST: Storage	STAGE STATIC TEST: Pre-Static Checkout	STAGE STATIC TEST: Static Test Preparation	STAGE STATIC TEST: Post-Static-Test Securing
900			A	B	C	D	E	F	G	H	I	J	K	L
		LEAK AND FUNCTION TESTS (cont)												
932	35	Thrust chamber pneumatic leak		1.3.39										
900	36	Thrust chamber prefill line leak and function											1.3.40B	
903	36A	Ignition monitor valve poppet position verification											1.3.41A	
	37	Thrust chamber liquid leak											1.3.42	1.3.42
	38	(Deleted)												
		STORAGE PREPARATION												
	39	Engine			1.4.1			1.4.2			1.4.2			
	40	Thrust chamber nozzle extension			1.4.3			1.4.3			1.4.3			
915	41	Ordnance									1.4.4			
	42	Miscellaneous loose equipment			1.4.5			1.4.5			1.4.5			
		SERVICING												
	43	LOX dome and gas generator LOX injector flush											1.5.1	
	44	Thrust chamber fuel jacket flush											1.5.3	1.5.3
	45	Engine residual fluid removal											1.5.5	1.5.5
902 920	46	Admitting fuel to engine											1.5.9	
	47	Admitting prefill to engine											1.5.10	
	48	Admitting LOX to engine											1.5.12	
	49	LOX feed system boiloff												1.5.14
902	50	Fuel feed system drain								1.5.15				1.5.16
	51	Gas generator combustor drain												1.5.18

* Activity requires removal and reinstallation of thermal insulation panels. Refer to section II for panel location.
** For engines stored in accordance with MSFC-STD-500, refer to paragraph 2.5.11.1 for checkout requirements after

Figure 1-1. Scheduled Authorized Field Activities (Sh

'AGE STATIC		STAGE STATIC TEST						STAGE POST-STATIC TEST				VEHICLE (KSC)					
Storage#	Shipment	Receiving Inspection	Storage	Pre-Static Checkout	Static Test Preparation	Post-Static-Test Securing	Shipment	Receiving Inspection	Post-Static-Test Checkout	Storage**	Shipment	Stage Receiving Inspection	Storage	Vehicle Checkout at VAB	Countdown Demonstration Tests	Countdown Demonstration Test--Securing	Launch Preparation
F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
									1.3.40					1.3.40A			1.3.43*
					1.3.40B				1.3.41					1.3.41			
					1.3.41A												1.3.41A
					1.3.42	1.3.42											1.3.42
.4.2			1.4.2							1.4.2			1.4.2				
.4.3			1.4.3							1.4.3			1.4.3				
			1.4.4										1.4.4				
.4.5			1.4.5							1.4.5			1.4.5				
					1.5.1												1.5.1*
					1.5.3	1.5.3											1.5.3*
					1.5.5	1.5.5										1.5.5A*	
					1.5.9										1.5.9*		1.5.9*
					1.5.10										1.5.10		1.5.10
					1.5.12										1.5.13		1.5.13
						1.5.14										1.5.14A	
		1.5.15				1.5.16						1.5.15					
						1.5.18											

anels. Refer to section II for panel location.
'agraph 2.5.11.1 for checkout requirements after removal from storage.

: 1-1. Scheduled Authorized Field Activities (Sheet 3 of 5)

Activity Number	Activity \ Event	SINGLE ENGINE				STAGE PRE-STATIC			STAGE STATIC TEST					
		Receiving Inspection	Checkout	Storage**	Installation in Stage		Storage**	Shipment	Receiving Inspection	Storage	Pre-Static Checkout	Static Test Preparation	Post-Static-Test Securing	Shipment
		A	B	C	D	E	F	G	H	I	J	K	L	M
	SERVICING (cont)													
52	Thrust chamber fuel jacket drain												1.5.20	
53	Thrust chamber fuel inlet manifold drain											1.5.21		
54	Turbopump preservation			1.5.22			1.5.22			1.5.22			1.5.22	
	HANDLING													
55	Engine installation				1.6.1									
56	Thrust chamber nozzle extension installation										1.6.2			
57	Igniter harness installation										1.6.3			
58	Thermal insulation installation													
59	Engine environmental cover installation													
60	Hypergol cartridge weight check											1.6.6		
61	Igniter installation											1.6.7		
62	Hypergol cartridge installation											1.6.10		
63	Engine environmental cover removal													
64	Expended hypergol cartridge removal												1.6.13	
65	Igniter removal												1.6.14	
66	Thrust chamber nozzle extension removal												1.6.16	
67	Igniter harness removal													
68	Thrust chamber throat closure installation		1.6.18	1.6.18			1.6.18	1.6.18		1.6.18	1.6.18		1.6.18	1.6.18

* Activity requires removal and reinstallation of thermal insulation panels. Refer to section II for panel location.
** For engines stored in accordance with MSFC-STD-500, refer to paragraph 2.5.1.1 for checkout requirements after rem

Figure 1-1. Scheduled Authorized Field Activities (Sheet 4

TIC	STAGE STATIC TEST						STAGE POST-STATIC TEST				VEHICLE (KSC)						
Shipment	Receiving Inspection	Storage	Pre-Static Checkout	Static Test Preparation	Post-Static-Test Securing	Shipment	Receiving Inspection	Post-Static-Test Checkout	Storage**	Shipment	Stage Receiving Inspection	Storage	Vehicle Checkout at VAB	Countdown Demonstration Tests	Countdown Demonstration Test--Securing	Launch Preparation	900
G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	
					1.5.20												
				1.5.21										1.5.21*	1.5.21A*		920
		1.5.22			1.5.22				1.5.22			1.5.22					
			1.6.2										1.6.2				
			1.6.3					1.6.3									
													1.6.4				
													1.6.5				
				1.6.6												1.6.6	
				1.6.7										1.6.8*		1.6.7*	
				1.6.10												1.6.10*	
																1.6.12	
					1.6.13												
					1.6.14										1.6.15*		
					1.6.16												
								1.6.17									
1.6.18		1.6.18	1.6.18		1.6.18	1.6.18		1.6.18	1.6.18	1.6.18		1.6.18					900 921

. Refer to section II for panel location.
ph 2.5.11.1 for checkout requirements after removal from storage.

. Scheduled Authorized Field Activities (Sheet 4 of 5)

		Event	SINGLE ENGINE				STAGE PRE-STATIC			STAGE STATIC TEST				
900	Activity Number	Activity	Receiving Inspection	Checkout	Storage**	Installation in Stage		Storage**	Shipment	Receiving Inspection	Storage	Pre-Static Checkout	Static Test Preparation	Post-Static-Test Securing
			A	B	C	D	E	F	G	H	I	J	K	L
		HANDLING (cont)												
921 900	69	Thrust chamber throat closure removal		1.6.19		1.6.19						1.6.19		
	70	Thrust chamber throat plug installation		1.6.20										
	71	Thrust chamber throat plug removal		1.6.21										
	72	Turbine exhaust exit pressure test fixture installation												
	73	Turbine exhaust exit pressure test fixture removal												
915 900	74	Cover and closure installation	1.6.24	1.6.24	1.6.24			1.6.25	1.6.25	1.6.25	1.6.25	1.6.25		1.6.25
	75	Cover and closure removal	1.6.26	1.6.26		1.6.27				1.6.28		1.6.28	1.6.28	

** For engines stored in accordance with MSFC-STD-500, refer to paragraph 2.5.11.1 for checkout requirements afte

Figure 1-1. Scheduled Authorized Field Activities (S

STAGE RE-STATIC		STAGE STATIC TEST						STAGE POST-STATIC TEST				VEHICLE (KSC)					
Storage**	Shipment	Receiving Inspection	Storage	Pre-Static Checkout	Static Test Preparation	Post-Static-Test Securing	Shipment	Receiving Inspection	Post-Static-Test Checkout	Storage**	Shipment	Stage Receiving Inspection	Storage	Vehicle Checkout at VAB	Countdown Demonstration Tests	Countdown Demonstration Test--Securing	Launch Preparation
F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
				1.6.19					1.6.19					1.6.19			
									1.6.20					1.6.20			
									1.6.21					1.6.21			
									1.6.22					1.6.22			
									1.6.23					1.6.23			
1.6.25	1.6.25	1.6.25	1.6.25	1.6.25		1.6.25	1.6.25	1.6.25	1.6.25	1.6.25	1.6.25	1.6.25	1.6.25	1.6.25			
		1.6.28		1.6.28	1.6.28			1.6.28	1.6.28			1.6.28		1.6.28			

paragraph 2.5.11.1 for checkout requirements after removal from storage.

igure 1-1. Scheduled Authorized Field Activities (Sheet 5 of 5)

Activity Number	Activity \ Event	MAF		STAGE STATIC TEST (MTF)								
					Recycle Prior to Start of Automatic Sequence				Recycle Due to Abort Subsequent to Start of Automatic Sequence			
		Uninstalled Engine	Installed Engine--Stage Horizontal	Installed Engine--Stage Vertical	Ordnance Installed	Fuel Admitted	Prefill Admitted	LOX Admitted	Checkout Valve to Stage Command to Igniters Firing Command	Igniters Firing Command to Engine Control Valve Start Signal	Engine Control Valve Start Signal to Hypergol Burst	Hypergol Burst to/or Mainstage
		A	B	C	D	E	F	G	H	I	J	K
	INSPECTIONS											
1	Checkout valve ground position verification					1.1.13	1.1.13	1.1.13	1.1.13	1.1.13	1.1.13	1.1.13
2	Propellant valves closed verification					1.1.14	1.1.14	1.1.14	1.1.14	1.1.14	1.1.14	1.1.14
3	LOX dome and gas generator LOX injector purge operation verification									1.1.15	1.1.15	1.1.15
4	Hypergol installed switch pickup verification				1.1.16	1.1.16	1.1.16	1.1.16	1.1.16	1.1.16	1.1.16	
5	Igniter links installed verification				1.1.17	1.1.17	1.1.17	1.1.17	1.1.17			
6	Turbopump heater power on verification							1.1.18	1.1.18	1.1.18	1.1.18	1.1.18
6A	Turbopump LOX seal purge on verification					1.1.18A	1.1.18A	1.1.18A	1.1.18A	1.1.18A	1.1.18A	1.1.18A
7	LOX dome and gas generator LOX injector purge off verification								1.1.19	1.1.19	1.1.20	1.1.20
8	Cocoon purge on verification											
9	Thermal insulation visual											
10	Overall engine visual	1.1.23									1.1.6	1.1.6
11	Thrust chamber nozzle extension visual										1.1.8	1.1.8
12	Thrust chamber tubes visual										1.1.9	1.1.9
13	Thrust chamber injector contamination										1.1.10	1.1.10
14	Thrust chamber injector damage										1.1.11	1.1.11
15	Thrust chamber drain adapter torque verification											1.1.12

*Activity requires removal and reinstallation of thermal insulation panels. Refer to section II for panel location.

Figure 1-2. Nonscheduled Authorized Field Activities (Sheet

STAGE STATIC TEST (MTF)								VEHICLE (KSC)								
ecycle Prior to Start of Automatic Sequence				Recycle Due to Abort Subsequent to Start of Automatic Sequence					Recycle Prior to Start of Automatic Sequence				Recycle Due to Abort Subsequent to Start of Automatic Sequence			
nstalled	Fuel Admitted	Prefill Admitted	LOX Admitted	Checkout Valve to Stage Command to Igniters Firing Command	Igniters Firing Command to Engine Control Valve Start Signal	Engine Control Valve Start Signal to Hypergol Burst	Hypergol Burst to/or Mainstage	Installed Engine--Stage Vertical	Ordnance Installed	Fuel Admitted	Prefill Admitted	LOX Admitted	Checkout Valve to Stage Position Command to Igniter Firing Command	Igniter Firing Command to Engine Control Valve Start Signal	Engine Control Valve Start Signal to Hypergol Burst	Hypergol Burst to Vehicle Lift-Off
	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
	1.1.13	1.1.13	1.1.13	1.1.13	1.1.13	1.1.13	1.1.13			1.1.13	1.1.13	1.1.13	1.1.13	1.1.13	1.1.13	1.1.13
	1.1.14	1.1.14	1.1.14	1.1.14	1.1.14	1.1.14	1.1.14			1.1.14	1.1.14	1.1.14	1.1.14	1.1.14	1.1.14	1.1.14
					1.1.15	1.1.15	1.1.15							1.1.15	1.1.15	1.1.15
16	1.1.16	1.1.16	1.1.16	1.1.16	1.1.16	1.1.16			1.1.16	1.1.16	1.1.16	1.1.16	1.1.16	1.1.16	1.1.16	
17	1.1.17	1.1.17	1.1.17	1.1.17					1.1.17	1.1.17	1.1.17	1.1.17	1.1.17			
			1.1.18	1.1.18	1.1.18	1.1.18	1.1.18					1.1.18	1.1.18	1.1.18	1.1.18	1.1.18
	1.1.18A	1.1.18A	1.1.18A	1.1.18A	1.1.18A	1.1.18A	1.1.18A			1.1.18A	1.1.18A	1.1.18A	1.1.18A	1.1.18A	1.1.18A	1.1.18A
				1.1.19	1.1.19	1.1.20	1.1.20						1.1.19	1.1.19	1.1.20	1.1.20
												1.1.21	1.1.21	1.1.21	1.1.21	1.1.21
															1.1.22	1.1.22
						1.1.6	1.1.6									
						1.1.8	1.1.8								1.1.25	1.1.25
						1.1.9	1.1.9								1.1.9	1.1.9
						1.1.10	1.1.10								1.1.10	1.1.10
						1.1.11	1.1.11								1.1.11	1.1.11
							1.1.12									1.1.12*

902

ls. Refer to section II for panel location.

1-2. Nonscheduled Authorized Field Activities (Sheet 1 of 3)

	Activity Number	Activity / Event	MAF		STAGE STATIC TEST (MTF)								
						Recycle Prior to Start of Automatic Sequence				Recycle Due to Abort Subsequent to Start of Automatic Sequence			
			Uninstalled Engine	Installed Engine--Stage Horizontal	Installed Engine--Stage Vertical	Ordnance Installed	Fuel Admitted	Prefill Admitted	LOX Admitted	Checkout Valve to Stage Command to Igniters Firing Command	Igniters Firing Command to Engine Control Valve Start Signal	Engine Control Valve Start Signal to Hypergol Burst	
			A	B	C	D	E	F	G	H	I	J	
		INSPECTIONS (cont)											
	16	Thrust chamber nozzle extension fastener torque verification											1.
902	16A	Thrust chamber drain plug torque verification											
		ELECTRICAL TESTS											
	17	Flight instrumentation system function										1.2.2	1.
906	18	Igniter harness test										1.2.14	1.
	18A	Checkout valve engine return switch position verification								1.2.15	1.2.15	1.2.15	1.
	19	Igniter test									1.2.9	1.2.9	1.
	19A	Thrust OK pressure switch function test											1.
		LEAK AND FUNCTION TESTS											
	20	Turbopump torque function									1.3.1	1.3.1	1.
909	20A	Ignition monitor valve poppet position verification											1.3
	21	Thrust chamber liquid leak											1.
		SERVICING											
	21A	LOX dome flush			1.5.1A								
	21B	Gas generator LOX injector flush			1.5.1B								
	22	LOX feed system boiloff									1.5.14	1.5.14	1.
	23	Fuel feed system drain										1.5.25	1.
	24	Gas generator combustor drain										1.5.18	1.
	25	Thrust chamber fuel jacket drain											1.
	26	Thrust chamber fuel jacket flush											1.
902	27	Engine residual fluid removal									1.5.5	1.5.5	1.
	28	Turbopump preservation	1.5.22	1.5.22	1.5.22							1.5.22	1.
920	29	Admitting fuel to engine										1.5.9	1.
	30	Admitting prefill to engine										1.5.10	1.

* Activity requires removal and reinstallation of thermal insulation panels. Refer to section II for panel location.

Figure 1-2. Nonscheduled Authorized Field Activities (Sh

STAGE STATIC TEST (MTF)								VEHICLE (KSC)								
Recycle Prior to Start of Automatic Sequence				Recycle Due to Abort Subsequent to Start of Automatic Sequence					Recycle Prior to Start of Automatic Sequence				Recycle Due to Abort Subsequent to Start of Automatic Sequence			
Ordnance Installed	Fuel Admitted	Prefill Admitted	LOX Admitted	Checkout Valve to Stage Command to Igniters Firing Command	Igniters Firing Command to Engine Control Valve Start Signal	Engine Control Valve Start Signal to Hypergol Burst	Hypergol Burst to/or Mainstage	Installed Engine--Stage Vertical	Ordnance Installed	Fuel Admitted	Prefill Admitted	LOX Admitted	Checkout Valve to Stage Position Command to Igniter Firing Command	Igniter Firing Command to Engine Control Valve Start Signal	Engine Control Valve Start Signal to Hypergol Burst	Hypergol Burst to Vehicle Lift-Off
D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
							1.1.27									
																1.1.28*
						1.2.2	1.2.2								1.2.2	1.2.2
						1.2.14	1.2.14								1.2.14*	1.2.14*
				1.2.15	1.2.15	1.2.15	1.2.15						1.2.15	1.2.15	1.2.15	1.2.15
					1.2.9	1.2.9	1.2.9							1.2.9	1.2.9	1.2.9
							1.2.13									1.2.13
					1.3.1	1.3.1	1.3.1							1.3.1*	1.3.1*	1.3.1*
							1.3.41A									1.3.41A*
							1.3.42									1.3.42
								1.5.1A*								
								1.5.1B*								
					1.5.14	1.5.14	1.5.14							1.5.14A	1.5.14A	1.5.14A
						1.5.25	1.5.25								1.5.17*	1.5.17*
						1.5.18	1.5.18								1.5.18*	1.5.18*
							1.5.20									1.5.20*
							1.5.3									1.5.3*
					1.5.5	1.5.5	1.5.5							1.5.5A*	1.5.5A*	1.5.5A*
						1.5.22	1.5.22	1.5.22*							1.5.22*	1.5.22*
						1.5.9	1.5.9								1.5.9*	1.5.9*
						1.5.10	1.5.10								1.5.10	1.5.10

panels. Refer to section II for panel location.

gure 1-2. Nonscheduled Authorized Field Activities (Sheet 2 of 3)

Activity Number	Activity \ Event	MAF: Uninstalled Engine	MAF: Installed Engine--Stage Horizontal	STAGE STATIC TEST (MTF): Installed Engine--Stage Vertical	Recycle Prior to Start of Automatic Sequence: Ordnance Installed	Recycle Prior to Start of Automatic Sequence: Fuel Admitted	Recycle Prior to Start of Automatic Sequence: Prefill Admitted	Recycle Prior to Start of Automatic Sequence: LOX Admitted	Recycle Due to Abort Subsequent to Start of Automatic Sequence: Checkout Valve to Stage Command to Igniters Firing Command	Recycle Due to Abort Subsequent to Start of Automatic Sequence: Igniters Firing Command to Engine Control Valve Start Signal	Recycle Due to Abort Subsequent to Start of Automatic Sequence: Engine Control Valve Start Signal to Hypergol Burst	Hypergol Burst
		A	B	C	D	E	F	G	H	I	J	K
	SERVICING (cont)											
31	Admitting LOX to engine										1.5.12	1.5.1
	HANDLING											
32	Thrust chamber throat closure installation	1.6.18	1.6.18	1.6.18								
33	Thrust chamber throat closure removal	1.6.19	1.6.19	1.6.19								
34	Cover and closure installation	1.6.24	1.6.25	1.6.25								
35	Cover and closure removal	1.6.26	1.6.28	1.6.28								
36	Engine environmental cover installation											
37	Engine environmental cover removal											
38	Thrust chamber nozzle extension removal			1.6.16								
39	Engine removal		1.6.30	1.6.31								
40	Engine installation		1.6.1	1.6.33								
41	Thermal insulation removal											
42	Thermal insulation installation											
43	Igniter removal			1.6.36						1.6.14	1.6.14	1.6.1
44	Hypergol cartridge removal			1.6.39							1.6.39	1.6.1
45	(Deleted)											
46	(Deleted)											
47	Hypergol cartridge weight check										1.6.6	1.6.6
48	Igniter installation									1.6.7	1.6.7	1.6.7
49	Hypergol cartridge installation										1.6.10	1.6.1

*Activity requires removal and reinstallation of thermal insulation panels. Refer to section II for panel location

Figure 1-2. Nonscheduled Authorized Field Activities (She

	STAGE STATIC TEST (MTF)								VEHICLE (KSC)								
Recycle Prior to Start of Automatic Sequence				Recycle Due to Abort Subsequent to Start of Automatic Sequence					Recycle Prior to Start of Automatic Sequence				Recycle Due to Abort Subsequent to Start of Automatic Sequence				
Installed	Fuel Admitted	Prefill Admitted	LOX Admitted	Checkout Valve to Stage Command to Igniters Firing Command	Igniters Firing Command to Engine Control Valve Start Signal	Engine Control Valve Start Signal to Hypergol Burst	Hypergol Burst to/or Mainstage	Installed Engine--Stage Vertical	Ordnance Installed	Fuel Admitted	Prefill Admitted	LOX Admitted	Checkout Valve to Stage Position Command to Igniter Firing Command	Igniter Firing Command to Engine Control Valve Start Signal	Engine Control Valve Start Signal to Hypergol Burst	Hypergol Burst to Vehicle Lift-Off	
	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	
						1.5.12	1.5.12								1.5.13	1.5.13	
								1.6.18									
								1.6.19									921
								1.6.25									
								1.6.28									
								1.6.5									
								1.6.12									902
								1.6.16*									
								1.6.31*									
								1.6.33*									
								1.6.35									
								1.6.4									
					1.6.14	1.6.14	1.6.14	1.6.36*						1.6.14*	1.6.14*	1.6.14*	
						1.6.39	1.6.13	1.6.39*							1.6.39*	1.6.13*	
						1.6.6	1.6.6								1.6.6	1.6.6	
					1.6.7	1.6.7	1.6.7							1.6.7*	1.6.7*	1.6.7*	
						1.6.10	1.6.10								1.6.10*	1.6.10*	

els. Refer to section II for panel location

e 1-2. Nonscheduled Authorized Field Activities (Sheet 3 of 3)

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1	INSPECTIONS			
1.1.1	OVERALL ENGINE VISUAL INSPECTION FOR UNINSTALLED ENGINES DURING RECEIVING INSPECTION	a. Verify receipt of all equipment listed on shipping documentation.		
		b. Visually verify that all exposed and accessible portions of engine have not sustained damage due to shipment.	Damage within limits of figure 1-3	
		c. Remove all engine protective closures. Inspect oxidizer overboard drain line and nitrogen purge overboard drain line exits for fluid.	Fluid is not allowable.	Retain protective covers for reinstallation. 901
		d. Visually verify that engine exterior is free of residual fluid.	Residual fluid is not allowable.	
		e. Visually verify that hydraulic control system exterior does not exhibit surface wetting.	Surface wetting is not allowable.	If surface wetting is noted on component or flanged joints, refer to section II for criteria to use to establish joint acceptability.
		f. Visually verify that all machined areas of thrust chamber outrigger arms, turbopump mounts, and inside diameter of engine handler bearing are coated with corrosion preventative.	Machined areas without corrosion preventative are not allowable.	
		g. Visually verify that turbopump and outrigger arm surfaces do not contain scratches through paint.	Metal visible in scratch is not allowable.	
		h. Visually verify that gas generator fuel feed line gimbal joint yokes are not corroded and are coated with corrosion preventative.	Corrosion is not allowable, and yokes without corrosion preventative are not allowable.	
		i. Visually verify that gas generator fuel and oxidizer feed line bellows are not corroded.	Corrosion is not allowable.	
		j. Visually verify that aluminum foil tape is installed over space between thrust chamber exhaust manifold and thrust chamber tubes and that white sealant RTV-102 (General Electric), or equivalent, is installed between thrust chamber tubes and external bands.	Missing or damaged tape or voids in sealant are not allowable.	Verification that white sealant, or equivalent, is installed, applies only to engines in which white sealant was installed during engine manufacture.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.1 (cont)		k. Visually verify that thrust chamber interior and exterior and thrust chamber exhaust manifold exterior surfaces do not exhibit damage, such as dents, cracks, or bent or broken studs.	Damage within limits of figure 1-3	
		l. Visually verify that engine exterior does not contain dents, scratches, broken or missing lockwire, chafed bellows restrainers, or open taps.	Damage within limits of figure 1-3	
		m. Visually verify line markings for correct color coding and flow direction.	Missing or incorrectly coded line markings are not allowable.	
		n. After completion of visual inspection, reinstall all engine protective closures except for fuel overboard drain line exit cover.		
		nA. Install a clean polyethylene bag (one gallon minimum volume) on fuel overboard drain line.		Polyethylene bag installed on fuel overboard drain line must allow free flow but prevent entry of contaminants. 901 Bag must be secured in a manner that allows rotation of engine from horizontal to vertical with bag filled with fluid.
		o. Visually verify that turbopump housing cavities do not contain voids in cavity filler material.	Voids in cavity filler material are not allowable.	
		p. Visually verify that humidity indicator in thrust chamber throat closure is blue.	Color other than blue is not allowable.	CAUTION 921 Personnel must not enter a horizontal thrust chamber without using protective pads since damage to thrust chamber tubes will occur.
		q. Verify that engine orifice sizes as identified on engine are same as those specified in Engine Log Book. NOTE The actual orifice diameter and the orifice diameter recorded in the Engine Log Book may differ by the allowable machining tolerance of the individual orifice.	Orifice sizes other than those specified in Engine Log Book are not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks	
1.1.1 (cont)		r. Verify that engine serialized components are same as those specified in Engine Log Book.	Serialized components other than those specified in Engine Log Book are not allowable.		
		s. Remove turbopump shaft pre-load fixture.			
		t. Visually verify that LOX pump inlet and the 2 fuel pump inlet closure humidity indicators (30% spots) are blue.	Color other than blue in 30% spots is not allowable.		
1.1.2	<u>OVERALL ENGINE VISUAL INSPECTION FOR UNINSTALLED ENGINES IN STORAGE</u>	a. Remove Engine Cover G4047, if installed.			
		b. (Deleted)			910
		c. (Deleted)			930
		d. Visually verify that all machined areas of thrust chamber outrigger arms, turbopump mounts, and inside diameter of engine handler bearing are coated with corrosion preventative.	Machined area without corrosion preventative is not allowable.	Steps d and e are performed every six months.	910 930
		e. Visually verify that gas generator fuel feed line gimbal joint yokes are not corroded and are coated with corrosion preventative.	Corrosion is not allowable, and yoke without corrosion preventative is not allowable.		
		f. (Deleted)			910
		g. (Deleted)			930
		h. Visually verify that humidity indicator (30% spot) in thrust chamber throat closure is blue.	Color other than blue is not allowable.	CAUTION Personnel must not enter a horizontal thrust chamber without using protective pads since damage to thrust chamber tubes will occur.	910 921

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.2 (cont)		i. (Deleted)		
		j. (Deleted)		
		k. (Deleted)		
		l. Determine if turbopump requires represervation; represerve turbopump, if necessary, and enter date in Engine Log Book.		Refer to Engine Log Book for date of last turbopump preservation. Refer to section II for turbopump represervation frequency.
		m. Visually verify that LOX pump inlet and the 2 fuel pump inlet closure humidity indicators (30% spots) are blue.	Color other than blue in 30% spots is not allowable.	
		n. Reinstall engine cover if removed in step a.		
1.1.3	<u>OVERALL ENGINE VISUAL INSPECTION FOR INSTALLED ENGINES IN STORAGE</u>	a. (Deleted)		
		b. (Deleted)		
		c. Visually verify that all machined areas of thrust chamber outrigger arms, turbopump mounts, and inside diameter of engine handler bearing are coated with corrosion preventative.	Machined areas without corrosion preventative are not allowable.	Steps c and d are performed every six months.
		d. Visually verify that gas generator fuel feed line gimbal joint yokes are not corroded and are coated with corrosion preventative.	Corrosion is not allowable, and yokes without corrosion preventative are not allowable.	
		e. (Deleted)		

910 930 902 921 937 910 902 930 910 930 910

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks	
1.1.3 (cont)		f. Visually verify that humidity indicator (30% spot) in thrust chamber throat security closure is blue.	Color other than blue is not allowable.	CAUTION Personnel must not enter a horizontal thrust chamber without using protective pads since damage to thrust chamber tubes will occur.	910 921 930
		g. (Deleted)			
		h. (Deleted)			910
		i. (Deleted)			
		j. (Deleted)			930 901
		k. Determine if turbopump requires representation; represerve turbopump, if required, and enter date in Engine Log Book.		Refer to Engine Log Book for date of last turbopump preservation. Refer to section II for turbopump represervation frequency.	902 921 937
		l. (Deleted)			910 930
1.1.4	<u>OVERALL ENGINE VISUAL INSPECTION FOR INSTALLED ENGINES PRIOR TO STAGE SHIPMENT TO MAF OR MTF</u>	a. Verify that all equipment required for shipment is listed on shipping documentation and available for shipment.			
		b. Visually verify that all exposed and accessible portions of equipment are not damaged.	Damage within limits of figure 1-3		
		c. Remove all engine protective closures. Inspect oxidizer overboard drain line and nitrogen purge overboard drain line exits for fluid.	Fluid is not allowable.		901

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.4 (cont)		d. Visually verify that all machined areas of thrust chamber outrigger arms, turbopump mounts, and inside diameter of engine handler bearing are coated with corrosion preventative.	Machined areas without corrosion preventative are not allowable.	
		e. Visually verify that turbopump and outrigger arm surfaces do not contain scratches through paint.	Metal visible in scratch is not allowable.	
		f. Visually verify that gas generator fuel feed line gimbal joint yokes are not corroded and are coated with corrosion preventative.	Corrosion is not allowable, and yokes without corrosion-preventative are not allowable.	
		g. Visually verify that gas generator fuel and oxidizer feed line bellows are not corroded.	Corrosion is not allowable.	
		h. Visually verify that aluminum foil tape is installed over space between thrust chamber exhaust manifold and thrust chamber tubes and that white sealant RTV-102 (General Electric), or equivalent, is installed between thrust chamber tubes and external bands.	Missing or damaged tape or voids in sealant are not allowable.	Verification that white sealant, or equivalent, is installed, applies only to engines in which white sealant was installed during engine manufacture.
		i. Visually verify that thrust chamber and thrust chamber exhaust manifold exterior surfaces do not exhibit damage, such as dents, cracks, or bent or broken studs.	Damage within limits of figure 1-3	
		j. Visually verify that engine exterior does not contain dents, scratches, broken or missing lockwire, chafed bellows restrainers, or open taps.	Damage within limits of figure 1-3	
		k. Visually verify that engine exterior is free of residual fluid.	Residual fluid is not allowable.	
		l. Visually verify line markings for correct color coding and flow direction.	Missing or incorrectly coded line markings are not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.4 (cont)		m. Visually verify that hydraulic control system exterior does not exhibit surface wetting.	Surface wetting is not allowable.	If surface wetting is noted on component or flanged joints, refer to section II for criteria to use to establish joint acceptability.
		n. Remove fuel overboard drain system isolation hoses and install polyethylene bags on drain system as outlined in section II. Visually inspect fuel overboard drain system isolation polyethylene bags for fluid prior to shipment. Empty bags and measure quantity of fluid in accordance with section II.		901 930
		o. Visually verify that turbopump housing cavities do not contain voids in cavity filler material.	Voids in cavity filler material are not allowable.	
		p. After completion of visual inspection, install all engine protective closures and install gimbal boot.		901 930
		q. Visually verify that humidity indicator in thrust chamber throat closure is blue.	Color other than blue is not allowable.	CAUTION Personnel must not enter a horizontal thrust chamber without using protective pads since damage to thrust chamber tubes will occur. 921
		r. Determine if turbopump requires represervation; represerve turbopump, if required, and enter date in Engine Log Book.		Refer to Engine Log Book for date of last turbopump preservation. Refer to section II for turbopump represervation frequency. 902 921 937
1.1.4A	<u>OVERALL ENGINE VISUAL INSPECTION FOR INSTALLED ENGINES DURING RECEIVING INSPECTION AT MAF.</u>	a. Verify receipt of all equipment listed on shipping documentation.		
		b. Visually verify that all exposed and accessible portions of engine have not sustained damage due to shipment.	Damage within limits of figure 1-3.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.4A (cont)		c. Remove all engine protective closures. Inspect oxidizer overboard drain line and nitrogen purge overboard drain line exits for fluid.	Fluid is not allowable.	Retain protective covers for reinstallation 901
		cA. Visually inspect bags installed on fuel overboard drain system disconnections for fluid; empty bags and measure quantity of fluid in accordance with section II.		901
		d. Visually verify that all machined areas of thrust chamber outrigger arms, turbopump mounts, and inside diameter of engine handler bearing are coated with corrosion preventative.	Machined areas without corrosion preventative are not allowable.	
		e. Visually verify that turbopump and outrigger arm surfaces do not contain scratches through paint.	Metal visible in scratch is not allowable.	
		f. Visually verify that gas generator fuel feed line gimbal joint yokes are not corroded and are coated with corrosion preventative.	Corrosion is not allowable, and yokes without corrosion preventative are not allowable.	
		g. Visually verify that gas generator fuel and oxidizer feed line bellows are not corroded.	Corrosion is not allowable.	
		h. Visually verify that aluminum foil tape is installed over space between thrust chamber exhaust manifold and thrust chamber tubes and that white sealant RTV-102 (General Electric), or equivalent, is installed between thrust chamber tubes and external bands.	Missing or damaged tape or voids in sealant are not allowable.	Verification that white sealant, or equivalent, is installed, applies only to engines in which white sealant was installed during manufacture.
		i. Visually verify that thrust chamber and thrust chamber exhaust manifold exterior surfaces do not exhibit damage, such as dents, cracks, or bent or broken studs.	Damage within limits of figure 1-3	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.4A (cont)		j. Visually verify that engine exterior does not contain dents, scratches, broken or missing lockwire, chafed bellows restrainers, or open taps.	Damage within limits of figure 1-3	
		k. After completion of visual inspection, reinstall LOX and fuel high-pressure duct covers, thrust chamber stud covers, oxidizer overboard drain line cover, and nitrogen purge overboard drain line cover.		901
		l. Visually verify that turbopump housing cavities do not contain voids in cavity filler material.	Voids in cavity filler material are not allowable.	
		m. Visually verify that humidity indicator in thrust chamber throat closure is blue.	Color other than blue is not allowable.	CAUTION Personnel must not enter a horizontal thrust chamber without using protective pads since damage to thrust chamber tubes will occur. 921
		n. Verify that engine orifice sizes as identified on engine are same as those specified in Engine Log Book. NOTE The actual orifice diameter and the orifice diameter recorded in the Engine Log Book may differ by the allowable machining tolerance of the individual orifice.	Orifice sizes other than those specified in Engine Log Book are not allowable.	
		o. Verify that components listed on Engine Log Book Post-Delivery Serialized Component Replacement Record are same as those installed on engine.	Serialized components other than those specified in Engine Log Book are not allowable.	909
1.1.4B	<u>OVERALL ENGINE VISUAL INSPECTION FOR INSTALLED ENGINES PRIOR TO STAGE SHIPMENT TO KSC</u>	a. Verify that all loose equipment required for shipment is listed on shipping documentation and available for shipment.		
		b. Visually verify that all exposed and accessible portions of loose equipment are not damaged.	Damage within limits of figure 1-3.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.4B (cont)		c. Remove all engine protective closures. Inspect oxidizer overboard drain line and nitrogen purge overboard drain line exits for fluid.	Fluid is not allowable.	901
		d. Visually verify/accomplish that thermal insulation bracketry shown in figure 2-14 is installed.		
		e. Visually verify/accomplish that loose equipment is installed with exception of the following items and attaching parts: (1) Thrust chamber nozzle extension (2) Nitrogen purge overboard drain tube (3) Fuel overboard drain line (4) Oxidizer overboard drain line (5) Igniters (6) Hypergol cartridge		
		f. Visually verify that all machined areas of thrust chamber outrigger arms, turbopump mounts, and inside diameter of engine handler bearing are coated with corrosion preventative.	Machined areas without corrosion preventative are not allowable.	
		g. Visually verify that turbopump and outrigger arm surfaces do not contain scratches through paint.	Metal visible in scratch is not allowable.	
		h. Visually verify that gas generator fuel feed line gimbal joint yokes are not corroded and are coated with corrosion preventative.	Corrosion is not allowable, and yokes without corrosion preventative are not allowable.	
		i. Visually verify that gas generator fuel and oxidizer feed line bellows are not corroded.	Corrosion is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks	
1.1.4B (cont)		j. Visually verify that aluminum foil tape is installed over space between thrust chamber exhaust manifold and thrust chamber tubes and that white sealant RTV-102 (General Electric), or equivalent, is installed between thrust chamber tubes and external bands.	Missing or damaged tape or voids in sealant are not allowable.	Verification that white sealant, or equivalent, is installed, applies only to engines in which white sealant was installed during engine manufacture.	
		k. Visually verify that thrust chamber and thrust chamber exhaust manifold exterior surfaces do not exhibit damage, such as dents, cracks, or bent or broken studs.	Damage within limits of figure 1-3		
		l. Visually verify that engine exterior does not contain dents, scratches, broken or missing lockwire, chafed bellows restrainers, open taps.	Damage within limits of figure 1-3		
		m. Visually verify that engine exterior is free of residual fluid.	Residual fluid is not allowable.		
		n. Visually verify line markings for correct color coding and flow direction.	Missing or incorrectly coded line markings are not allowable.		
		o. Visually verify that hydraulic control system exterior does not exhibit surface wetting.	Surface wetting is not allowable	If surface wetting is noted on components or flanged joints, refer to section II for criteria to use to establish joint acceptability.	
		p. Remove fuel overboard drain system isolation hoses and install polyethylene bags on drain system as outlined in section II. Visually inspect fuel overboard drain system isolation polyethylene bags for fluid prior to shipment. Empty bags and measure quantity of fluid in accordance with section II.			901 930
		q. Visually verify that turbopump housing cavities do not contain voids in cavity filler material.	Voids in cavity filler material are not allowable.		901
		r. After completion of visual inspection, install all engine protective closures and install gimbal boot.			930

Paragraph	Activities		Requirements	Limits	Special Constraints and Remarks	
1.1.4B (cont)		s.	Visually verify that humidity indicator (30% spot) in thrust chamber throat security closure is blue.	Color other than blue is not allowable.	CAUTION Personnel must not enter a horizontal thrust chamber without using protective pads since damage to thrust chamber tubes will occur.	921 930
		t.	Determine if turbopump requires represervation: represerve turbopump, if required, and enter date in Engine Log Book.		Refer to Engine Log Book for date of last turbopump preservation. Refer to section II for turbopump represervation frequency.	902 921 937
1.1.5	<u>OVERALL ENGINE VISUAL INSPECTION FOR INSTALLED ENGINES DURING RECEIVING INSPECTION AT MTF AND KSC</u>	a.	Verify receipt of all equipment listed on shipping documentation.			
		b.	Visually verify that all exposed and accessible portions of engine have not sustained damage due to shipment.	Damage within limits of figure 1-3		
		c.	Remove all engine protective closures. Inspect oxidizer overboard drain line and nitrogen purge overboard drain line exits for fluid.	Fluid is not allowable.	Retain protective covers for reinstallation.	901
		d.	Visually inspect bags installed on fuel overboard drain system disconnections for fluid; empty bags and measure quantity of fluid in accordance with section II.			901
		e.	Verify that engine soft good installed life is within limits specified in section II.			
		f.	Visually verify that all machined areas of thrust chamber outrigger arms, turbopump mounts, and inside diameter of engine handler bearing are coated with corrosion preventative.	Machined areas without corrosion preventative is not allowable.		
		g.	Visually verify that turbopump and outrigger arm surfaces do not contain scratches through paint.	Metal visible in scratch is not allowable.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.5 (cont)		h. Visually verify that gas generator fuel feed line gimbal joint yokes are not corroded and are coated with corrosion preventative.	Corrosion is not allowable, and yokes without corrosion preventative are not allowable.	
		i. Visually verify that gas generator fuel and oxidizer feed line bellows are not corroded.	Corrosion is not allowable.	
		j. Visually verify that aluminum foil tape is installed over space between thrust chamber exhaust manifold and thrust chamber tubes and that white sealant RTV-102 (General Electric), or equivalent, is installed between thrust chamber tubes and external bands.	Missing or damaged tape or voids in sealant are not allowable.	Verification that white sealant, or equivalent, is installed, applies only to engines in which white sealant was installed during engine manufacture.
		k. Visually verify that thrust chamber and thrust chamber exhaust manifold exterior surfaces do not exhibit damage, such as dents, cracks, or bent or broken studs.	Damage within limits of figure 1-3	
		l. Visually verify that engine exterior does not contain dents, scratches, broken or missing lockwire, chafed bellows restrainers, or open taps.	Damage within limits of figure 1-3	
		m. After completion of visual inspection, reinstall LOX and fuel high-pressure duct covers and thrust chamber jacket covers.		901
		n. Visually verify that turbopump housir. cavities do not contain voids in cavity filler material.	Voids in cavity filler material are not allowable.	
		o. Verify that engine orifice sizes as identified on engine are same as those specified in Engine Log Book. NOTE The actual orifice diameter and the orifice diameter recorded in the Engine Log Book may differ by the allowable machining tolerance of the individual orifice.	Orifice sizes other than those specified in Engine Log Book are not allowable.	
		p. Verify that components listed on Engine Log Book Post-Delivery Serialized Component Replacement Record are same as those installed on engine.	Serialized components other than those specified in Engine Log Book are not allowable.	909

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.6	<u>OVERALL ENGINE VISUAL INSPECTION SUBSEQUENT TO ENGINE STATIC TEST AND TEST ABORT</u>	a. Visually verify that aluminum tape is installed over space between thrust chamber hot-gas manifold flame shield and thrust chamber tubes and that white sealant RTV-102 (General Electric), or equivalent, is installed between thrust chamber tubes and external bands.	Missing or damaged tape or voids in sealant are not allowable.	Verification that white sealant, or equivalent, is installed, applies only to engines in which white sealant was installed during engine manufacture.
		b. Visually verify that thrust chamber and thrust chamber exhaust manifold exterior surfaces do not exhibit damage, such as dents, cracks, tension tie deformation, and bent or broken studs.	Damage within limits of figure 1-3	
		c. Visually verify that overall engine exterior does not contain dents, scratches, broken or missing lockwire, chafed bellows restrainers.	Damage within limits of figure 1-3	
1.1.7	<u>THRUST CHAMBER NOZZLE EXTENSION VISUAL INSPECTION DURING RECEIVING INSPECTION</u>	Inspect nozzle extension to verify that interior and exterior surface damage (e.g., cracks, dents, missing nut plates, loose or damaged blind nuts, thread damage, or flange sealing surface damage) has not occurred during shipping and handling.	Damage within limits of figure 1-3	
1.1.8	<u>THRUST CHAMBER NOZZLE EXTENSION VISUAL INSPECTION SUBSEQUENT TO ENGINE STATIC TEST</u>	Inspect nozzle extension for following (1) Distortion of outer shell (2) Buckles or cracks in outer bands (3) Carbon deposits around flange area (indication of seal leakage) (4) Nutplates and blind nuts damaged, loose, or missing (5) Internal erosion (6) Shingle separation from Z-bars (7) Shingle thermal buckling	Damage within limits of figure 1-3	Perform after thrust chamber fuel jacket drain and fuel feed system drain.

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Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.9	THRUST CHAMBER TUBES VISUAL INSPECTION	Inspect thrust chamber internal surfaces for errosion, nicks, dents, and tube splits.	See figure 1-3 for damage limits.	Perform after thrust chamber fuel jacket drain and fuel feed system drain.
1.1.10	THRUST CHAMBER INJECTOR CONTAMINATION INSPECTION	Visually inspect for the following: (1) Injector orifices are restricted by foreign matter. (2) Back of injector rings (as inspected through injector orifices) contain foreign matter.	No contamination is allowable.	Accomplish subsequent to LOX dome flush, thrust chamber fuel jacket flush, thrust chamber liquid leak test, and thrust chamber pneumatic leak test, if performed.
1.1.11	THRUST CHAMBER INJECTOR DAMAGE INSPECTION	Visually inspect thrust chamber injector for the following: (1) Baffle separation (2) Baffle deformation (3) Face and/or baffle erosion (4) Baffle orifice distortion and cracks (5) Ring orifice distortion (6) Baffle-to-baffle cracks (7) Ring-to-land separation	See figure 1-3 for damage limits.	Accomplish subsequent to thrust chamber fuel jacket flush, LOX dome flush, and thrust chamber liquid leak test, if performed.
1.1.12	THRUST CHAMBER DRAIN ADAPTER TORQUE VERIFICATION	Retorque and safetywire the 4 thrust chamber exit manifold drain adapters. Record actual torque value.		Perform prior to thrust chamber liquid leak test, if performed.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.12A	<u>ENGINE JOINTS CLOSURE REMOVAL VERIFICATION AT MTF</u>	Visually verify removal of protective closures from the following joints: (1) No. 1 fuel high-pressure duct to igniter fuel supply tube (2) Igniter fuel supply tube to igniter fuel valve (3) Hypergol manifold to hypergol manifold outlet hose (4) Hypergol manifold to hypergol bleed adapter (5) Thrust OK pressure switch to thrust chamber fuel manifold (6) Oxidizer bypass hose to GOX duct (heat exchanger end) (7) Helium supply duct (heat exchanger end) to helium bypass hose (8) Helium bypass hose to helium return duct (heat exchanger end) (9) Engine control valve ground hydraulic supply hose to GSE hydraulic supply check valve (10) Engine control valve supply tube to engine hydraulic supply check valve (11) Engine control valve to propellant valves close tube (12) Propellant valves open tube to No. 1 oxidizer valve (13) Propellant valves open tube to No. 2 oxidizer valve (14) No. 2 oxidizer valve sequence valve to sequence valve line		Perform after last maintenance on specified joints and prior to admitting fluid to joint for engine static test. Closure removal between stage and engine interface shall be performed and verified by stage contractor.

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Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.12A (cont)		(15) Sequence valve line to No. 1 oxidizer valve sequence valve		
		(16) No. 1 oxidizer valve to gas generator open tube		
		(17) Gas generator ball valve (oxidizer side) to gas generator injector		
		(18) Fuel impeller balance cavity return hose to turbopump (orifice end)		
		(19) Oxidizer seal vent tube to oxidizer overboard drain line		
		(20) Cover plate to fuel drain manifold		
		(21) Fuel drain manifold to fuel overboard drain line		
		(22) Fuel overboard drain line to fuel overboard drain line		
		(23) Turbopump to turbine bearing lube drain hose		
		(24) No. 2 bearing lube drain line to fuel drain manifold (cover on engines incorporating MD145 change)		
		(25) No. 1 bearing lube drain line to fuel drain manifold (cover on engines incorporating MD145 change)		
		(26) Turbine bearing lube drain hose to fuel drain manifold		
		(27) Gas generator oxidizer purge tube to purge check valve		
		(28) Purge check valve to gas generator ball valve		
		(29) Pump seal purge line to oxidizer pump seal purge tube		

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Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.12B	<u>ENGINE JOINTS CLOSURE REMOVAL VERIFICATION AT KSC</u>	Visually verify removal of protective closures from the following joints: (1) No. 1 fuel high-pressure duct to igniter fuel supply tube (2) Igniter fuel supply tube to igniter fuel valve (3) Hypergol manifold to hypergol manifold outlet hose (4) Hypergol manifold to hypergol bleed adapter (5) Thrust OK pressure switch to thrust chamber fuel manifold (6) Oxidizer bypass hose to GOX duct (heat exchanger end) (7) Helium supply duct (heat exchanger end) to helium bypass hose (8) Helium bypass hose to helium return duct (heat exchanger end) (9) Engine control valve ground hydraulic supply hose to GSE hydraulic supply check valve (10) Engine control valve supply tube to engine hydraulic supply check valve (11) Engine control valve to propellant valves close tube (12) Propellant valves open tube to No. 1 oxidizer valve (13) Propellant valves open tube to No. 2 oxidizer valve (14) No. 2 oxidizer valve sequence valve to sequence valve line		Perform after last maintenance on specified joints and prior to closing out thermal insulation installation over specified joints. Closure removal between stage and engine interface shall be performed and verified by stage contractor.

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Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.12B (cont)		(15) Sequence valve line to No. 1 oxidizer valve sequence valve		
		(16) No. 1 oxidizer valve to gas generator open tube		
		(17) Gas generator ball valve (oxidizer side) to gas generator injector		
		(18) Fuel impeller balance cavity return hose to turbopump (orifice end)		
		(19) Oxidizer seal vent tube to oxidizer overboard drain line		
		(20) Cover plate to fuel drain manifold		
		(21) Fuel drain manifold to fuel overboard drain line		
		(22) Fuel overboard drain line to fuel overboard drain line		
		(23) Turbopump to turbine bearing lube drain hose		
		(24) No. 2 bearing lube drain line to fuel drain manifold (cover on engines incorporating MD145 change)		
		(25) No. 1 bearing lube drain line to fuel drain manifold (cover on engines incorporating MD145 change)		
		(26) Turbine bearing lube drain hose to fuel drain manifold		
		(27) Gas generator oxidizer purge tube to purge check valve		
		(28) Purge check valve to gas generator ball valve		
		(29) Pump seal purge line to oxidizer pump seal purge tube		
1.1.13	CHECKOUT VALVE GROUND POSITION VERIFICATION	Verify by instrumentation indication that checkout valve is in the ground position.		Perform prior to fuel feed system drain, if performed.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.14	PROPELLANT VALVES CLOSED VERIFICATION	Verify by instrumentation indication that the following propellant valves are closed: (1) No. 1 fuel valve (2) No. 2 fuel valve (3) Gas generator ball valve (4) No. 1 oxidizer valve (5) No. 2 oxidizer valve		Perform prior to fuel feed system drain, if performed.
1.1.15	LOX DOME AND GAS GENERATOR LOX INJECTOR PURGE OPERATION VERIFICATION	Verify by instrumentation indication that operational high-level purge was on.	Within limits specified in section II	If purge was off or not within limits during engine shutdown, the LOX dome and gas generator LOX injector must be flushed.
1.1.16	HYPERGOL INSTALLED SWITCH PICKUP VERIFICATION	Verify by instrumentation indication that hypergol installed switch remains picked up.		
1.1.17	IGNITER LINKS INSTALLED VERIFICATION	Verify by instrumentation indication that igniter links have not broken.		
1.1.18	TURBOPUMP HEATER POWER ON VERIFICATION	Verify that turbopump heater power is turned on and thermostats are cycling as long as LOX remains in engine system.	Within limits specified in section II	
1.1.18A	TURBOPUMP LOX SEAL PURGE VERIFICATION	Verify by instrumentation indication that purge is operating as long as propellants remain in engine system.	Within pressure limits specified in section II	
1.1.19	LOX DOME AND GAS GENERATOR LOX INJECTOR PURGE OFF VERIFICATION FOR ABORT PRIOR TO GAS GENERATOR IGNITION	Turn operational high-level purge off as soon as it has been verified that ignition did not occur.	Within limits specified in section II	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.20	LOX DOME AND GAS GENERATOR LOX INJECTOR PURGE OFF VERIFICATION FOR ABORT AFTER GAS GENERATOR IGNITION	Turn off operational high-level purge, and turn on operational low-level purge. Maintain operational low-level purge for one hour after engine shutdown.	Within limits specified in section II	
1.1.21	COCOON PURGE ON VERIFICATION	Verify that cocoon purge is cycled, as required.	To maintain engine temperature within limits specified in section II	
1.1.22	THERMAL INSULATION VISUAL INSPECTION	Visually inspect exterior surfaces for cracks, dents, broken fasteners, missing or loose fasteners, and erosion.	Damage within limits of figure 1-4	
1.1.23	OVERALL ENGINE VISUAL INSPECTION FOR UNINSTALLED ENGINES PRIOR TO SHIPMENT	a. Verify that all loose equipment required for shipment is listed on shipping documentation and available for shipment.		
		b. Visually verify that all exposed and accessible portions of loose equipment are not damaged.	Damage within limits of figure 1-3	
		c. Visually verify that all machined areas of thrust chamber outrigger arms, turbopump mounts, and inside diameter of engine handler bearing are coated with corrosion preventative.	Machined areas without corrosion preventative are not allowable.	
		d. Visually verify that turbopump and outrigger arm surfaces do not contain scratches through paint.	Metal visible in scratch is not allowable.	
		e. Visually verify that gas generator fuel feed line gimbal joint yokes are not corroded and are coated with corrosion preventative.	Corrosion is not allowable, and yokes without corrosion preventative are not allowable.	
		f. Visually verify that gas generator fuel and oxidizer feed line bellows are not corroded.	Corrosion is not allowable.	

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Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.23 (cont)		g. Visually verify that aluminum foil tape is installed over space between thrust chamber exhaust manifold and thrust chamber tubes and that white sealant RTV-102 (General Electric), or equivalent, is installed between thrust chamber tubes and external bands.	Missing or damaged tape or voids in sealant are not allowable.	Verification that white sealant, or equivalent, is installed, applies only to engines in which white sealant was installed during engine manufacture.
		h. Visually verify that thrust chamber and thrust chamber exhaust manifold exterior surfaces do not exhibit damage, such as dents, cracks, or bent or broken studs.	Damage within limits of figure 1-3	
		i. Visually verify that engine exterior does not contain dents, scratches, broken or missing lockwire, chafed bellows restrainers, or open taps.	Damage within limits of figure 1-3	
		j. Visually verify that turbopump housing cavities do not contain voids in cavity filler material.	Voids in cavity filler material are not allowable.	
		k. Remove drainage line from fuel overboard drain line exit; then after completion of visual inspection, install all engine protective covers and install gimbal boot.		930
		l. Visually verify that humidity indicator in thrust chamber throat closure is blue.	Color other than blue is not allowable.	CAUTION Personnel must not enter a horizontal thrust chamber without using protective pads since damage to thrust chamber tubes will occur. 921
		m. Determine if turbopump requires representation; represerve turbopump, if required, and enter date in Engine Log Book.		Refer to Engine Log Book for date of last turbopump preservation. Refer to section II for turbopump represervation frequency. 902 921 937
		n. Install turbopump shaft preload fixture.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.23 (cont)		o. Visually verify that LOX pump inlet and the 2 fuel pump inlet closure humidity indicators (20% spots) are blue.	Color other than blue is not allowable.	
1.1.24	(Deleted)			
1.1.25	<u>THRUST CHAMBER NOZZLE EXTENSION VISUAL INSPECTION SUBSEQUENT TO LAUNCH ABORT</u>	Visually inspect nozzle extension interior for erosion, shingle separation from Z-bars, and shingle thermal buckling.	See figure 1-3 for damage limits.	Perform subsequent to fuel feed system drain and thrust chamber fuel jacket drain
1.1.26	(Deleted)			
1.1.27	<u>THRUST CHAMBER NOZZLE EXTENSION FASTENER TORQUE VERIFICATION SUBSEQUENT TO STATIC TEST ABORT</u>	Perform torque check of nozzle extension flange fasteners. Record results.	Torque-check every tenth fastener. If any fastener is not within limits, retorque all 240 fasteners.	
1.1.28	<u>THRUST CHAMBER DRAIN PLUG TORQUE VERIFICATION</u>	Retorque and safetywire the 4 thrust chamber exit manifold drain plugs. Record actual torque value.		Perform after thrust chamber liquid-leak test and thrust chamber fuel jacket flush. 902
1.2	<u>ELECTRICAL TESTS</u>			
1.2.1	<u>FLIGHT INSTRUMENTATION SYSTEM FUNCTION TEST FOR UNINSTALLED ENGINES</u>	a. Measure and record ambient (run) output voltage of each pressure transducer.	The voltage limits for ambient (run) c[illegible]tions must be withi[illegible] ±5 [illegible] (±250 millivolts) of full scale of the value recorded in the Engine Log Book, F-1 Final Acceptance Checkout Data, after correction for ambient pressure difference. (Refer to section II for individual pressure transducer data.)	Perform prior to hydraulic system leak and function test, valve timing test, fuel feed system leak test, LOX feed system leak test, heat exchanger helium system leak test, heat exchanger LOX system leak test, exhaust system leak test, turbopump heater function test, safety circuits function test, and sequence verification test, if performed.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.1 (cont)		b. Measure and record 20% and 80% output voltage of each pressure transducer.	The voltage limits for 20% and 80% conditions must be within ±2% (±100 millivolts) of full scale of the adjusted value recorded in the Engine Log Book, F-1 Final Acceptance Checkout Data. (Refer to section II.)	Use section II table for initial pressure transducer data for those instruments that have no data available in Engine Log Book.
		c. Measure and record resistance of the following temperature transducers:		
		(1) LOX pump bearing No. 1:	Resistance value in ohms:	
		(a) Pins A to B	465 ±34	
		(b) Pins A to C	465 ±34	
		(2) (Deleted)		
		(3) Turbine inlet[c]:		
		(a) Pins A to B	54.6 ±4	
		(b) Pins A to C	54.6 ±4	
		(4) Engine environmental:		
		(a) Pins A to B	54.6 ±4[b]	
		(b) Pins A to C	54.6 ±4[b]	
		(5) Fuel pump inlet No. 2[a]:		
		(a) Pins A to B	1,370 ±100	
		(b) Pins A to C	1,370 ±100	
		(6) Heat exchanger LOX inlet:		
		(a) Pins A to B	1,370 ±100	
		(b) Pins A to C	1,370 ±100	
		(7) Heat exchanger GOX outlet[a]:		
		(a) Pins A to B	465 ±34	
		(b) Pins A to C	465 ±34	
		(8) Heat exchanger helium outlet[a]:		
		(a) Pins A to B	465 ±34	
		(b) Pins A to C	465 ±34	

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(a) Engines not incorporating MD96 change
(b) Resistance value is 465 ±34 ohms on engines incorporating MD159 change
(c) Engines not incorporating MD176 change

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.1 (cont)		d. Measure and record output of each heat exchanger flowmeter transducer primary coil with 5.0 to 7.5 vac peak, 200 ±20 cps input on secondary coil.	0.2 to 3.0 vac peak and approximately same frequency and wave shape as input voltage	
		e. Measure and record output of primary coil of turbopump speed transducer with 5.0 to 7.5 vac peak, 200 ±20 cps input on secondary coil.	0.4 to 5.0 vac peak and approximately same frequency and wave shape as input voltage	
		f. Measure and record resistance of the following valve potentiometers:	Resistance value in ohms:	Connectors listed in Requirements column are on interface panel.
		(1) No. 1 oxidizer valve (closed):		
		(a) J102, pins G to E	482 ±80	
		(b) J102, pins E to F	2,120 ±150	
		(c) J102, pins G to F	2,000 ±120	
		(d) J103, pin R to J100 or J101, pin C	5 maximum	
		(e) J103, pins R to S	infinity	
		(2) No. 1 fuel valve (closed):		
		(a) J102, pins P to B	500 ±80	
		(b) J102, pins B to C	2,095 ±345	
		(c) J102, pins P to C	2,000 ±120	
		(d) J103, pin F, to J100 or J101, pin C	5 maximum	
		(e) J103 pins E to F	infinity	
		(3) No. 2 oxidizer valve (closed):		
		(a) J102, pins T to H	482 ±80	
		(b) J102, pins H to J	2,120 ±150	
		(c) J102, pins T to J	2,000 ±120	
		(d) J103, pin T, to J100 or J101, pin C	5 maximum	
		(e) J103, pins T to J	infinity	
		(4) No. 2 fuel valve (closed):		
		(a) J102, pins S to D	500 ±80	
		(b) J102, pins D to R	2,095 ±345	
		(c) J102, pins S to R	2,000 ±120	
		(d) J103, pin H, to J100 or J101, pin C	5 maximum	
		(e) J103, pins G to H	infinity	

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Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.1 (cont)		(5) No. 1 oxidizer valve (open):		
		(a) J102, pins G to E	2,135 ±285	
		(b) J102, pins E to F	465 ±195	
		(c) J102, pins G to F	2,000 ±120	
		(d) J103, pin S, to J100 or J101, pin C	5 maximum	
		(e) J103, pins R to S	infinity	
		(6) No. 1 fuel valve (open):		
		(a) J102, pins P to B	2,095 ±345	
		(b) J102, pins B to C	495 ±165	
		(c) J102, pins P to C	2,000 ±120	
		(d) J103, pin E, to J100 or J101 pin C	5 maximum	
		(e) J103, pins E to F	infinity	
		(7) No. 2 oxidizer valve (open):		
		(a) J102, pins T to H	2,135 ±285	
		(b) J102, pins H to J	465 ±195	
		(c) J102, pins T to J	2,000 ±120	
		(d) J103, pin C, to J100 or J101, pin C	5 maximum	
		(e) J103, pins T to J	infinity	
		(8) No. 2 fuel valve (open):		
		(a) J102, pins S to D	2,095 ±345	
		(b) J102, pins D to R	495 ±165	
		(c) J102, pins S to R	2,000 ±120	
		(d) J103, pin G, to J100 or J101 pin C	5 maximum	
		(e) J103, pins G to H	infinity	
		(9) Gas generator ball valve (open):		
		(a) J103, pin C, to J100 or J101 pin C	5 maximum	
		(b) J103, pins C to D	infinity	
		(10) Gas generator ball valve (closed):		
		(a) J103, pin D, to J100 or J101, pin C	5 maximum	
		(b) J103, pins C to D	infinity	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.2	FLIGHT INSTRUMENTATION SYSTEM FUNCTION TEST FOR INSTALLED ENGINES	a. Measure and record ambient (run) output voltage of each pressure transducer.	Voltage limits for ambient (run) conditions must be within ±5% (±250 millivolts) of full scale of the value recorded in the Engine Log Book, F-1 Final Acceptance Checkout Data, after correction for ambient pressure difference.	Perform prior to hydraulic control system leak and function test, valve timing test, fuel feed system leak and function test, LOX feed system leak and function test, heat exchanger helium system leak test, heat exchanger LOX system leak test, exhaust system leak test, turbopump heater function test, safety circuit function test, and sequence verification test, if performed. Instrument sensing diaphragms must be exposed to ambient pressure during test.
		b. Measure and record 20% and 80% output voltage of each pressure transducer.	Voltage limits for 20% and 80% conditions must be within ±2% (±100 millivolts) of full scale of the adjusted value recorded in the Engine Log Book, F-1 Final Acceptance Checkout Data.	Use section II table for initial pressure transducer data for those instruments that have no data available in the Engine Log Book.
		c. Test each temperature transducer in conjunction with stage signal conditioning equipment during ambient calibration, for continuity and resistance	Ambient resistance value of each instrument must meet values listed in paragraph 1.2.1. Continuity must exist between all pins.	
		d. Test heat exchanger flowmeter secondary and primary coil for continuity in conjunction with stage signal conditioning equipment.	Continuity must exist through secondary and/or primary coil.	
		e. Test turbopump speed transducer secondary and/or primary coil for continuity in conjunction with stage signal conditioning equipment.	Continuity must exist through secondary and/or primary coil.	
1.2.3	TURBOPUMP HEATER FUNCTION TEST	a. Measure and record LOX pump bearing No. 1 temperature at which turbopump thermostats cycle.	Thermostat pickup and dropout must occur between 65° and 180° F.	Perform prior to safety circuits function test and sequence verification tests, if performed, and after flight instrumentation systems test.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.3 (cont)		b. Measure and record turbopump heater current drain.	7.5 ±2.5 amperes per heater	
1.2.4	<u>HYPERGOL INSTALLED SWITCH FUNCTION TEST</u>	Mechanically simulate hypergol installed switch pickup and drop-out indication.	Hypergol-installed indication must occur when hypergol installed is simulated mechanically and must drop out when hypergol-installed simulation is removed.	Perform prior to safety circuits function test, ignition monitor valve interflow test, and sequence verification test, if performed. 909 CAUTION Use extreme care when installing hypergol system test tool, to prevent damage to hypergol cartridge follower. • Make sure that threads of test tool cap are clean and free of nicks, to prevent galling threads of cap and inlet port. Use hypergol system test tool 9021279, or equivalent, from Hypergol System Tool Kit G3135 to actuate and deactuate switch. 902 Hypergol system test tool must be tested for proper operation, prior to installing in hypergol manifold.
1.2.5	<u>CHECKOUT VALVE TIMING TEST</u>	Measure and record time required to cycle checkout valve from ground position to engine position and from engine position to ground position. (Repeat test 3 times.)	Ground position switch drop-out to engine position pickup must be between 0.5 and 3.5 seconds. Engine position switch dropout to ground position switch pickup must be between 0.5 and 3.5 seconds.	Perform prior to safety circuits function test, sequence verification test, and hydraulic control system leak and function test, if performed. CAUTION Ground hydraulic pressure must not be applied to the engine during checkout valve cycling.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.6	<u>ENGINE SAFETY CIRCUITS FUNCTION TEST AT MTF</u>	Verify safety circuits acceptability by performing electromechanical simulation of a static test for each safety circuit.	Within limits specified in section II for static test safety circuits	Perform subsequent to hydraulic control system leak test, hypergol installed switch test, turbopump heater test, thrust OK pressure switch leak and function test, flight instrumentation system test, and checkout valve timing test, if applicable. Perform prior to engine sequence test and valve timing test.
1.2.7	<u>ENGINE SAFETY CIRCUITS FUNCTION TEST AT KSC</u>	Verify safety circuits acceptability by performing an electromechanical simulation of a launch for each safety circuit.	Within limits specified in Section II for launch safety circuits	Perform subsequent to hydraulic control system leak test, hypergol installed switch test, turbopump heater test, thrust OK pressure switch leak and function test, checkout valve timing test, and flight instrumentation system test. Perform prior to engine sequence test and valve timing test.
1.2.8	<u>ENGINE SEQUENCE VERIFICATION TEST</u>	Perform electromechanical simulation of an engine sequence to verify proper operation of each individual and combined electrical and mechanical sequence requirement of section II.	Within limits specified in section II for engine sequence acceptability	Perform subsequent to safety circuits function test.
1.2.9	<u>IGNITER TEST</u>	a. Visually inspect each igniter prior to testing for:		Perform prior to installation on engine. 914
		(1) Closure damage	No damage is allowable.	Use Igniter Tester G3153, or equivalent. The igniter tester must be tested for proper operation prior to conducting this test. 902 916
		(2) Thread damage	No damage is allowable.	
		(3) Bent or loose receptacle pins	No damage is allowable.	
		(4) Nicked or scratched gasket or gasket seating surfaces	No damage is allowable.	During testing, the igniter must be installed in a protective device that will prevent injury to personnel in event of accidental firing of an igniter.
		(5) Six-month time exceeded since igniter was removed from container.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.9 (cont)		(6) Service life expired	Service life must meet requirements of section II.	916
		b. Utilizing a high-voltage igniter tester, verify meter indications for the following switch selector settings in the order listed:		
		(1) No fire test	Less than one milliampere	
		(2) Fire test	3.5 to 8.0 milliamperes	
		(3) Insulation test 1, 2, and 3	100 megohms minimum	
		(4) Link	In green area of meter	
1.2.10	<u>INERT IGNITER TEST</u>	a. Visually inspect each inert igniter prior to testing for:		Perform prior to installation on engine. 914
		(1) Closure damage	No damage is allowable.	
		(2) Thread damage	No damage is allowable.	
		(3) Dent or loose receptacle pins	No damage is allowable.	916
		(4) Nicked or scratched gasket or gasket seating surfaces	No damage is allowable.	
		b. Utilizing a high-voltage igniter tester, verify meter indications for the following switch selector in the order listed:		
		(1) No fire test	Less than one milliampere	
		(2) Fire test	Less than one milliampere	
		(3) Insulation test 1, 2, and 3	Greater than 100 megohms	
		(4) Link	In green area of meter	
		c. Test insulation resistance at the following pins using 500 vdc for 5-60 seconds:		916
		(1) Pin B to case	Greater than 200 megohms	
		(2) Pin A to D	Greater than 200 megohms	
1.2.11	<u>IGNITER HARNESS CONTINUITY TEST</u>	a. (Deleted)		Perform prior to igniter installation.
		b. Verify igniter harness pin-to-pin continuity.	Pin-to-pin continuity.	906 914
		c. (Deleted)		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.12	VIBRATION SAFETY CUTOFF VERIFICATION TEST	a. Install accelerometers in engine taps CZA1, CZA10, and CZA4.		CAUTION Torque must not exceed 20 inch-pounds or the accelerometer may be twisted off. The accelerometer cable must be disconnected (if attached) prior to the installation of the accelerometer, to prevent possible twisting. The accelerometer is a sensitive instrument that can be damaged by rough treatment, such as dropping, sharp blows, or overtorquing.
		b. Connect and secure accelerometer cable.		Do not secure accelerometer cable to cryogenic lines or surfaces. Verify that cable is not twisted or damaged.
		c. Visually verify the following vibration safety cutoff unit dial settings:		
		(1) DELAY TIME	276 ±5%	
		(2) STORAGE TIME	zero	
		d. Allow isolation amplifier and vibration safety cutoff unit temperature to stabilize.		
		e. Disconnect accelerometer leads from accelerometer and test each isolation amplifier output to its vibration safety cutoff unit input as follows:		Utilize a signal generator set at 2,000 ±20 cps and an ac voltage source of less than 0.25 volts rms.
		(1) Increase input voltage to each isolation amplifier to calculated cutoff voltage, ±5%.	Cutoff indication on vibration safety cutoff unit. No engine cutoff from voting logic.	
		(2) Test voting logic circuit by paralleling input voltages to isolation amplifiers at calculated cutoff voltage ±5% (2,000 ±20 cps).	Engine cutoff must occur.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.12 (cont)		c. Perform an audio tap test after installation of accelerometer leads by tapping gently on thrust chamber dome.	Audible output must exist from each vibration safety cutoff unit.	
1.2.13	<u>THRUST OK PRESSURE SWITCH FUNCTION TEST</u>	Cycle switches 3 times from zero to 1,240 ±30 psig with gaseous nitrogen applied at calibration port.	Switch pickup pressure 1,060 ±65 psig on second and subsequent cycles; switch dropout pressure 50-100 psig below pickup pressure on second and subsequent cycles.	CAUTION Pressurization rates must be limited to 50 psig/sec from 0-895 psig and 5 psig/sec from 895 to 1,270 psig. Depressurization rates must be limited to 5 psig/sec from 1,270 to 895 psig. 902
1.2.14	<u>IGNITER HARNESS CONTINUITY AND INSULATION RESISTANCE TEST</u>	a. Disconnect igniter harness plug P47 from receptacle J47.		Perform prior to igniter installation.
		b. Measure igniter harness pin-to-pin resistance as follows:	One ohm maximum between pins	

<u>From</u>	<u>To</u>
P47-B	P43-B
P47-D	P43-D
P47-C	P43-A
P47-T	P43-C
P47-U	P44-C
P47-A	P44-A
P47-J	P44-D
P47-F	P44-B
P47-K	P45-B
P47-H	P45-D
P47-M	P45-C
P47-R	P45-A
P47-N	P46-C
P47-G	P46-A
P47-S	P46-B
P47-E	P46-D

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.14 (cont)		c. Apply 500 vdc for 6-50 seconds between each pin and connector shell and every other pin in the same connector except those pins that are interconnected to the shielding and measure harness insulation resistance.	200 megohms minimum	CAUTION Insulation resistance test must not be performed if connectors are wet and voltage must not be applied to interconnected pins at the same time since a short circuit can result in damage to equipment.
		d. Connect igniter harness plug P47 to receptacle J47. Torque and safetywire plug to receptacle.		
1.2.15	<u>CHECKOUT VALVE ENGINE RETURN SWITCH POSITION VERIFICATION</u>	Verify continuity of engine return switch motor circuit (J-18, pins <u>t</u> to <u>p</u>).		Perform requirement subsequent to last checkout valve actuation prior to static test at MTF and launch at KSC Connectors listed in Requirements column are on interface panel. Measurement may be taken in facility circuitry. 906
1.3	<u>LEAK AND FUNCTION TESTS</u>			
1.3.1	<u>TURBOPUMP TORQUE TEST</u>	Rotate turbopump one full revolution (minimum) in clockwise and counterclockwise direction. Measure and record turbopump shaft breakaway and running torque.	20 foot-pounds maximum. No binding, scuffing, rubbing, or uneven torque is allowable.	Perform prior to fuel feed system leak test and LOX feed system leak test and after fuel feed system drain and LOX feed system boiloff when required by static test or launch abort. One revolution of the turbopump shaft requires 5 revolutions of the torque pinion gear. Locking pin and torque pinion gear must be fully extended after test.
1.3.2	(Deleted)			
1.3.3	<u>THRUST OK PRESSURE SWITCH LEAK AND FUNCTION TEST</u>	a. Leak-test all joints at 1,125-1,200 psig gaseous nitrogen pressure.	No external leakage is allowable.	Perform prior to safety circuits function test, sequence verification test, and thrust chamber pneumatic leak test, if performed. 914

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.3 (cont)		b. Cycle switches 3 times from zero to 1,240 ±30 psig with gaseous nitrogen pressure applied at calibration port.	Switch pickup pressure 1,060 ±65 psig on second and subsequent cycles; switch dropout pressure 50-100 psig below pickup pressure on second and subsequent cycles.	Perform switch pickup and dropout pressure test subsequent to leak testing of joints. CAUTION Pressurization rates must be limited to 50 psig/sec from 0-895 psig and 5 psig/sec from 895 to 1,270 psig. Depressurization rates must be limited to 5 psig/sec from 1,270 to 895 psig. 902
1.3.4	<u>LOX DOME AND GAS GENERATOR LOX INJECTOR PURGE LEAK AND FUNCTION TEST FOR UNINSTALLED ENGINES</u>	a. Perform external leak test of joints and fittings at 100 ±5 psig gaseous nitrogen.	No external leakage is allowable.	Perform after thrust chamber pneumatic leak test and exhaust system leak test. The turbine exhaust system must be vented during performance of this activity. 902
		b. Verify purge flow.	Audible flow from gas generator igniter port, thrust chamber injector, and overboard drain line; or by feeling individual purge system lines.	Thrust chamber exit and throat closures and LOX overboard drain line closure must be removed during this test. Leak-test compound must not be used on overboard drain line exits or braided flex line bellows.
1.3.5	<u>LOX DOME AND GAS GENERATOR LOX INJECTOR PURGE LEAK AND FUNCTION TEST FOR INSTALLED ENGINES AT MAF</u>	a. Perform external leak test of joints and fittings at 120-220 psig gaseous nitrogen.	No external leakage is allowable.	Perform after exhaust system leak test and sequence verification test.
		b. Verify purge flow at 120-220 psig.	Audible flow from gas generator igniter port, thrust chamber injector, and overboard drain line; or by feeling individual purge system lines.	Thrust chamber exit and throat closures; and LOX overboard drain line closure must be removed during this test. Leak-test compound must not be used on overboard drain line exits or braided flex line bellows.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.5A	<u>LOX DOME AND GAS GENERATOR LOX INJECTOR PURGE LEAK AND FUNCTION TEST AT MTF AND KSC</u>	a. Perform external leak test of joints and fittings at 120-220 psig gaseous nitrogen.	No external leakage is allowable.	Perform after exhaust system leak test and sequence verification test.
		b. Verify purge flow at 120-220 psig.	Audible flow from gas generator igniter port, thrust chamber injector, and overboard drain line; or by feeling individual purge system lines.	Thrust chamber exit and throat closures and LOX overboard drain line closure must be removed during this test. Leak-test compound must not be used on overboard drain line exits or braided flex line bellows.
		c. Verify and record operational low-level and high-level purge pressure settings:		
		(1) Low-level purge	120-220 psig	
		(2) High-level purge	600-1,000 psig	
		(3) Maximum purge system lockup pressure	1,200 psig	
1.3.6	<u>LOX PUMP SEAL PURGE LEAK AND FUNCTION TEST AT MAF AND KSC</u>	a. Perform external leak test of joints and fittings at 85 ±10 psig gaseous nitrogen.	No external leakage is allowable.	Perform this test prior to drain system leak test, and LOX feed system leak test if performed. Leak-test compound must not be used on overboard drain line exits or braided flex line bellows. Oxidizer overboard drain line and nitrogen purge drain line closures must be removed during this test. **NOTE** Absence of fluid from oxidizer and nitrogen purge overboard drain lines must be verified when covers are removed from lines and when turbopump LOX seal purge pressure is first applied.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.6 (cont)		b. Simultaneously measure and record (at 85 ±10 psig) purge system flowrate from oxidizer overboard drain line and nitrogen purge drain line.	5,000 scim maximum from each drain line. Combined drain line flowrate must be in excess of 0 scim.	Perform flow test from drain lines after external leak test.
1.3.7	<u>LOX PUMP SEAL PURGE LEAK AND FUNCTION TEST AT MTF</u>	a. Perform external leak test of joints and fittings at 85 ±10 psig gaseous nitrogen.	No external leakage is allowable.	Leak-test compound must not be used on overboard drain line exits or braided flex line bellows.
		b. Verify purge flow.	Purge flow from oxidizer overboard drain line and/or nitrogen purge drain line, or by feeling purge supply line.	Oxidizer overboard drain line and nitrogen purge drain line closures must be removed during this test. NOTE Absence of fluid from oxidizer and nitrogen purge overboard drain lines must be verified when covers are removed from lines and when turbopump LOX seal purge pressure is first applied. 901
1.3.8	<u>COCOON PURGE SYSTEM LEAK AND FUNCTION TEST AT MAF</u>	a. Perform external leak test of system joints at 20 ±5 psig gaseous nitrogen pressure.	Fuzz leakage (as defined in section II) is allowable.	Leak-test compound must not be used on purge manifold orifices or braided flex line bellows.
		b. Verify purge flow at leak-test pressure.	Audible flow from purge manifold, or by feeling purge supply line	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.9	COCOON PURGE SYSTEM LEAK AND FUNCTION TEST AT KSC	a. Perform external leak test of system joints at gaseous nitrogen pressure within interface acceptability limits specified in section II.	Fuzz leakage (as defined in section II) is allowable.	Perform prior to thermal insulation installation. Pressure-temperature acceptability limits may be obtained using umbilical measurements corrected for measurement tapoff location. Leak-test compound must not be used on purge manifold orifices or braided flex line bellows.
		b. Verify purge flow at leak-test pressure.	Audible flow from purge manifold	
		c. Verify purge interface pressure-temperature relationship is acceptable.	Within limits specified in section II	
1.3.10	HEAT EXCHANGER HELIUM SYSTEM LEAK TEST FOR UNINSTALLED ENGINES	a. Leak-test at 400 ±10 psig gaseous helium or nitrogen and refrigerant, Type 12, the following system parts:		
		(1) (Deleted)		
		(2) Flanges, fittings, instrumentation lines, and bellows	No external leakage is allowable except at joints listed in substep 3.	Leak-test compound must not be used on braided flex line bellows.
		(3) Joints having allowable external leakage: (a) Helium supply duct (heat exchanger end) to heat exchanger (b) Heat exchanger to helium return duct (heat exchanger end) (c) Helium bypass hose to helium return duct (heat exchanger end)	Fuzz leakage (as defined in section II) is allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks	
1.3.10 (cont)		(d) Heat exchanger helium outlet instrumentation hose to helium return duct instrumentation tap HH3a (on engines not incorporating MD96 change)			
		(e) Heat exchanger helium outlet instrumentation hose to transducer (on engines not incorporating MD96 change)			913
		(f) Heat exchanger helium outlet temperature transducer to helium outlet duct instrumentation tap HH3b (on engines not incorporating MD96 change)			
		b. Using a leak detector at thrust chamber exhaust manifold exit, determine helium coil leakage at leak-test pressure.	No leakage is allowable.		
1.3.11	HEAT EXCHANGER HELIUM SYSTEM LEAK TEST AT KSC	Leak-test at 200 ±10 psig gaseous helium, nitrogen, or nitrogen and refrigerant, Type 12, the following system parts:			900
		(1) (Deleted)			
		(2) Flanges, fittings, instrumentation lines, and bellows	No external leakage is allowable except at joints listed in substep 3.	Leak-test compound must not be used on braided flex line bellows.	
		(3) Joints having allowable external leakage:	Fuzz leakage (as defined in section II) is allowable.		
		(a) Helium supply duct (heat exchanger end) to heat exchanger			913
		(b) Heat exchanger to helium return duct (heat exchanger end)			
		(c) Helium bypass hose to helium return duct (heat exchanger end)			

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks	
1.3.11 (cont)		(d) Helium return duct (heat exchanger end) to helium wrap-around duct			
		(e) Heat exchanger helium outlet instrumentation hose to helium return duct instrumentation tap HH3a (on engines not incorporating MD96 change)			913
		(f) Heat exchanger helium outlet instrumentation hose to transducer (on engines not incorporating MD96 change)			
		(g) Heat exchanger helium outlet temperature transducer to helium outlet duct instrumentation tap HH3b (on engines not incorporating MD96 change)			
1.3.12	<u>HEAT EXCHANGER HELIUM SYSTEM LEAK TEST AT MTF</u>	Leak-test at 200 ±10 psig gaseous helium or nitrogen the following system parts:			
		(1) Flanges, fittings, instrumentation lines, and bellows	No external leakage is allowable except at joints listed in substep 2.		
		(2) Joints having allowable external leakage:	Fuzz leakage (as defined in section II) is allowable.	Leak-test compound must not be used on braided flex line bellows.	
		(a) Helium supply duct (heat exchanger end) to heat exchanger			
		(b) Heat exchanger to helium return duct (heat exchanger end)			913
		(c) Helium bypass hose to helium return duct (heat exchanger end)			
		(d) Helium return duct (heat exchanger end) to helium wrap-around duct			

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.12 (cont)		(e) Heat exchanger helium outlet instrumentation hose to helium return duct instrumentation tap HH3a (on engines not incorporating MD96 change)		
		(f) Heat exchanger helium outlet instrumentation hose to transducer (on engines not incorporating MD96 change)		
		(g) Heat exchanger helium outlet temperature transducer to helium outlet duct instrumentation tap HH3b (on engines not incorporating MD96 change)		
1.3.13	HEAT EXCHANGER HELIUM SYSTEM LEAK TEST AT MAF SUBSEQUENT TO STATIC TEST	a. Leak-test at 200 ±10 psig gaseous helium or nitrogen and refrigerant, Type 12, the following system parts:		
		(1) (Deleted)		
		(2) Flanges, fittings, instrumentation lines, and bellows	No external leakage is allowable except at joints listed in substep 3.	Leak-test compound must not be used on braided flex line bellows.
		(3) Joints having allowable external leakage:	Fuzz leakage (as defined in section II) is allowable.	
		(a) Helium supply duct (heat exchanger end, to heat exchanger		
		(b) Heat exchanger to helium return duct (heat exchanger end)		
		(c) Helium bypass hose to helium return duct (heat exchanger end)		
		(d) Helium return duct (heat exchanger end) to helium wrap-around duct		

913

913

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.13 (cont)		(e) Heat exchanger helium outlet instrumentation hose to helium return duct instrumentation tap HH3a (on engines not incorporating MD96 change)		
		(f) Heat exchanger helium outlet instrumentation hose to transducer (on engines not incorporating MD96 change)		913
		(g) Heat exchanger helium outlet temperature transducer to helium outlet duct instrumentation tap HH3b (on engines not incorporating MD96 change)		
		b. Using a leak detector at thrust chamber exhaust manifold exit, determine helium coil leakage at leak-test pressure.	No leakage is allowable.	
1.3.14	HEAT EXCHANGER LOX SYSTEM LEAK TEST FOR UNINSTALLED ENGINES	a. Leak-test at 1,400 ±20 psig gaseous nitrogen and refrigerant, Type 12, the following system parts:		Perform prior to thrust chamber pneumatic leak test. 905
		(1) (Deleted)		
		(2) Flanges, fittings, bellows, and instrumentation lines	No external leakage is allowable except at joints listed in substep 3.	Leak-test compound must not be used on braided flex line bellows.
		(3) Joints having allowable external leakage:	Fuzz leakage (as defined in section II) is allowable.	913
		(a) Heat exchanger to GOX duct (heat exchanger end)		
		(b) Oxidizer bypass hose to GOX duct (heat exchanger end)		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.14 (cont)		b. Perform reverse-flow leak test of heat exchanger check valve at 100 ±5 psig gaseous nitrogen and refrigerant, Type 12.	50 scim maximum	Install Thrust Chamber Throat Plug G3136 to monitor heat exchanger check valve reverse-flow leakage. 905
		c. Using a leak detector at thrust chamber exhaust manifold exit, determine LOX coil leakage at leak-test pressure.	No leakage is allowable.	
1.3.15	HEAT EXCHANGER LOX SYSTEM LEAK TEST AT KSC	Leak-test at 300 ±10 psig gaseous nitrogen the following system parts:		Perform prior to thrust chamber pneumatic leak test, if performed. 900
		(1 (Deleted)		
		(2 Flanges, fittings, instrumentation lines, and bellows	No external leakage is allowable except at joints listed in substep 3.	Leak-test compound must not be used on braided flex line bellows.
		(3) Joints having allowable external leakage:	Fuzz leakage (as defined in section II is allowable.	913
		(a) Heat exchanger to GOX duct (heat exchanger end)		
		(b) Oxidizer bypass hose to GOX duct (heat exchanger end)		
1.3.16	HEAT EXCHANGER LOX SYSTEM LEAK TEST AT MTF	Leak-test at 1,000 ±50 psig gaseous nitrogen as follows:		905
		(1) Flanges, fittings, instrumentation lines, and bellows	No external leakage is allowable except at joints listed in substep 2.	Leak-test compound must not be used on braided flex line bellows.
		(2) Joints having allowable external leakage:	Fuzz leakage (as defined in section II) is allowable.	905 913
		(a) Heat exchanger to GOX duct (heat exchanger end)		
		(b) Oxidizer bypass hose to GOX duct (heat exchanger end)		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.16 (cont)		(c) GOX duct (heat exchanger end) to heat exchanger GOX wrap-around duct		
1.3.17	<u>HEAT EXCHANGER LOX SYSTEM LEAK TEST AT MAF SUBSEQUENT TO STATIC TEST</u>	a. Leak-test at 300 ±10 psig gaseous nitrogen and refrigerant, Type 12, the following system parts:		Perform prior to thrust chamber pneumatic leak test.
		(1) (Deleted)		
		(2) Flanges, fittings, bellows, and instrumentation lines	No external leakage is allowable except at joints listed in substep 3.	Leak-test compound must not be used on braided flex line bellows.
		(3) Joints having allowable external leakage:	Fuzz leakage (as defined in section II) is allowable.	
		(a) Heat exchanger to GOX duct (heat exchanger end)		
		(b) Oxidizer bypass hose to GOX duct (heat exchanger end)		
		b. Perform reverse-flow leak test of heat exchanger check valve at 300 ±10 psig gaseous nitrogen and refrigerant, Type 12	50 scim maximum	Install Thrust Chamber Throat Plug G3136 to monitor heat exchanger check valve reverse-flow leakage.
		c. Using a leak detector at thrust chamber exhaust manifold exit, determine LOX coil leakage at leak-test pressure.	No leakage is allowable	
1.3.18	(Deleted)			
1.3.19	<u>HYDRAULIC CONTROL SYSTEM LEAK AND FUNCTION TEST FOR UNINSTALLED ENGINE, AND INSTALLED ENGINE AT MTF (PRIOR TO STATIC TEST) AND AT KSC</u>	a. Leak-test closed side of hydraulic control system at 1,800 ±50 psig hydraulic pressure and as outlined in steps b through d.	No external leakage is allowable.	Perform this test prior to ignition monitor valve interflow test, ignition monitor valve shuttle pressure test, exhaust system leak test, thrust chamber pneumatic leak test, thrust chamber liquid leak test, LOX feed system leak test, engine valve timing test, and fuel feed system leak test, if performed, and after flight instrumentation system test and ignition monitor valve diaphragm test, if performed.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.19 (cont)				If surface wetting is noted on components or flanged joints, refer to section II for criteria to use to establish joint acceptability. Checkout valve must be in ground return position. The engine propellant feed systems must be at ambient pressure during this test. The redundant shutdown valve must not be energized more than 15 minutes, since the temperature buildup will cause the valve to actuate slower. Deenergizing the redundant shutdown valve will cause approximately 25 cc of hydraulic fluid to be expelled from the DRAIN port. Personnel must be clear of DRAIN port, and hydraulic fluid must not drain onto the engine. Apply pressure to hydraulic control system at suitable increments beginning with lowest pressure capability, increasing to maximum test pressure required, and monitor for leakage while pressure is increased.
		b. Monitor fuel overboard drain line, at thrust chamber exit, for fuel leakage. Any leakage may require isolation from overboard drain line and recording of leakage rate of the following components:		Past recorded component leakage shall be used as a guide for determining component isolation requirement. When leakage is accounted for, no further isolation is required.
		(1) Redundant shutdown valve	2 cc/m fuel leakage maximum from drain port	
		(2) Ignition monitor valve	5 cc/m fuel leakage maximum from drain port	
		(3) Engine control valve	5 cc/m fuel leakage maximum from override drain port	
		(4) All other components common to this drain system	No leakage is allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.19 (cont)		c. Monitor checkout valve ball seal leakage at engine hydraulic return line quick-disconnect.	2 cc/m maximum	
		d. Monitor engine control valve engine supply check valve reverse leakage at engine hydraulic supply line quick-disconnect.	2 cc/m maximum	
		e. Leak-test gimbal hydraulic return line quick-disconnect (center engine only) at 1,550 ±50 psig hydraulic pressure with cap removed.	5 drops per minute	914
		f. Leak-test open side of hydraulic control system at 1,800 ±50 psig hydraulic pressure and as outlined in step g.	No external leakage is allowable.	Actuate engine valves at hydraulic supply pressure between 900 and 1,600 psig and hydraulic return system pressure below 100 psig. 909 CAUTION Supply pressure to ignition monitor valve CONTROL port must not exceed 100 psig since damage to ignition monitor valve and hypergol manifold can result. • Do not allow hydraulic return system leak-test pressure to exceed 525 psig. If surface wetting is noted on components or flanged joints, refer to section II for criteria to use to establish joint acceptability. Hydraulic leakage may be noted from the fuel overboard drain system during actuation of the redundant shutdown valve. This leakage is acceptable.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.19 (cont)		g. Monitor fuel overboard drain line, at thrust chamber exit, for fuel leakage. Any leakage may require isolation from overboard drain line and recording of leakage rate of the following components:		Past recorded component leakage shall be used as a guide for determining component isolation requirement. When leakage is accounted for, no further isolation is required.
		(1) Redundant shutdown valve	2 cc/m fuel leakage maximum from drain port	
		(2) Ignition monitor valve	5 cc/m fuel leakage maximum from drain port	
		(3) Engine control valve	5 cc/m fuel leakage maximum from override drain port	
		(4) All other components common to this drain system	No leakage is allowable.	
1.3.19A	<u>HYDRAULIC CONTROL SYSTEM LEAK AND FUNCTION TEST AT MTF SUBSEQUENT TO STATIC TEST</u>	a. Leak-test closed side of hydraulic control system at 1,800 ±50 psig hydraulic pressure.	No external leakage is allowable.	Perform this test subsequent to fuel feed system drain and prior to stage rotation to horizontal. If surface wetting is noted on components or flanged joints, refer to section II for criteria to use to establish joint acceptability. Checkout valve must be in ground return position. Apply pressure to hydraulic control system at suitable increments beginning with lowest pressure capability, increasing to maximum test pressure required, and monitor for leakage while pressure is increased.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.19A (cont)		b. Monitor fuel overboard drain line, at thrust chamber exit, for fuel leakage. Any leakage may require isolation from overboard drain line and recording of leakage rate of the following components:		Fast recorded component leakage shall be used as a guide for determining component isolation requirement. When leakage is accounted for, no further isolation is required.
		(1) Redundant shutdown valve	2 cc/m fuel leakage maximum from drain port	915
		(2) Ignition monitor valve	5 cc/m fuel leakage maximum from drain port	
		(3) Engine control valve	5 cc/m fuel leakage maximum from override drain port	901
		(4) All other components common to this drain system	No leakage is allowable.	
		c. Monitor checkout valve ball seal leakage at engine hydraulic return line quick-disconnect.	2 cc/m maximum	
		d. Monitor engine control valve engine supply check valve reverse leakage at engine hydraulic supply line quick-disconnect.	2 cc/m maximum	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.19B	<u>HYDRAULIC CONTROL SYSTEM LEAK AND FUNCTION TEST AT MAF SUBSEQUENT TO STATIC TEST</u>	a. Leak-test closed side of hydraulic control system at 1,800 ±50 psig hydraulic pressure.	No external leakage is allowable.	Perform this test prior to ignition monitor valve interflow test, ignition monitor valve shuttle pressure test, exhaust system leak test, thrust chamber pneumatic leak test, LOX feed system leak test, engine valve timing test, and fuel feed system leak test, if performed, and after flight instrumentation system test and ignition monitor valve diaphragm test, if performed. If surface wetting is noted on components or flanged joints, refer to section II for criteria to use to establish joint acceptability. Checkout valve must be in ground return position. 901 The engine propellant feed systems must be at ambient pressure during this test. The redundant shutdown valve must not be energized more than 15 minutes, since the temperature buildup will cause the valve to actuate slower. Apply pressure to hydraulic control system at suitable increments beginning with lowest pressure capability, increasing to maximum test pressure required, and monitor for leakage while pressure is increased.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.19B (cont)		b. Leak-test gimbal hydraulic return line quick-disconnect (center engine only) at 1,550 ±50 psig hydraulic pressure with cap removed.	5 drops per minute	
		c. Leak-test open side of hydraulic control system at 1,800 ±50 psig hydraulic pressure.	No external leakage is allowable.	
				Actuate engine valves at hydraulic supply pressure between 900 and 1,600 psig and hydraulic return system pressure below 100 psig. CAUTION Supply pressure to ignition monitor valve CONTROL port must not exceed 100 psig since damage to ignition monitor valve and hypergol manifold can result. • Do not allow hydraulic return system leak-test pressure to exceed 525 psig. If surface wetting is noted on components or flanged joints, refer to section II for criteria to use to establish joint acceptability.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.20	<u>IGNITION MONITOR VALVE DIAPHRAGM LEAK TEST</u>	a. Measure and record leakage from ignition monitor valve ATMOS REF port with 1,400 ±20 psig gaseous nitrogen applied to CONTROL port.	No leakage is allowable.	Perform prior to hydraulic control system leak test and thrust chamber leak test. CAUTION The hypergol cartridge installed switch must not be actuated when performing steps a and b. 932
		b. Leak-test ignition monitor valve cap external joints at 1,400 ±20 psig gaseous nitrogen.	No external leakage is allowable.	Perform external leak test after measurement of diaphragm leakage and reconnection and torquing of drain tube to ATMOS REF port.
		c. Verify hypergol installed switch actuation and hypergol cartridge follower freedom of movement when hypergol cartridge follower is manually depressed with CONTROL port pressure at zero psig.		Thrust chamber throat plug, closure, and or exit closure must be removed during performance of this activity. 921 932
1.3.21	<u>HYPERGOL MANIFOLD LEAK AND FUNCTION TEST</u>	a. Measure and record leakage at the following ports at 200 ±10 psig gaseous nitrogen:		Perform prior to thrust chamber leak test and fuel feed system leak test.
		(1) Purge quick-disconnect	3 scim maximum	Apply pressure through drain quick-disconnect.
		(2) Igniter fuel valve vent port	0.25 scim maximum	The hypergol manifold outlet line must be blocked during this test.
		(3) Ignition monitor valve ATMOS REF port	0.25 scim maximum	If igniter fuel valve relieves at a pressure lower than 200 ±10 psig, decrease pressure until valve reseats, then increase level to value just below that required for igniter fuel valve to relieve. Perform test at this pressure.
		b. Leak-test hypergol manifold external joints and ports at 200 ±10 psig gaseous nitrogen pressure.	No external leakage is allowable.	Perform external leak test after completion of all flow measurements and after installation and torquing of all flow measurement port fittings.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.21 (cont)		c. Measure and record igniter fuel valve relieving pressure using gaseous nitrogen pressure. (Repeat test 3 times.)	270 psig maximum	The engine fuel feed system must be vented to preclude pressure buildup during this test.
1.3.22	<u>IGNITION MONITOR VALVE INTERFLOW TEST</u>	Apply 1,550 ±50 psig hydraulic pressure and mechanically simulate hypergol cartridge installed. Apply 28 ±2 psig gaseous nitrogen pressure to ignition monitor valve CONTROL port for 5 minutes with gas generator ball valve and main oxidizer valves in open position.	Fuel valves must remain in the closed position.	Perform this test after hydraulic control system leak test, ignition monitor valve diaphragm leak test, ignition monitor valve shuttle pressure test, hypergol installed switch test, and flight instrumentation system test. The engine propellant feed systems must be at ambient pressure during this test. CAUTION Supply pressure to ignition monitor valve CONTROL port must not exceed 100 psig since damage to ignition monitor valve or hypergol manifold will result. • Extreme care must be used when installing the hypergol test tool, to prevent damage to the hypergol cartridge follower. • Threads of the test tool cap must be clean and free of nicks, to prevent galling of threads of the cap and inlet port.
1.3.23	<u>IGNITION MONITOR VALVE SHUTTLE PRESSURE TEST</u>	Measure and record gaseous nitrogen pressure (applied to CONTROL port) at which ignition monitor valve actuates during 3 cycles with 1,550 ±50 psig hydraulic control system pressure applied.	20 ±4 psig with sense line to thrust chamber blanked off or 21 ±4 psig with sense line to thrust chamber not blanked off. Each shuttle pressure must be within ±2 psig of the other shuttle pressures.	Perform this test after hydraulic control system leak test, ignition monitor valve diaphragm leak test, hypergol installed switch test, and flight instrumentation system test. The engine propellant feed systems must be at ambient pressure during this test.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.23 (cont)				Ignition monitor valve operation is indicated by opening of the fuel valves.
1.3.24	<u>VALVE TIMING TEST FOR UNINSTALLED ENGINES</u>	a. Cycle gas generator ball valve, oxidizer valves, and fuel valves to the open and closed positions a minimum of 4 times with hydraulic control system pressure at 1,550 ±20 psig as follows:		Perform this test after hydraulic control system leak test, ignition monitor valve interflow test, ignition monitor valve diaphragm leak test, ignition monitor valve shuttle pressure test, and flight instrumentation system test.
		(1) During each opening cycle, first open gas generator ball valve and oxidizer valves; then shuttle the ignition monitor valve to open fuel valves.		
		(2) For 3 closing cycles, apply a signal to engine control valve stop solenoid without a signal applied to redundant shutdown valve.		Checkout valve must be in ground return position.
		(3) For one closing cycle, apply a signal to redundant shutdown valve without a signal applied to engine control valve stop solenoid.		CAUTION The supply pressure to the ignition monitor valve CONTROL port must not exceed 100 psig since damage to the ignition monitor valve and hypergol manifold will result.
		b. Record the following actual valve and sequence times for those valve cycles that apply a signal to engine control valve stop solenoid:		NOTE Potentiometer times are for reference only.

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Paragraph	Activities	Requirements	Limits: Potentiometer (msec)	Limits: Switch (msec)	Special Constraints and Remarks
1.3.24 (cont)		(1) Time from power application to engine control valve start solenoid to valve closed switch dropout indication:	Potentiometer (msec)	Switch (msec)	
		(a) No. 1 oxidizer valve	40 ±25	155 ±50	
		(b) No. 2 oxidizer valve	40 ±25	155 ±50	
		(c) Gas generator ball valve	--	155 ±25	
		(2) Valve opening times from closed switch dropout indication to open switch pickup indication:			
		(a) No. 1 oxidizer valve	615 ±125	350 ±60	
		(b) No. 2 oxidizer valve	615 ±125	350 ±60	
		(c) Gas generator ball valve	--	215 ±75	
		(d) No. 1 fuel valve	690 ±150	545 ±100	
		(e) No. 2 fuel valve	690 ±150	545 ±100	
		(f) Time from either fuel valve closed switch dropout to other fuel valve closed switch dropout	--	0 ±100	
		(3) Time from power application to engine control valve stop solenoid to valve open switch dropout indication:			
		(a) Gas generator ball valve	--	50 ±20	
		(b) No. 1 oxidizer valve	45 ±40	165 ±60	
		(c) No. 2 oxidizer valve	45 ±40	165 ±60	
		(d) No. 1 fuel valve	35 ±30	120 ±50	
		(e) No. 2 fuel valve	35 ±30	120 ±50	

Paragraph	Activities	Requirements	Limits		Special Constraints and Remarks
1.3.24 (cont)		(4) Valve closing times from open switch dropout indication to closed switch pick-up indication:	Potentiometer (msec)	Switch (msec)	
		(a) No. 1 oxidizer valve	600 ±150	335 ±60	
		(b) No. 2 oxidizer valve	600 ±150	335 ±60	
		(c) Gas generator ball valve	--	140 ±30	
		(d) No. 1 fuel valve	800 ±150	655 ±75	
		(e) No. 2 fuel valve	800 ±150	655 ±75	
		c. Record time from redundant shutdown solenoid signal to gas generator ball valve open switch dropout for valve cycle that applied a signal to redundant shutdown valve without a signal applied to engine control valve stop solenoid.	0.300 sec maximum		
		d. Measure and record hydraulic flow rate at 1,550 ±20 psig supply pressure and 45 ±20 psig return pressure as follows:			
		(1) Valves open	11.6 ±1.1 gpm		
		(2) Valves closed	11.6 ±1.1 gpm		
		e. Measure and record current drains as follows:			
		(1) Engine control valve start solenoid	0.60 amperes maximum		
		(2) Engine control valve stop solenoid	0.60 amperes maximum		
		(3) Redundant shutdown valve solenoid	2.0 amperes maximum		
1.3.25	<u>VALVE TIMING TEST FOR INSTALLED ENGINES</u>	a. Cycle gas generator ball valve, oxidizer valves, and fuel valves to the open and closed positions a minimum of 4 times with hydraulic control system pressure at 1,550 ±50 psig as follows:			Perform this test after the hydraulic control system leak test, ignition monitor valve interflow test, ignition monitor valve diaphragm leak test, ignition monitor valve shuttle pressure test, and flight instrumentation system test.

Paragraph	Activities	Requirements	Limits		Special Constraints and Remarks
1.3.25 (cont)		(1) During each opening cycle, first open gas generator ball valve and oxidizer valves; then shuttle the ignition monitor valve to open fuel valves.			The engine propellant feed systems must be at ambient pressure during this test.
		(2; (Deleted)			909 91.
		(3) For one closing cycle, apply a signal to redundant shutdown valve without a signal applied to engine control valve stop solenoid.			Checkout valve must be in ground return position.
		(4) For 3 closing cycles, apply signals to both engine control valve stop solenoid and redundant shutdown valve.			CAUTION The supply pressure to the ignition monitor valve CONTROL port must not exceed 100 psig since damage to the ignition monitor valve and hypergol manifold will result. 914
		b. Record the following actual valve and sequence times for those valve cycles that apply a signal to both engine control valve stop solenoid and redundant shutdown valve:			
		(1) Time from power application to engine control valve start solenoid to valve closed switch dropout indication:	Potentiometer (msec)	Switch (msec)	NOTE
		(a) No. 1 oxidizer valve	40 ±25	155 ±50	Potentiometer times are for reference only.
		(b) No. 2 oxidizer valve	40 ±25	155 ±50	
		(c) Gas generator ball valve	--	145 ±25	
		(2) Valve opening times from closed switch dropout indication to open switch pickup indication:			
		(a) No. 1 oxidizer valve	525 ±100	300 ±70	
		(b) No. 2 oxidizer valve	525 ±100	300 ±70	
		(c) Gas generator ball valve	--	170 ±50	

Paragraph	Activities	Requirements	Limits: Potentiometer (msec)	Limits: Switch (msec)	Special Constraints and Remarks
1.3.25 (cont)					
		(d) No. 1 fuel valve	650 ±100	530 ±100	
		(e) No. 2 fuel valve	650 ±100	530 ±100	
		(f) Time from either fuel valve closed switch dropout to other fuel valve closed switc dropout	--	0 ±100	
		(3) Time from power application to engine control valve stop solenoid to valve open switch dropout indication:			
		(a) Gas generator ball valve	--	50 ±20	
		(b) No. 1 oxidizer valve	45 ±40	185 ±75	
		(c) No. 2 oxidizer valve	45 ±40	185 ±75	
		(d) No. 1 fuel valve	35 ±30	125 ±50	
		(e) No. 2 fuel valve	35 ±30	125 ±50	
		(4) Valve closing times from open switch dropout indication to closed switch pickup indication:			
		(a) No. 1 oxidizer valve	525 ±100	300 ±70	
		(b) No. 2 oxidizer valve	525 ±100	300 ±70	
		(c) Gas generator ball valve	--	145 ±30	
		(d) No. 1 fuel valve	750 ±100	630 ±120	
		(e) No. 2 fuel valve	750 ±100	630 ±120	
		c. Record time from redundant shutdown solenoid signal to gas generator ball valve open switch dropout for valve cycle that applied a signal to redundant shutdown valve without a signal applied to engine control valve stop solenoid.	0.300 sec maximum		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.26	FUEL FEED SYSTEM LEAK TEST FOR UNINSTALLED ENGINES	a. Measure and record leakage at 80 ±5 psig gaseous nitrogen, from the following system parts:		Perform this test subsequent to hydraulic control system leak test, valve timing test, and hypergol manifold leak and function test, and prior to turbopump bearing coolant system leak test.
		(1) Quick-disconnects	3 scim maximum	
		(2) Gas generator ball valve fuel shaft seal	0.25 scim maximum	
		(3) (Deleted)		Hydraulic control system pressure of 1,550 ±50 psig must be applied, and the checkout valve must be in the ground return position during this test. 913
		(4) Igniter fuel valve seat	0.5 scim maximum	
		(5) Turbopump primary fuel seal. (Slowly rotate turbopump main shaft to find maximum leakage rate whether rotating or stationary.)	50 scim maximum	CAUTION During removal of the gas generator ball valve fuel inlet drain quick-disconnect cap, the quick-disconnect body must not be allowed to turn.
		(6) Turbopump fuel inlet seal. (Slowly rotate turbopump main shaft to find maximum leakage rate whether rotating or stationary.)	50 scim maximum	The turbine exhaust system must be vented during performance of this activity. 902
		(7) Bearing coolant control valve check valves	2 scim maximum	Thrust chamber exit, thrust chamber throat, and overboard drain line closures must be removed for this test.
		(8) Combined fuel valves and gas generator ball valve fuel ball seal leakage	15 scim maximum	Install fuel seal drain manifold adapter 9020907 in drain manifold. Isolate gas generator ball valve fuel shaft vent line from fuel overboard drain system.
		(9) Combined No. 1 and No. 2 fuel valve nose and skirt seal leakage	15 scim maximum	Perform substeps 9 and 10 only if substep 8 limit is exceeded.
		(10) Gas generator ball valve fuel ball seal leakage	20 scim maximum	
		(11) No. 1 fuel valve nose and skirt seal leakage	15 scim maximum	Perform substeps 11 and 12 only if substep 9 limit is exceeded.
		(12) No. 2 fuel valve nose and skirt seal leakage	15 scim maximum	
		b. Leak-test at 80 ±5 psig gaseous nitrogen, system flanges, fittings, bellows, and instrumentation lines.	No external leakage is allowable.	Leak-test compound must not be used on overboard drain line exits or braided flex line bellows.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.26 (cont)				Perform external leak test after completion of all flow measurements and after installation and torquing of all flow measurement port fittings.
1.3.27	(Deleted)			
1.3.28	<u>FUEL FEED SYSTEM LEAK TEST AT MTF</u>	Leak-test at 10 ±1 psig gaseous nitrogen, all system flanges and ports.	No external leakage is allowable.	Perform this test subsequent to hydraulic control system leak test and valve timing test. 900 During this test, hydraulic control system pressure of 1,550 ±50 psig must be applied, and the checkout valve must be in the ground return position or the hydraulic control system must be blanked off. Thrust chamber exit, thrust chamber throat, and overboard drain line closures must be removed for this test. Leak-test compound must not be used on overboard drain line exits or braided flex line bellows.
1.3.29	<u>FUEL FEED SYSTEM LEAK TEST AT MAF SUBSEQUENT TO STATIC TEST AND AT KSC</u>	a. Measure and record leakage at 10 ±1 psig gaseous nitrogen, from the following system parts:		Perform this test after hydraulic control system leak test, valve timing test, LOX feed system leak test, and hypergol manifold leak and function test, and prior to turbopump bearing coolant system leak test. 902
		(1) Quick-disconnects	3 scim maximum	
		(2) Gas generator ball valve fuel shaft seal	0.25 scim maximum	During this test, hydraulic control system pressure of 1,550 ±50 psig must be applied, and the checkout valve must be in the ground return position or the hydraulic control system must be blanked off. 913
		(3) (Deleted)		
		(4) Igniter fuel valve seat	0.5 scim maximum	
		(5) Turbopump primary fuel seal. (Slowly rotate turbopump main shaft to find maximum leakage rate whether rotating or stationary.)	50 scim maximum	During this test, the LOX feed system pressure must be applied and maintained at 10 ±1 psig. 902

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.29 (cont)		(6) Turbopump fuel inlet seal. (Slowly rotate turbopump main shaft to find maximum leakage rate whether rotating or stationary.)	50 scim maximum	**CAUTION** During removal of the gas generator ball valve fuel inlet quick-disconnect cap, the quick-disconnect body must not be allowed to turn.
		(7) Bearing coolant control valve check valves	2 scim maximum	Thrust chamber exit, thrust chamber throat, and overboard drain line closures must be removed for this test. Install fuel seal drain manifold adapter 9020907 in drain manifold. **NOTE** Thrust chamber throat plug must be installed and vented for substeps 8 through 10. Leakage rates in substeps 8 through 10 must be obtained by determining difference in leakage rate through thrust chamber throat plug vent when only the LOX feed system is pressurized at 10 ±1 psig and when the LOX feed and fuel feed systems are simultaneously pressurized at 10 ±1 psig. 902
		(8) Combined No. 1 and No. 2 fuel valve nose and skirt seal leakage	15 scim maximum	Isolate gas generator ball valve fuel shaft vent line from fuel overboard drain system.
		(9) No. 1 fuel valve nose and skirt seal leakage	15 scim maximum	Perform substeps 9 and 10 only if substep 8 limit is exceeded.
		(10) No. 2 fuel valve nose and skirt seal leakage	15 scim maximum	If fuel valve leakage rates exceed the specified limits, apply 1,550 ±50 psig hydraulic control system pressure and repeat leak test of fuel valves.
		b. Leak-test at 10 ±1 psig gaseous nitrogen, system flanges, fittings, bellows, and instrumentation lines.	No external leakage is allowable.	Leak-test compound must not be used on overboard drain exits or braided flex line bellows. Perform external leak test after completion of all flow measurements and after installation and torquing of all measurement port fittings.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.30	<u>LOX FEED SYSTEM LEAK TEST FOR UN-INSTALLED ENGINES</u>	a. (Deleted)		Perform this test subsequent to hydraulic control system leak test, valve timing test, and LOX pump seal purge leak and function test. 913 Thrust chamber exit, thrust chamber throat, and overboard drain line closures must be removed for this test. The turbine exhaust system must be vented during performance of this activity. 902 This test may be performed without pressure applied to hydraulic control system. If oxidizer valve leakage rates exceed the specified limits, apply 1,550 ±50 psig hydraulic control system pressure and repeat leak test of oxidizer valves.
		b. Leak-test at 80 ±5 psig gaseous nitrogen, system flanges, fittings, bellows, and instrumentation lines.	No external leakage is allowable, except on engines not incorporating MD128 change, fuzz leakage is allowable between gas generator ball valve LOX housing and actuator cavity housing joint.	Leak-test compound must not be used on overboard drain line exits or braided flex line bellows. 913
		c. Measure and record leakage at 80 ±5 psig gaseous nitrogen from the following system parts:		During this test, the LOX dome purge vent line, gas generator ball valve LOX shaft vent line, and No. 1 and No. 2 oxidizer valve vent lines must be isolated from the oxidizer overboard drain line, and the nitrogen purge overboard drain line exit must be plugged.
		(1) Gas generator ball valve LOX vent port	10 scim maximum	
		(2) No. 1 oxidizer valve bottom rod lip seal (OXID VENT port)	30 scim maximum	
		(3) No. 2 oxidizer valve bottom rod lip seal (OXID VENT port)	30 scim maximum	
		(4) Turbopump primary LOX seal. (Slowly rotate turbopump main shaft to find maximum leakage rate whether rotating or stationary.)	700 scim maximum	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.30 (cont)		(5) Combined oxidizer valves poppet and gas generator ball valve LOX ball seal leakage	10 scim maximum	
		(6) Combined No. 1 and No. 2 oxidizer valve poppet leakage	56 scim maximum	Perform substeps 6 and 7 only if substep 5 limit is exceeded.
		(7) Gas generator ball valve LOX ball seal leakage	10 scim maximum	
		(8) No. 1 oxidizer valve poppet leakage	56 scim maximum	Perform substeps 8 and 9 only if substep 6 limit is exceeded.
		(9) No. 2 oxidizer valve poppet leakage	56 scim maximum	
1.3.31	(Deleted)			
1.3.32	<u>LOX FEED SYSTEM LEAK TEST AT MTF</u>	Leak-test all system joints at 10 ±1 psig gaseous nitrogen.	No external leakage is allowable.	Perform after hydraulic system leak test and valve timing test. 900 Thrust chamber exit, thrust chamber throat, and overboard drain line closures must be removed for this test. Leak-test compound must not be used on overboard drain line exits.
1.3.33	<u>LOX FEED SYSTEM LEAK TEST AT MAF SUBSEQUENT TO STATIC TEST AND AT KSC</u>	a. (Deleted)		Perform this test prior to fuel feed system leak test and after hydraulic control system leak test, valve timing test, and LOX pump seal purge leak and function test. 902 913 Thrust chamber exit, thrust chamber throat, and overboard drain line closures must be removed for this test. This test may be performed without pressure applied to the hydraulic control system. If oxidizer valve leakage rates exceed the specified limits, apply 1,550 ±50 psig hydraulic control system pressure and repeat leak test of oxidizer valves.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1 3.33 (cont)		b. Leak-test all system joints at 10 ±1 psig gaseous nitrogen or gaseous nitrogen and refrigerant, Type 12.	No external leakage is allowable.	913
				Leak-test compound must not be used on overboard drain line exits or braided flex line bellows.
		c. Measure and record leakage at 10 ±1 psig gaseous nitrogen from the following system parts:		Isolate heat exchanger check valve, oxidizer dome and gas generator oxidizer injector purge system, and thrust chamber prefill system.
		(1) Gas generator ball valve LOX vent port	10 scim maximum	
		(2) Turbopump primary LOX seal. (Slowly rotate turbopump main shaft to find maximum leakage rate whether rotating or stationary.)	500 scim maximum	During this test, the gas generator ball valve oxidizer shaft vent line must be isolated from the oxidizer overboard drain line, and the nitrogen purge overboard drain line exit must be plugged.
		(3) Combined No. 1 and No. 2 oxidizer valve poppet leakage	56 scim maximum	Perform substeps 4 and 5 only if substep 3 limit is exceeded. Thrust Chamber Throat Plug G3136 must be installed and vented for substeps 3 through 5.
		(4) No. 1 oxidizer valve poppet leakage	56 scim maximum	
		(5) No. 2 oxidizer valve poppet leakage	56 scim maximum	
1.3.34	(Deleted)			
1.3.35	<u>EXHAUST SYSTEM LEAK TEST AT MAF</u>	Leak-test at 10 ±1 psig gaseous nitrogen or gaseous nitrogen and refrigerant, Type 12, the following system parts:		Perform this test prior to oxidizer dome and gas generator injector purge leak and function test, and after hydraulic system leak test and valve timing test. 913 917
		a. Measure and record leakage from the following seal monitoring port flanges:		**CAUTION**
		(1) Gas generator injector to combustor	10 scim maximum	The exhaust system must be pressurized from the LOX side and depressurized from an exhaust system port.
		(2) Gas generator combustor to turbine manifold inlet	10 scim maximum	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.35 (cont)		(3) Turbine manifold outlet to heat exchanger inlet	10 scim maximum	
		(4) Heat exchanger outlet to thrust chamber hot-gas manifold	10 scim maximum	
		(5) (Deleted)		
		b. All flanges, fittings, and instrumentation lines except as listed in steps c and cA.	No leakage is allowable.	Leak-test compound must not be used on braided flex line bellows. Perform external leak test after completion of flange seal monitor port leak test and after installation and torquing of port plugs unless otherwise specified.
		c. Leak-test the following flanges with leakage-monitoring port plugs removed:		Utilize Turbine Exhaust Exit Pressure Check Fixture G3144 for pressurizing the exhaust system on engines installed in the stage.
		(1) Gas generator injector to combustor	No leakage is allowable.	
		(2) (Deleted)		929
		(3) Turbine manifold outlet to heat exchanger inlet	Fuzz leakage (as defined in section II) is allowable.	913
		(4) Heat exchanger outlet to hot-gas manifold	Fuzz leakage (as defined in section II) is allowable.	
		cA. Leak-test the following flanges:		
		(1) Turbine manifold temperature transducer to turbine manifold instrumentation tap TG4a (on engines not incorporating MD176 change)	Fuzz leakage (as defined in section II) is allowable.	
		(2) Cover plate to turbine manifold instrumentation tap TG4a (on engines incorporating MD176 change)	No leakage is allowable.	
		(3) Turbine outlet pressure transducer hose to heat exchanger instrumentation tap TG5c	Fuzz leakage (as defined in section II) is allowable.	
		d. Measure and record reverse-flow leakage of gas generator injector purge check valve.	25 scim maximum	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.35A	<u>EXHAUST SYSTEM LEAK TEST AT KSC</u>	Leak-test at 10 ±1 psig gaseous nitrogen or gaseous nitrogen and refrigerant, Type 12, the following system parts:		Perform this test prior to oxidizer dome and gas generator injector purge leak and function test, and after hydraulic system leak test and valve timing test.
		a. Measure and record leakage from the following seal monitoring port flanges:		CAUTION
		(1) Cas generator injector to combustor	10 scim maximum	The exhaust system must be pressurized from the LOX side and depressurized from an exhaust system port.
		(2) Gas generator combustor to turbine manifold inlet	10 scim maximum	
		(3) Turbine manifold outlet to heat exchanger inlet	10 scim maximum	
		(4) Heat exchanger outlet to thrust chamber hot-gas manifold	10 scim maximum	917
		b. All flanges, fittings, and instrumentation lines except as listed in steps c and d.	No leakage is allowable.	Leak-test compound must not be used on braided flex line bellows. Perform external leak test after completion of flange seal monitor port leak test and after installation and torquing of port plugs unless otherwise specified.
		c. Leak-test the following flanges with leakage-monitoring port plugs removed:		Utilize Turbine Exhaust Exit Pressure Check Fixture G3144 for pressurizing the exhaust system.
		(1) Cas generator injector to combustor	No leakage is allowable.	
		(2) (Deleted)		920

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.35A (cont)		(3) Turbine manifold outlet to heat exchanger inlet	Fuzz leakage (as defined in section II) is allowable.	
		(4) Heat exchanger outlet to hot-gas manifold	Fuzz leakage (as defined in section II) is allowable.	
		d. Leak-test the following flanges:		
		(1) Turbine manifold temperature transducer to turbine manifold instrumentation tap TG4a (on engines not incorporating MD176 change)	Fuzz leakage (as defined in section II) is allowable.	917
		(2) Cover plate to turbine manifold instrumentation tap TG4a (on engines incorporating MD176 change)	No leakage is allowable.	
		(3) Turbine outlet pressure transducer hose to heat exchanger instrumentation tap TG5c	Fuzz leakage (as defined in section II) is allowable.	
1.3.36 and 1.3.37	(Deleted)			

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.38	<u>TURBOPUMP BEARING COOLANT SYSTEM LEAK AND FUNCTION TEST</u>	a. Supply turbopump LOX seal purge to engine.	Purge must meet requirements of section II. No external leakage is allowable.	This test must be performed after the LOX pump seal purge leak and function test and fuel feed system leak test.
		b. Leak-test fittings and joints downstream of bearing coolant control valve at 10 ±1 psig gaseous nitrogen supply pressure.	No external leakage is allowable.	CAUTION Pressure in the drain system must not be allowed to exceed 15 psig since damage to drain line bellows can result. 902 The turbine exhaust system must be vented during performance of this activity. 902 If purge wrap-around line is not installed, decrease purge supply pressure by 5 psig. Leak-test compound must not be used on overboard drain line exit or braided flex line bellows. The engine valves vent system must be isolated from the overboard drain system during this test.
1.3.39	<u>THRUST CHAMBER PNEUMATIC LEAK TEST FOR UNINSTALLED ENGINES</u>	a. Leak-test at 30 (-0, -3) psig gaseous nitrogen or refrigerant, Type 12, the following components: (1) (Deleted)		Perform this test prior to LOX dome and gas generator LOX injector purge leak and function test and after the hydraulic control system leak test, engine valve timing test, ignition monitor valve diaphragm leak test, ignition monitor valve interflow test, hypergol manifold and igniter fuel valve leak and function test, ignition monitor valve shuttle pressure test, thrust OK pressure switch leak and function test, and heat exchanger LOX system leak test. 913
		(2) Measure and record leakage at the following quick-disconnects (a) No. 1 and No. 2 thrust chamber fuel inlet manifold drains (b) Ignition monitor valve drain (c) Hypergol manifold drain	3 scim maximum	CAUTION The thrust chamber must be pressurized from the LOX side and depressurized from the fuel or combustion zone side.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.39 (cont)		(d) No. 1 and No. 2 fuel valve quick-disconnects		
		(3) Flanges, fittings, joints, and thrust chamber tubes	No external leakage is allowable	Leak-test compound must not be used on braided flex line bellows.
		b. Measure and record reverse leakage of prefill check valve at 30 (+0, -3) psig gaseous nitrogen or refrigerant, Type 12.	50 scim maximum	Thrust Chamber Throat Plug G3136 and hypergol system test tool 9021279, or equivalent, from Hypergol System Tool Kit G3135 must be used for this test. 902 CAUTION Use extreme care when installing hypergol system test tool, to prevent damage to hypergol cartridge follower. • Make sure that threads of test tool cap are cleaned and free of nicks, to prevent galling threads of cap and inlet port.
		c. Measure and record reverse-flow leakage of LOX dome purge check valve at 30 (+0, -3) psig gaseous nitrogen or refrigerant, Type 12.	10 scim maximum	The heat exchanger LOX system must be blocked during this test. Thrust chamber protective cover and thrust chamber exit, oxidizer overboard drain line, and thrust chamber throat closures must be removed during this test. 913 CAUTION During removal and installation of No. 1 and No. 2 fuel inlet manifold quick-disconnect caps, the quick-disconnect body must not be allowed to turn since damage to the quick-disconnect body can result.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.40	<u>THRUST CHAMBER PNEUMATIC LEAK TEST FOR INSTALLED ENGINES AT MAF</u>	a. Leak-test at 30 (+0, -3) psig gaseous nitrogen or refrigerant, Type 12, the following components:		Perform this test prior to prefill system leak test and LOX dome and gas generator LOX injector purge leak and function test and after hydraulic control system leak test, engine valve timing test, ignition monitor valve diaphragm leak test, ignition monitor valve interflow test, hypergol manifold and igniter fuel valve leak and function test, ignition monitor valve shuttle pressure test, thrust OK pressure switch leak and function test, and heat exchanger LOX system leak test. 902 913
		(1) (Deleted)		
		(2) Measure and record leakage at the following quick-disconnects: (a) No. 1 and No. 2 thrust chamber fuel inlet manifold drains (b) Ignition monitor valve drain (c) Hypergol manifold drain (d) No. 1 and No. 2 fuel valve quick-disconnects	3 scim maximum	CAUTION The thrust chamber must be pressurized from the LOX side and depressurized from the fuel or combustion zone side.
		(3) Flanges, fittings, joints, and thrust chamber external tube surfaces	No external leakage is allowable.	Leak-test compound must not be used on braided flex line bellows.
		b. Measure and record reverse leakage of prefill check valve at 30 (+0, -3) psig gaseous nitrogen.	50 scim maximum	Thrust Chamber Throat Plug G3136 and hypergol system test tool 9021279, or equivalent, from Hypergol System Tool Kit G3135 must be used for this test. 902 CAUTION The hypergol system tool must be tested for proper operation prior to mounting on the hypergol assembly.
		c. Measure and record reverse-flow leakage of LOX dome purge check valve at 30 (+0, -3) psig gaseous nitrogen.	10 scim maximum	• Extreme care must be used when installing the hypergol system test tool, to prevent damage to the hypergol cartridge follower.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.40 (cont)				• Threads of the test tool cap must be clean and free of nicks, to prevent galling threads of the cap and inlet port. The heat exchanger LOX system must be blocked during this test. Thrust chamber protective cover and thrust chamber exit, oxidizer overboard drain line, and thrust chamber throat closures must be removed during this test. 913 CAUTION During removal and installation of No. 1 and No. 2 fuel inlet manifold quick-disconnect caps, the quick-disconnect body must not be allowed to turn since damage to the quick-disconnect body can result.
1.3.40A	<u>THRUST CHAMBER PNEUMATIC LEAK TEST FOR INSTALLED ENGINES AT KSC</u>	a. Leak-test at 30 (+0, -3) psig gaseous nitrogen, the following components: (1) (Deleted) (2) Measure and record leakage at the following quick-disconnects:	 3 scim maximum	Perform this test prior to prefill system leak test and LOX dome gas generator LOX injector purge leak and function test and after hydraulic control system leak test, engine valve timing test, ignition monitor valve diaphragm leak test, ignition monitor valve interflow test, hypergol manifold and igniter fuel valve leak and function test, ignition monitor valve shuttle pressure test, thrust 913

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.40A (cont)		(a) No. 1 and No. 2 thrust chamber fuel inlet manifold drains		OK pressure switch leak and function test, and heat exchanger LOX system leak test.
		(b) Ignition monitor valve drain		CAUTION The thrust chamber must be pressurized from the LOX side and depressurized from the fuel or combustion zone side.
		(c) Hypergol manifold drain		
		(d) No. 1 and No. 2 fuel valve quick-disconnects		
		(3) Flanges, fittings, joints, and thrust chamber external tube surfaces	No external leakage is allowable.	Leak-test compound must not be used on braided flex line bellows. Thrust Chamber Throat Plug G3136 and hypergol system test tool 9021279, or equivalent, from Hypergol System Tool Kit G3135 must be used for this test. 902 917 CAUTION The hypergol system tool must be tested for proper operation prior to mounting on the hypergol assembly. • Extreme care must be used when installing the hypergol system test tool, to prevent damage to the hypergol cartridge follower. • Threads of the test tool cap must be clean and free of nicks, to prevent galling threads of the cap and inlet port. The heat exchanger LOX system must be blocked during this test. Thrust chamber protective cover, thrust chamber exit, oxidizer overboard drain line, and thrust chamber throat closures must be removed during this test.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.40A (cont)		c. Leak-test at 10 ±1 psig gaseous nitrogen, internal tubes between throat plug and thrust chamber exit	No leakage is allowable.	913 914
				CAUTION During removal and installation of No. 1 and No. 2 fuel inlet manifold quick-disconnect caps, the quick-disconnect body must not be allowed to turn since damage to the quick-disconnect body can result.
1.3.40B	<u>THRUST CHAMBER PREFILL LINE LEAK AND FUNCTION TEST AT MTF</u>	Leak-test external thrust *chamber prefill system connections while pre-*filling thrust chamber with ethylene glycol solution.	*No prefill system external leakage is* allowable.	*Perform this test after hy-*draulic control system leak test, valve timing test, LOX feed system leak test, fuel feed system leak test, LOX dome and gas generator LOX injector purge leak and function test, and thrust chamber fuel jacket flush. When this test is not being performed in conjunction with admitting prefill to engine (paragraph 1.5.10), hydraulic supply pressure to control system is not required provided engine fuel feed system is pressurized or drain hoses are installed on No. 1 and No. 2 fuel high-pressure duct quick-disconnects. 900 909

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.40B (cont)				Low LOX dome and gas generator LOX injector purge must be on during filling and overflow operations of thrust chamber. 900 Thrust chamber protective cover and thrust chamber exit and throat closures must be removed during this test.
1.3.41	<u>THRUST CHAMBER PREFILL LINE LEAK AND FUNCTION TEST</u>	a. Perform external leak test of joints and fittings at 15 (-0, +5) psig gaseous nitrogen.	No external leakage is allowable.	Perform this test prior to LOX dome and gas generator LOX injector flush, if performed, and after thrust chamber pneumatic leak test.
		b. Verify purge flow. No purge flow requires isolation test of prefill check valve.	Audible flow from thrust chamber exit, or by feeling prefill supply line	A pressure of 40 ±5 psig gaseous nitrogen applied at the stage umbilical is acceptable to perform leak test and purge flow. Thrust chamber exit and throat closures must be removed during this test. Leak-test compound must not be used on braided flex line bellows.
1.3.41A	<u>IGNITION MONITOR VALVE POPPET POSITION VERIFICATION</u>	Verify by position switch indication, for a minimum of 3 minutes, that fuel valves remain closed when hydraulic control system is pressurized to 1,500 ±50 psig, zero pressure is applied at ignition monitor valve CONTROL port, and engine control valve start solenoid is energized.	Fuel valve closed position switches must remain on. Fuel valve open position switches must not come on.	Perform this test subsequent to last application of gaseous nitrogen to ignition monitor valve CONTROL port and prior to static test or start of launch countdown. The operational low-level LOX dome and gas generator LOX injector purge must be on if test is performed subsequent to LOX dome and gas generator LOX injector flush. Purge must meet requirements of section II. 903 CAUTION *The hypergol manifold* assembly cam rod must not be depressed during this test.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.42	<u>THRUST CHAMBER LIQUID LEAK TEST</u>	Leak-test internal and external thrust chamber surfaces with trichloro-ethylene or ethylene glycol solutions.	No thrust chamber internal or external liquid leakage is allowable.	Perform this test prior to thrust chamber injector visual inspections, and thrust chamber post-flush leak test and after hydraulic control system leak test, valve timing test, LOX feed system leak test, fuel feed system leak test, and LOX dome and gas generator LOX injector purge leak and function test. This requirement may be accomplished during performance of thrust chamber fuel jacket flush or admitting prefill to thrust chamber. Hydraulic control system pressure of 1,550 ±50 psig must be applied or drain lines connected to fuel high-pressure duct quick-disconnects, or the engine fuel propellant feed system pressurized to 2 psig minimum. 909 Thrust chamber protective cover and thrust chamber exit and throat closures must be removed during this test. Drain hoses must be installed on No. 1 and No. 2 fuel high-pressure duct drain quick-disconnects and monitored for leakage if fuel feed system is not pressurized during performance of this activity. 902

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.43	<u>THRUST CHAMBER POST-FLUSH PNEUMATIC LEAK TEST AT KSC</u>	Perform external leak test at 9 ±1 psig gaseous nitrogen of all thrust chamber system joints invalidated during accomplishment of LOX dome and gas generator LOX injector flush and thrust chamber fuel jacket flush, except the thrust chamber fuel inlet manifold drain quick disconnects and the one LOX system joint used for accomplishing this test.	No external leakage is allowable.	Perform this test prior to thrust chamber injector visual inspection and after LOX dome and gas generator LOX injector flush, thrust chamber fuel jacket flush, heat exchanger LOX system leak test, and thrust chamber liquid leak test. CAUTION The thrust chamber must be pressurized from the LOX side and depressurized from the fuel or combustion zone side. Thrust Chamber Throat Plug G3136 and hypergol system test tool 9021279, or equivalent, from Hypergol System Tool Kit G3135 must be used for this test. CAUTION The hypergol system tool must be tested for proper operation prior to mounting on the hypergol assembly. • Extreme care must be used when installing the hypergol system test tool, to prevent damage to the hypergol cartridge follower. • Threads of the test tool cap must be clean and free of nicks, to prevent galling threads of the cap and inlet port. The heat exchanger LOX system must be blocked during this test. The oxidizer overboard drain line, and thrust chamber throat closures must be removed during this test.

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Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1. .	STORAGE PREPARATION			
1.4.1	STORAGE PREPARATION FOR UNINSTALLED ENGINES	a. Visually verify that all exposed and accessible portions of engine are not damaged.	Damage within limits of figure 1-3	
		b. Coat all machined areas of thrust chamber outrigger arms, turbopump mounts, and inside and outside diameter of engine handler bearing with corrosion preventative.		
		c. Repaint all turbopump and outrigger arm surfaces that contain scratches.		
		d. Remove any corrosion from gas generator feed line gimbal joint yokes; then coat yokes with corrosion preventative.		
		e. Remove any corrosion from gas generator fuel and oxidizer feed line bellows.		
		f. Verify or install 425 aluminum-foil tape (Minnesota Mining and Mfg) over space between thrust chamber exhaust manifold and thrust chamber tubes, and white sealant RTV-102 (General Electric) between thrust chamber tubes and bands.		White sealant is only required on engines where sealant was installed during engine manufacture.
		g. Replace or install any broken lockwire, and plug any open engine taps.		
		h. Refill any void in turbopump housing cavity material.		
		i. Determine if turbopump requires re-preservation; re-preserve turbopump (if required) and enter date in Engine Log Book.	Refer to section II for re-preservation limits.	Refer to Engine Log Book for date of last turbopump preservation.
		j. Verify that LOX pump and fuel inlet closures are installed and that desiccant in closures is as specified in section II.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks	
1.4.1 (cont)		k. Verify that thrust chamber throat security closure is installed and that desiccant in closure is as specified in section II.			921 930
		l. Install Gimbal Bearing Locks G4059.			910
		lA. Visually verify that oxidizer overboard drain and nitrogen purge overboard drain line exits are free of fluid.	Residual fluid is not allowable.		
	Change see Sup. No. 69	lB. Install protective closures on oxidizer overboard drain and nitrogen purge overboard drain line exits, hypergol container, and electrical connectors. All other covers and closures except as noted in this step and in steps j and k are to be removed including the gimbal bearing boot and the fuel overboard drain line exit.			930 910
		lC. Install suitable drainage line on fuel overboard drain line exit, and route line exit so that leakage flows externally from engine.			
		m. Install engine on Air Transport Engine Handler G4044, Engine Handler G4069, or Engine Handling Dolly G4058, or equivalent.		Do not store engine in a position where LOX pump elevation is below fuel pump elevation by more than 7 degrees.	
		n. Cover engine with engine cover G4047, or equivalent, except when engines are stored in accordance with MSFC-STD-500, then install covers in accordance with MSFC-STD-500.			930
		o. Store engine in an environmentally controlled area meeting criteria specified in section II or Standard S-IC Stage Storage Specification MSFC-STD-500, as applicable.			
1.4.2	<u>STORAGE PREPARATION FOR INSTALLED ENGINES</u>	a. Visually verify that all exposed and accessible portions of engine are not damaged.	Damage within limits of figure 1-3		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.4.2 (cont)		b. Coat all exposed machined areas of thrust chamber outrigger arms, turbopump mounts, and inside and outside diameter of engine handler bearing with corrosion preventative.		
		c. Repaint all turbopump and outrigger arm surfaces that contain scratches through paint.		
		d. Remove any corrosion from gas generator feed line gimbal joint yokes; then coat yokes with corrosion preventative.		
		e. Remove any corrosion from gas generator fuel and oxidizer feed line bellows.		
		f. Verify or install 425 aluminum-foil tape (Minnesota Mining and Mfg) over space between thrust chamber exhaust manifold and thrust chamber tubes and thrust chamber, and white sealant RTV-102 (General Electric) between thrust chamber tubes and bands.		White sealant is only required on those engines in which sealant was installed during engine manufacture.
		g. Replace or install any broken lockwire, and plug any open engine taps.		
		h. Refill any voids in turbopump housing cavity filler material.		
		i. Determine if turbopump requires re-preservation; re-preserve turbopump, if required, and enter date in Engine Log Book.	Refer to Section II for re-preservation limits.	Refer to Engine Log Book for date of last turbopump preservation.
		j. Install desiccant in thrust chamber throat closure as specified in section II.		

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Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.4.2 (cont)		k. Install thrust chamber throat security closure.		
		l. (Deleted)		
		m. Visually verify that oxidizer overboard drain and nitrogen purge overboard drain line exits are free of fluid.	Fluid is not allowable.	
		mA. For engines installed in a horizontal stage, perform the following:		
	Change See ECN No. 69	(1) Install protective closures on oxidizer overboard drain, fuel overboard drain and nitrogen purge overboard drain line exits, hypergol container, and igniter harness electrical connectors. All other covers and closures except as noted in this step and in step k are to be removed, including the gimbal bearing boot.		
		(2) Remove and replace fuel overboard drain system bags with drain hoses, and route hoses so that leakage flows externally from engine.		
	Change See ECN No. 69	mB. For engines stored in a vertical stage, install protective closures on oxidizer purge overboard drain line and nitrogen purge overboard drain line exits, hypergol container, and igniter harness electrical connectors. All other closures except as noted in this step and in step k are to be removed, including the gimbal bearing boot and fuel overboard drain line exit. Install suitable drainage line on fuel overboard drain line exit, and route line exit so that leakage flows externally from engine.		

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Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.4.2 (cont)		n. Lock engine to stage attachment gimbal actuators to prevent engine movement.		Do not lock actuators in positions that will cause LOX pump elevation to be below fuel pump elevation by more than 7 degrees.
		o. Store stage in an environmentally controlled area as specified in section II or Standard S-IC Stage Storage Specification MSFC-STD-500, as applicable.		
1.4.3	<u>STORAGE PREPARATION FOR THRUST CHAMBER NOZZLE EXTENSION</u>	a. Visually verify that all exposed surfaces of nozzle extension are not damaged.	Damage within limits of figure 1-3	Nozzle extensions 209210, 209210-11, and 209210-21 may be stacked three high on pallets with support provided between pallets. Nozzle extension 209210-31 must be stored singularly or as the top unit on a stack.
		b. Install plugs in igniter bosses.		
		c. Install nozzle extension on Nozzle Extension Handling Fixture G4080 and Nozzle Extension Handling Adapter G4081, or shipping container RK392-40013-11, for horizontal storage, or on a pallet for vertical storage.		**CAUTION** Before installing the nozzle extension on the pallet, the pallet must be pre-positioned in the storage area. Damage can result if the nozzle extension is moved while resting on the pallet. • The nozzle extension must be cushioned on the pallet with a layer of Ethafoam (Dow Chemical Corp), or equivalent, to prevent damage to the nozzle extension area that contacts the pallet.
		d. Cover nozzle extension attach flange to auxiliary shingle area with Ethafoam (Dow Chemical Corp), or equivalent, secured with pressure-sensitive tape RB0195-002 (Rocketdyne), or equivalent.		
		e. Enclose nozzle extension with a suitable waterproof cover.		Ventilation should be provided in the covers to prevent condensation of moisture in the enclosure.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.4.4	<u>STORAGE PREPARATION FOR ORDNANCE</u>	Prepare and store ordnance as specified in section II.		
1.4.5	<u>STORAGE PREPARATION FOR MISCELLANEOUS LOOSE EQUIPMENT</u>	a. Verify that equipment is not damaged. b. Install plugs in all open ports and closures on all flange sealing surfaces. c. Store equipment in an environmentally controlled area as specified in section II.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5	SERVICING			Unless otherwise specified, servicing requirements must be performed after completion of engine inspections, electrical tests, and leak and function tests.
1.5.1	LOX DOME AND GAS GENERATOR LOX INJECTOR FLUSH	a. Install Oxidizer Dome Flushing Kit G2030 as specified in section II.		Perform prior to thrust chamber injector contamination inspection and after LOX dome and gas generator LOX injector purge leak and function test, thrust chamber prefill system leak and function test, heat exchanger LOX system leak and function test, and last opening actuation of gas generator ball, fuel, and oxidizer valves with LOX dome and gas generator LOX injector purge off.
		b. Clean mating threads of hypergol test tool and hypergol container with drycleaning solvent (Federal Specification P-D-680). Lubricate bore of container with FS1281 grease (Dow Corning Corp), and install hypergol system test tool. Aline hole in test tool cap with hole in container and secure with pin.		
		c. Verify that any test instrumentation lines that could trap trichloroethylene during flush are disconnected and the ports capped off.		Thrust chamber throat and exit closures and overboard drain line closures must be removed during this operation. Heat exchanger check valve must be removed or GOX return line must be pressurized a minimum of 4 psig during this operation.
		d. Connect a pneumatic system to hypergol manifold purge quick-disconnect.	Purge must meet requirements of section II.	When performing this operation with the environmental cover installed, the rope that secures the exit end of the cover must be untied and the end of the cover turned up and secured to prevent trichloroethylene from accumulating in the cover. At the completion of the operation, the cover must be lowered and secured.
		e. Connect a pneumatic system to fuel jacket purge quick-disconnect on each fuel valve.	Purge must meet requirements of section II.	
		f. Pressurize flushing kit pneumatic system.	175 ±25 psig	Engine must be in a null position and the stage in the vertical position during this operation.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.1 (cont)		g. Pressurize hypergol purge.	150 ±50 psig	In steps requiring hose coupling torque in excess of torque required for unions, unions must be held to avoid overtorquing or possible twisting of hose. Steps in Requirements column must be performed in sequence listed.
		h. Pressurize fuel jacket purge.	300 ±100 psig	
		i. Pressurize flushing kit trichloroethylene system, and flush thrust chamber LOX dome and gas generator LOX injector cavity.	Flush for a minimum of 30 seconds at 90 ±10 psig.	
		j. Wait a minimum of 2 minutes after turning off flushing system; then depressurize pneumatic systems in the following order: (1) Fuel jacket purge (2) Hypergol purge (3) Flushing kit		
		k. Disconnect trichloroethylene system from flushing kit, and reinstall cap on quick-disconnect.		
		l. Pressurize purges in the following order, and allow flow to continue for a minimum of 5 minutes and until all vapors are expelled from thrust chamber exit: (1) Flushing kit (2) Hypergol purge (3) Fuel jacket purge		
		m. When all vapors are expelled from thrust chamber and 5-minute purge is completed, depressurize purges in the following order: (1) Fuel jacket purge (2) Hypergol purge (3) Flushing kit		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.1 (cont)		n. Remove plug from gas generator combustion drain port, and drain residual trichloroethylene; then reinstall plug in combustor using a new seal. Record actual plug torque value, and safetywire plug.		**CAUTION** If drain plug is left uninstalled at completion of drain, the resultant hot-gas leakage from the open port during subsequent engine operation could cause extensive engine damage and/or launch abort.
		o. Disconnect flush kit from LOX dome purge ports and from gas generator LOX injector purge ports. Do not plug LOX dome ports.		
		p. Reinstall gas generator purge check valve and line.		
		q. Turn on operational high-level LOX dome and gas generator LOX injector purge.	Purge must meet requirements of section II.	When operational low-level LOX dome and gas generator LOX injector purge is used, purge must flow for a minimum of 15 minutes. 915
		r. Pressurize purges in the following order, and allow flow to continue for a minimum of 5 minutes and until all vapors are expelled from thrust chamber exit:		
		(1) Flushing kit	175 ±25 psig	
		(2) Hypergol purge	150 ±50 psig	
		(3) Fuel jacket purge	300 ±100 psig	
		s. Leak-test gas generator purge check valve joint.	No external leakage is allowable.	
		t. When all vapors are expelled from thrust chamber and 5-minute purge is complete, depressurize purges in the following order:		
		(1) Hypergol purge		
		(2) Fuel jacket purge		
		(3) Flushing kit		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.1 (cont)		u. Turn off operational high-level LOX dome and gas generator LOX injector purge.		CAUTION The LOX dome and gas generator LOX injector purge must not be depressurized until the flushing kit purge indicates zero, since contamination of the LOX dome will occur.
		v. Disconnect the following pneumatic systems, and install caps on quick-disconnects: (1) Hypergol purge (2) Fuel jacket purge (3) Flushing kit		
		w. Reinstall heat exchanger check valve, if removed.		
		x. Disconnect flushing kit from engine, plug all open ports using new seals, then torque and safety-wire all plugs.		
		y. Remove hypergol system test tool, and reinstall hypergol container closure plug. Aline closure plug hole with container hole, and secure with pin.		
1.5.1A	<u>LOX DOME FLUSH</u>	a. Install Oxidizer Dome Flushing Kit G2030 as specified in section II, except do not connect gas generator purge and flush lines. Secure gas generator purge and flush lines to prevent movement, uncap lines, and position ends of lines to point into an area free of personnel and equipment.		Perform prior to thrust chamber injector contamination inspection and thrust chamber post-flush pneumatic leak test and after LOX dome and gas generator LOX injector purge leak and function test, thrust chamber prefill system leak and function test, heat exchanger LOX system leak and function test, and last opening actuation of

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.1A (cont)		b. Clean mating threads of hypergol test tool and hypergol container with dry-cleaning solvent (Federal Specification P-D-680). Lubricate bore of container with FS1281 grease (Dow Corning Corp), and install hypergol system test tool. Aline hole in test tool cap with hole in container and secure with pin.		fuel and oxidizer valves with LOX dome and gas generator LOX injector purge off. **CAUTION** Gaseous nitrogen and trichloroethylene will emit from the exits of the gas generator purge and flush lines during performance of this activity.
		c. Verify that any test instrumentation lines that could trap trichloroethylene during flush are disconnected and ports capped off.		Thrust chamber throat and exit closures and overboard drain line closures must be removed during this operation.
		d. Connect a pneumatic system to hypergol manifold purge quick-disconnect.	Purge must meet requirements of section II.	Heat exchanger check valve must be removed or GOX return line must be pressurized a minimum of 4 psig during this operation.
		e. Connect a pneumatic system to fuel jacket purge quick-disconnect on each fuel valve.	Purge must meet requirements of section II.	When performing this activity with environmental cover installed, rope that secures exit end of cover must be untied and end of cover turned up and secured to prevent trichloroethylene from accumulating in cover. At completion of activity, cover must be lowered and secured.
		f. Pressurize flushing kit pneumatic system.	175 ±25 psig	
		g. Pressurize hypergol purge.	150 ±50 psig	
		h. Pressurize fuel jacket purge.	300 ±100 psig	
		i. Pressurize flushing kit trichloroethylene system, and flush thrust chamber LOX dome and gas generator LOX injector cavity.	Flush for a minimum of 30 seconds at 90 ±10 psig.	Engine must be in a null position and stage in vertical position during this activity.
		j. Wait a minimum of 2 minutes after turning off flushing system; then depressurize pneumatic systems in the following order:		In steps requiring hose coupling torque in excess of torque required for unions, unions must be held to avoid overtorquing or possible twisting of hose.
		(1) Fuel jacket purge		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.1A (cont)		(2) Hypergol purge (3) Flushing kit		Steps in Requirements column must be performed in sequence listed.
		k. Disconnect trichloroethylene system from flushing kit, and reinstall cap on quick-disconnect.		
		l. Pressurize purges in the following order, and allow flow to continue for a minimum of 5 minutes and until all vapors are expelled from thrust chamber exit: (1) Flushing kit (2) Hypergol purge (3) Fuel jacket purge		
		m. When all vapors are expelled from thrust chamber and 5-minute purge is completed, depressurize purges in the following order: (1) Fuel jacket purge (2) Hypergol purge (3) Flushing kit		
		n. Disconnect flush kit from LOX dome purge ports. Do not plug LOX dome ports.		
		o. Turn on operational high-level LOX dome and gas generator LOX injector purge.	Purge must meet requirements of section II.	When operational low-level LOX dome and gas generator LOX injector purge is used, purge must flow for a minimum of 15 minutes. 915
		p. Pressurize purges in the following order, and allow flow to continue for a minimum of 5 minutes and until all vapors are expelled from thrust chamber exit: (1) (Deleted)		902

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.1A (cont)		(2) Hypergol purge	150 ±50 psig	
		(3) Fuel jacket purge	300 ±100 psig	
		q. When all vapors are expelled from thrust chamber and 5-minute purge is complete, depressurize purges in the following order:		
		(1) Hypergol purge		
		(2) Fuel jacket purge		
		(3) (Deleted)		
		r. Turn off operational high-level LOX dome and gas generator LOX injector purge.		
		s. Disconnect the following pneumatic systems, and install caps on quick-disconnects:		
		(1) Hypergol purge		
		(2) Fuel jacket purge		
		(3) Flushing kit		
		t. Reinstall heat exchanger check valve, if removed.		
		u. Disconnect flushing kit from engine, plug all open ports using new seals, then torque and safetywire all plugs.		
		v. Remove hypergol system test tool, and reinstall hypergol container closure plug. Aline closure plug hole with container hole, and secure with pin.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.1B	GAS GENERATOR LOX INJECTOR FLUSH	a. Install Oxidizer Dome Flushing Kit G2030 as specified in section II, except do not connect LOX dome purge and flush lines. Secure LOX dome purge and flush lines to prevent movement, uncap lines, and position ends of lines to point into an area free of personnel and equipment.		Perform after LOX dome and gas generator LOX injector purge leak and function test, and last opening actuation of gas generator ball valve with LOX dome and gas generator LOX injector purge off.
		b. Verify that any test instrumentation lines that could trap trichloroethylene during flush are disconnected and ports capped off.		CAUTION Gaseous nitrogen and trichloroethylene will emit from the exits of the LOX dome purge and flush lines during performance of this activity.
		c. Pressurize flushing kit pneumatic system.	175 -25 psig	
		d. Pressurize flushing kit trichloroethylene system, and flush gas generator LOX injector cavity.	Flush for a minimum of 30 seconds at 90 -10 psig.	Thrust chamber exit closures and overboard drain line closures must be removed during this activity.
		e. Wait a minimum of 2 minutes after turning off flushing system; then depressurize flushing kit pneumatic systems.		When performing this activity with environmental cover installed, rope that secures exit end of cover must be untied and end of cover turned up and secured to prevent trichloroethylene from accumulating in cover. At completion of operation, cover must be lowered and secured.
		f. Disconnect trichloroethylene system from flushing kit, and reinstall cap on quick-disconnect.		
		g. Pressurize flushing kit pneumatic system, and allow flow to continue for a minimum of 5 minutes and until all vapors are expelled from thrust chamber exit.	175 -25 psig	Engine must be in a null position and stage in vertical position during this activity.
		h. When all vapors are expelled from thrust chamber and 5-minute purge is completed, depressurize flushing kit pneumatic system.		In steps requiring hose coupling torque in excess of torque required for unions, unions must be held to avoid overtorquing or possible twisting of hose. Steps in Requirements column must be performed in sequence listed.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.1B (cont)		i. Remove plug from gas generator combustion drain port, verify presence of trichloroethylene, and drain residual trichloroethylene: then reinstall plug in combustor using a new seal. Record actual plug torque value, and safetywire plug.		CAUTION If drain plug is left uninstalled at completion of drain, the resultant hot-gas leakage from the open port during subsequent engine operation could cause extensive engine damage and/or launch abort.
		j. Disconnect flush kit from gas generator LOX injector purge ports.		
		k. Reinstall gas generator purge check valve and line.		
		l. Turn on operational high-level LOX dome and gas generator LOX injector purge.	Purge must meet requirements of section II.	When operational low-level LOX dome and gas generator LOX injector purge is used, purge must flow for a minimum of 15 minutes. 915
		m. Pressurize flushing kit pneumatic system, and allow flow to continue for a minimum of 5 minutes and until all vapors are expelled from thrust chamber exit.	175 ±25 psig	
		n. Leak-test gas generator purge check valve joint.	No external leakage is allowable.	
		o. When all vapors are expelled from thrust chamber exit and 5-minute purge is complete, depressurize flushing kit pneumatic system.		
		p. Turn off operational high-level LOX dome and gas generator LOX injector purge.		
		q. Disconnect flushing kit pneumatic system, and install cap on quick-disconnect.		
		r. Disconnect flushing kit from engine, plug all open ports using new seals, then torque and safetywire all plugs.		
1.5.2	(Deleted)			
1.5.3	<u>THRUST CHAMBER FUEL JACKET FLUSH</u>	a. Turn on operational low-level LOX dome and gas generator LOX purge.	Purge must meet requirements of section II.	Perform prior to thrust chamber injector contamination and damage inspections and after engine residual fuel drainage, LOX dome and gas generator

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.3 (cont)				LOX injector purge leak and function test, and thrust chamber prefill system leak test. Stage must be in vertical position and engines nulled. Hydraulic control system pressure of 1,550 ±50 psig must be applied and drain lines connected to fuel high-pressure duct quick-disconnects, or engine fuel propellant feed system pressurized to 2.5 psig minimum.
		b. Fill thrust chamber fuel jacket with trichloroethylene to injector overflow.	Overflow must continue for a minimum of 30 seconds. Trichloroethylene system must meet requirements of section II.	Fill thrust chamber fuel jacket with trichloroethylene through No. 1 and No. 2 fuel inlet manifold quick-disconnects. When performing this operation with the environmental cover installed, the rope that secures the exit end of the cover must be untied and the end of the cover turned up and secured to prevent trichloroethylene from accumulating in the cover. At the completion of the operation, the cover must be lowered and secured. CAUTION During removal and installation of the No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnect cap, the quick-disconnect body must not be allowed to turn, or damage to the quick-disconnect body can result.
		c. (Deleted)		Requirements must be performed in sequence listed. 902
		d. Pressurize fuel jacket purge system. Allow purges to flow until all heavy vapors cease to emit from thrust chamber exit.	Purge must meet requirements of section II.	902

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.3 (cont)		e. Depressurize fuel jacket purge system.		902
		f. Repeat steps b through e two additional times.		
		g. Fill thrust chamber fuel jacket with trichloroethylene to injector overflow, and allow overflow to continue for a minimum of 5 seconds.	Trichloroethylene system must meet requirements of section II.	
		h. Disconnect trichloroethylene system, and attach drain hose to each thrust chamber fuel inlet manifold quick-disconnect.		
		i. Turn off operational low-level LOX dome and gas generator LOX injector purge.		
		j. Inspect thrust chamber tubes for liquid leakage.	No liquid leakage is allowable.	
		k. Install drain tools from Fuel Drainage Kit G2037 and drain hose on thrust chamber exit manifold drain plugs; then open drain plugs.		When performing this activity subsequent to a static test or an abort, elapsed time between start of step b and start of step k must exceed one hour. 902
		l. Turn on operational low-level LOX dome and gas generator LOX injector purge.	Purge must meet requirements of section II.	
		m. Pressurize fuel jacket purge system. Allow purge to flow for a minimum of 3 minutes and until vapors cease to be emitted from thrust chamber.	Purge must meet requirements of section II.	
		n. Depressurize fuel jacket purge system.		
		o. Turn off operational low-level LOX dome and gas generator LOX injector purge.		902

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.3 (cont)		p. Remove drain hoses, and install all removed quick-disconnect caps.		
		q. Remove drain tools, and install thrust chamber exit manifold drain plugs, using new seals. Torque and safetywire plugs.		
		r. Attach a drain hose to the ignition monitor valve control port quick-disconnect and allow residual fluid to drain.		935
		s. Remove ignition monitor valve control port drain hose and reinstall and torque quick-disconnect cap.		
1.5.4	(Deleted)			
1.5.5	<u>ENGINE RESIDUAL FLUID REMOVAL AT MTF</u>	a. Remove section of thermal insulation that covers turbine manifold access cover, and remove access cover from water shield.		Perform prior to admitting LOX to engine and any time fluids are noted. 902
		b. If present, remove residual fluid from turbine manifold diaphragm, using a suction pump.		
		c. Reinstall access cover and thermal insulation covering access cover.		
		d. Remove residual fluid from top surfaces of thrust chamber LOX dome, using a suction pump.		
1.5.5A	<u>ENGINE RESIDUAL FLUID REMOVAL AT KSC</u>	Remove residual fluid from top surface of thrust chamber LOX dome.		Perform prior to admitting LOX to engine and any time fluids are noted. If engine is to be removed from stage or stage is to be recycled through VAB, remove residual fluid from turbine manifold diaphragm using a suction pump. 902
1.5.6 through 1.5.8	(Deleted)			

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.9	ADMITTING FUEL TO ENGINE	a. Verify that prefill from thrust chamber fuel inlet manifold has been drained and that drain hoses are attached to No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnects.		Perform prior to admitting LOX to engine and after LOX dome and gas generator LOX injector flush, thrust chamber fuel jacket flush, and admitting prefill to engine.
		b. (Deleted)		CAUTION
		c. Remove gas generator drain plug.		During removal and installation of No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnect caps, the quick-disconnect body must not be allowed to turn, since damage to the quick-disconnect body can result.
		d. Admit fuel to engine.	Fuel must meet requirements of section II.	While draining fluid, care must be used to prevent spilling fluid on other engine systems.
		e. Inspect for fuel leakage from fuel inlet manifold drain hoses after fuel is admitted to engine. Record volume of fluid leakage. Repeat inspection every 24 hours as long as drain hoses are installed. Leave drain hoses installed until last time access to engine area is available.	500 cc m maximum from each drain hose	After removing hydraulic pressure from engines which have the thrust chambers filled with prefill fluid and drain hoses installed on the fuel inlet manifold drain quick-disconnects, reprime the thrust chamber fuel inlet manifold with prefill fluid until overflow is noted from each drain line, if 8 hours will elapse before reapplying hydraulic pressure to the engine. Check overflow for fuel. If fuel valve leakage occurred without hydraulics applied to the engine, all fluid must be drained from the thrust chamber fuel inlet manifold, with the engine in the null position, before gimbaling.
		f. If no fuel leakage occurs, omit steps g through l and proceed to step m.		
		g. If fuel leakage occurs, apply hydraulic control system pressure (within limits of section III) and allow all fluid to drain from fuel inlet manifold. Monitor drain hoses for fuel leakage for one hour minimum.	No leakage is allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.9 (cont)		h. If no fuel leakage occurs in step g, omit steps i through l, turn off hydraulic supply pressure to engine, and proceed to step m.		
		i. If leakage is observed in step g, perform thrust chamber fuel jacket drain and thrust chamber fuel jacket flush and admit prefill to engine; then proceed to step j.		Turn on and maintain operational low-level LOX dome and gas generator LOX injector purge when removing or applying hydraulic control system pressure after admitting prefill. Hydraulic control system pressure is not required during thrust chamber fuel jacket flush if fuel is drained from engine, if engine is in null position, and if drain lines are connected to fuel high-pressure duct quick-disconnects or engine fuel propellant feed system is pressurized to 2 psig minimum.
		j. Drain prefill fluid from thrust chamber fuel inlet manifold after a minimum of 1.5 hours with fuel in engine.	1.5 hours	CAUTION During removal and installation of No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnect caps, the quick-disconnect body must not be allowed to turn, since damage to the quick-disconnect body can result. While draining fluid, care must be used to prevent spilling fluid on other engine systems.
		k. Visually verify that no fuel leakage exists in drained prefill solution.	No fuel is allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1 5.9 (cont)		l. When it is verified that no fuel leakage exists in drained prefill solution, turn off hydraulic supply pressure to engine.		Turn on and maintain operational low-level LOX dome and gas generator LOX injector purge when removing or applying hydraulic control system pressure after admitting prefill. Apply and remove hydraulic control system pressure as required. Maintain hydraulic control system pressure during and after admitting LOX to engine.
		m. Inspect for fuel leakage from gas generator combustor drain port after fuel is admitted to engine. Repeat inspection every 24 hours for as long as combustor drain plug is removed. Leave drain plug uninstalled until last time access to engine area is available.	No leakage is allowable.	
		mA. Visually monitor fuel systems for external leakage.	No leakage is allowable.	
		n. Monitor nitrogen purge overboard drain line at thrust chamber exit, for fuel leakage	No leakage is allowable.	
		o. Monitor fuel overboard drain line at thrust chamber exit, for fuel leakage. Leakage in excess of that recorded during hydraulic control system leak and function test requires isolation of overboard drain system components. Maximum allowable component leakage into overboard drain system is as follows:		
		(1) Redundant shutdown valve	2 cc m fuel leakage maximum from drain port	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.9 (cont)		(2) Ignition monitor valve	5 cc m fuel leakage maximum from drain port	
		(3) Engine control valve	5 cc/m fuel leakage maximum from override drain port	
		p. Remove drain hoses and install pressure-caps on No. 1 and No. 2 thrust chamber fuel inlet manifold drain quick-disconnects.		Perform requirement after final application of hydraulic control system pressure for engine operation if fuel leakage occurs without hydraulic pressure applied to engine.
		q. Install drain plug using a new seal in gas generator combustor drain port. Record actual torque, and safetywire plug.		CAUTION If the drain plug is left uninstalled, the resultant hot-gas leakage from the open port during subsequent engine operation could cause extensive engine damage and/or abort.
		r. Admit prefill to engine to injector overflow. Visually verify overflow.	Prefill overflow from injector.	Engines must not be gimbaled greater than 2 degrees when prefill solution is in thrust chamber fuel inlet manifold.
		s. Subsequent to final engine gimbaling, top-off prefill to injector overflow.		
1.5.10	<u>ADMITTING PREFILL TO ENGINE</u>	a. (Deleted)		Perform prior to admitting fuel and LOX to engine and after LOX dome and gas generator LOX injector flush, and last opening actuation of engine propellant valves. Drain lines must be connected to fuel high-pressure duct quick-disconnects, or engine fuel propellant feed system must be pressurized to 2 psig minimum during performance of this activity.

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Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks	
1.5.10 (cont)				If engine environmental cover is installed, exit end of cover must be untied, turned up, and secured.	
		b. Turn on operational low-level LOX dome and gas generator LOX injector purge.	Purge must meet requirements of section II.		902
		c. Admit prefill fluid to thrust chamber fuel jacket until injector overflows.	Prefill fluid must meet requirements of section II.		
		d. Turn off operational low-level LOX dome and gas generator LOX injector purge after injector overflow stops.		If engine is to be gimbaled after prefilling thrust chamber fuel jacket, turn on operational low-level LOX dome and gas generator LOX injector purge during gimbaling operation, and top-off thrust chamber fuel jacket with prefill fluid to injector overflow after completion of the last gimbaling operation.	902
		e. Monitor prefill fluid leakage from fuel overboard drain line.	No prefill fluid leakage is allowable.		902
				Prefill fluid may be retained in thrust chamber fuel jacket for a maximum period of 4 months.	903
1.5.11	(Deleted)				
1.5.12	<u>ADMITTING LOX TO ENGINE AT MTF</u>	a. Verify that hydraulic control system pressure is applied to engine.	Pressure must meet requirements of section II.	Perform after admitting fuel and thrust chamber prefill to engine and after all pre-static checkouts. Maintain hydraulic control system pressure during and after admitting LOX to engine.	
		b. Verify that hydraulic temperature is within limits of section II.			
		c. Verify that turbopump LOX seal purge is within limits of section II.			
		d. Make sure that turbopump heater power is on.			
		e. Verify that oxidizer valves and gas generator ball valve indicate closed.		Continuously monitor oxidizer valves and gas generator ball valve closed position indications before, during, and after admitting LOX to engine.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.12 (cont)		f. Admit LOX to engine propellant feed system.	LOX must meet requirements of section II.	
		g. Verify turbopump bearing temperature.	Bearing temperature must meet requirements of section II.	
		h. Monitor oxidizer overboard drain line and thrust chamber exit for LOX leakage.	No leakage is allowable.	
		i. Visually inspect LOX propellant feed system for external leakage.	No leakage is allowable.	
		j. Remove gas generator drain plug and inspect for LOX leakage past gas generator ball valve; then reinstall and torque plug. Record actual torque value.	No leakage is allowable.	CAUTION If the plug is not installed at completion of the inspection, the resultant hot gas leakage from the open port during subsequent engine operation could cause extensive engine damage and static test abort.
1.5.13	ADMITTING LOX TO ENGINE AT KSC	a. Remove engine environmental cover.		Perform after admitting fuel and thrust chamber prefill and after all operations requiring engine access to launch pad.
		b. Verify that hydraulic control system pressure is applied to engine.	Pressure must meet requirements of section II.	
		c. Verify that hydraulic temperature is within limits specified in section II.		Maintain hydraulic control system pressure during and after admitting LOX to engine.
		d. Verify that turbopump LOX seal purge is within limits of section II.		
		e. Make sure that turbopump heater power is on.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.13 (cont)		f. Verify that oxidizer valves and gas generator ball valve indicate closed.		Continuously monitor oxidizer valves and gas generator ball valve closed position indications before, during, and after admitting LOX to engine.
		g. Admit LOX to engine.	LOX must meet requirements of section II.	
		h. Verify turbopump bearing temperature.	Bearing temperature must meet requirements of section II.	
		i. Monitor engine ambient temperature within cocoon.	Maintain temperature within limits of section II.	
		j. Monitor oxidizer overboard drain line for LOX leakage.	No liquid leakage is allowable.	
		k. Monitor thrust chamber exit for LOX leakage.	No leakage is allowable.	
1.5.14	<u>LOX FEED SYSTEM BOILOFF AT MTF</u>	a. Verify that turbopump heaters are on at all times when LOX is in engine and that turbopump bearing temperature is within limits of section II.	Bearing temperature must meet requirements of section II.	WARNING The LOX tank vent system must not be closed with LOX in the engine, since injury to personnel and damage to the engine and stage can result from pressure buildup.
		b. Verify that hydraulic control system pressure is applied to engine.	Pressure must meet requirements of section II.	
		c. Verify that hydraulic temperature is within limits of section II.		
		d. Verify that oxidizer valves and gas generator ball valve indicate closed.		
		dA. Monitor the thrust chamber exit for LOX/GOX leakage (liquid droplets and/or GOX vapors).	No LOX/GOX leakage is allowable.	
		e. Verify that turbopump LOX seal purge is on.	Purge must meet requirements of section II.	
		f. Allow LOX in engine to boil off through stage LOX tank vent system.		

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Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.14A	<u>LOX FEED SYSTEM BOILOFF AT KSC</u>	a. Verify that turbopump heaters are on at all times when LOX is in engine and that turbopump bearing temperature is within limits.	Turbopump bearing temperature must meet requirements of section II.	WARNING The LOX tank vent system must not be closed with LOX in the engine since injury to personnel and damage to the engine and stage can result from pressure buildup.
		b. Verify that hydraulic control system pressure is applied to engine.	Pressure must meet requirements of section II.	
		c. Verify that hydraulic temperature is within limits of section II.		
		d. Verify that oxidizer valves and gas generator ball valve indicate closed.		
		e. Verify that turbopump LOX seal purge is on.	Purge must meet requirements of section II.	
		f. Monitor temperature within cocoon.	Maintain temperature within limits of section II.	
		g. Allow LOX in engine to boil off through stage LOX tank vent system.		Perform before actuating engine valves to open position.
1.5.15	<u>FUEL FEED SYSTEM DRAIN AT MTF AND KSC SUBSEQUENT TO STAGE ROTATION TO VERTICAL POSITION</u>	a. Connect fuel drain lines to the following quick-disconnects: (1) Turbopump fuel inlet No. 1 (2) No. 1 and No. 2 fuel high-pressure ducts (3) Gas generator ball valve fuel inlet drain (4) Engine hydraulic supply line (5) Engine hydraulic return line (6) Turbopump fuel inlet No. 2		The F-1 Fuel Drain Vent Adapter Kit 99-9012908 must be installed during this activity if stage fuel prevalves are closed. Prior to draining fuel, verify that engines are in a null position. CAUTION During removal of the gas generator ball valve fuel inlet drain quick-disconnect cap, the quick-disconnect body must not be allowed to turn. • While draining fuel, care must be used to prevent spilling fuel on other engine systems.
		b. Allow all fuel to drain.		
		c. Remove drain lines, and reinstall and torque caps on quick-disconnects.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.16	<u>FUEL FEED SYSTEM DRAIN DURING POST-STATIC-TEST SECURING</u>	a. Connect drain hoses to the following quick-disconnects: (1) Turbopump fuel inlet No. 1 (2) No. 1 and No. 2 fuel high-pressure ducts (3) Gas generator ball valve fuel inlet drain (4) Engine hydraulic supply line (5) Engine hydraulic return line (6) Turbopump fuel inlet No. 2		Perform prior to draining thrust chamber fuel jacket The F-1 Fuel Drain Vent Adapter Kit 99-9012908 must be installed during this activity if stage fuel pre-valves are closed. Prior to draining fuel, verify that the following conditions exist: (1) (Deleted) 902 (2) Hydraulic control system is pressurized within limits of section II. (3) Engines are in a null position. **CAUTION** During removal of the gas generator ball valve fuel inlet drain quick-disconnect cap, the quick-disconnect body must not be allowed to turn.
		b. Allow all fuel to drain.		Use care while draining fuel to prevent spillage on other engine systems.
		c. Remove drain hoses, and reinstall and torque caps on quick-disconnects.		
1.5.17	<u>FUEL FEED SYSTEM DRAIN WITH STAGE PRE-VALVES CLOSED</u>	a. Connect drain hoses to the following quick-disconnects: (1) Turbopump fuel inlet No. 1 (2) No. 1 and No. 2 fuel high-pressure duct		902 The F-1 Fuel Drain Vent Adapter Kit 99-9012908 must be installed during this activity if stage fuel pre-valves are closed.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.17 (cont)		(3) Gas generator ball valve fuel inlet drain (4) Engine hydraulic supply line b. Allow all fuel to drain. c. Remove drain hoses, and reinstall and torque caps on quick-disconnects.		Prior to draining fuel, verify that the following conditions exist: (1) (Deleted) 902 (2) Hydraulic control system is pressurized within limits of section II. (3) Engines are in null position. CAUTION During removal of the gas generator ball valve fuel inlet drain quick-disconnect cap, the quick-disconnect body must not be allowed to turn. Use care while draining fuel to prevent spillage on other engine systems.
1.5.18	<u>GAS GENERATOR COMBUSTOR DRAIN</u>	a. Remove drain plug from combustor, and allow residual fluid to drain. b. Reinstall drain plug in combustor using a new seal. Record actual plug torque value, and safetywire plug.		Perform after fuel feed system drain. CAUTION If drain port plug is left uninstalled at completion of inspection, the resultant hot-gas leakage from the open port during subsequent engine operation could cause extensive engine damage and/or abort.
1.5.19	(Deleted)			
1.5.20	<u>THRUST CHAMBER FUEL JACKET DRAIN</u>	a. Connect gaseous nitrogen purge lines to No. 1 and No. 2 fuel valve purge quick-disconnects.		Perform after fuel feed system drain, if applicable. Prior to draining thrust chamber fuel jacket, verify that fuel propellant

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.20 (cont)		b. Connect drain lines, and allow all fluids to drain from the following quick-disconnects: (1) Ignition monitor valve CONTROL port (2) No. 1 and No. 2 thrust chamber fuel inlet manifolds (3) Hypergol container drain		feed system is at vehicle standby pressure or hydraulic control system is pressurized within limits of section II. Engines must be in a null position. CAUTION During removal and installation of No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnect caps, the quick-disconnect body must not be allowed to turn, since damage to the quick-disconnect body can result. 902
		c. Install drain tools from Fuel Drainage Kit G2037 on thrust chamber fuel jacket ports (4 places), and install drain lines on drain tools		
		d. Turn on operational low-level LOX dome and gas generator LOX injector purge.	Purge must meet requirements of section II.	
		e. Pressurize fuel jacket purge, and allow purges to flow until all fluids and vapors are expelled from injector, thrust chamber exit drain lines, fuel inlet manifold drain lines, hypergol manifold drain, and ignition monitor valve drain line.	Purge must meet requirements of section II.	Perform requirements in sequence listed. CAUTION While draining fuel, care must be used to prevent spilling fuel on other engine systems.
		f. Depressurize fuel jacket purge.		
		g. Turn off operational low-level LOX dome and gas generator LOX injector purge.		902
		h. Remove drain and purge hoses, and install and torque all removed quick-disconnect caps.		
		i. Remove drain tools, and install thrust chamber exit manifold drain plugs, using new seals.		
1.5.21	<u>THRUST CHAMBER FUEL INLET MANIFOLD DRAIN</u>	a. Connect drain lines to No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnects.		902 920

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.21 (cont)		b. Allow all fluid to drain from thrust chamber fuel inlet manifold.		CAUTION During removal and installation of No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnect caps, the quick-disconnect body must not be allowed to turn, since damage to the quick-disconnect body can result. 920 902
		c. Leave drain lines attached to thrust chamber fuel inlet manifold quick-disconnects.		• While draining fluid, care must be used to prevent spilling fluid on other engine systems.
1.5.21A	<u>THRUST CHAMBER FUEL INLET MANIFOLD DRAIN, POST CDDT</u>	a. Connect drain lines to No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnects.		Hydraulic control system pressure, within limits specified in section II, must be applied to engine during performance of this activity if fuel valve leakage has occurred without hydraulic control system pressurized.
		b. Allow all fluid to drain from thrust chamber fuel inlet manifold. Visually inspect prefill fluid for evidence of fuel.	No fuel is allowable.	CAUTION During removal and installation of No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnect caps, the quick-disconnect body must not be allowed to turn, since damage to the quick-disconnect body can result. 920
		c. Leave drain lines attached to thrust chamber fuel inlet manifold quick-disconnects.		• While draining fluid, care must be used to prevent spilling fluid on other engine systems.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.22	TURBOPUMP PRESERVATION	Preserve turbopump as outlined in paragraphs 1.5.22.1 or 1.5.22.2, as applicable.		Turbopump preservation must be performed with engine or stage in vertical position. CAUTION During engine or stage rotation, the LOX pump must not be allowed to be lower than the fuel pump inlets by more than 7 degrees since contamination of the LOX pump could occur. Preserve turbopump within limits of section II. Following an abort preserve turbopump only if fuel was introduced into bearing coolant control system.
1.5.22.1	Turbopump Preservation (Engines Not Incorporating MD145 Change)	a. Provide instrumentation or pressure gage to measure pressure at tap LB1b.	Instrument range, 0-250 psig	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.22.1 (cont)		b. Connect gaseous nitrogen purge line to bearing coolant control valve PRESERVATIVE IN port.		
		c. Pressurize bearing coolant control valve, and purge for 5 minutes.	35 ±10 psig	Exit closure must be removed from oxidizer and fuel overboard drain lines. Pressures listed in limits column are as measured at tap LB1b.
		d. Disconnect purge line, and connect preservative supply to PRESERVATIVE IN port.	Preservation supply must meet requirements of section II.	Turbopump LOX pump seal purge must be on and meet requirements of section II before and during performance of this activity. Perform requirements in sequence listed.
		e. Slowly rotate turbopump one revolution minimum, and supply a minimum of 5 gallons of preservative oil to turbopump bearings.	200 ±25 psig	One revolution of the turbopump shaft requires 5 revolutions of the torque pinion gear. The locking pin and torque pinion gear must be fully extended after turbopump rotation is completed.
		f. Allow turbopump to drain for 15 minutes minimum.		
		g. Disconnect preservative supply line, and reconnect purge line to bearing coolant control valve PRESERVATIVE IN port. Purge turbopump bearings for 5 minutes.	35 ±10 psig	Re-preserve turbopump if gaseous nitrogen pressure exceeds 50 psig at any time.
		h. Record turbopump re-preservation date in Engine Log Book.		
1.5.22.2	Turbopump Preservation (Engines Incorporating MD145 Change)	a. Provide instrumentation or pressure gage to measure pressure at tap LB1b.	Instrument range 0-100 psig	The scavenge Pump G2039, or equivalent, must be used for this activity.
		b. Disconnect turbine bearing lube drain hose from fuel drain manifold, and vacuum fluid from turbine bearing lube drain hose.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.22.2 (cont)		. (Deleted)		Exit closures must be removed from oxidizer and fuel overboard drain lines.
		. Connect gaseous nitrogen purge line to bea[illegible]oolant control valve P[illegible]TIVE IN port.		Pressures listed in limits column are as measured at tap LB1b.
		e. Slowly in[illegible]pressure and purge turbopump bearings through PRESERVATIVE IN port for 1-2 minutes.	5-10 psig	The turbopump LOX pump seal purge must be on and meet requirements of section II before and during the performance of this activity.
		f. Disconnect purge line, and connect preservative supply to PRESERVATIVE IN port.	Preservation supply must meet requirements of section II.	Perform requirements in sequence listed.
		g. (Deleted)		
		h. Vacuum fluid from turbine bearing lube drain hose when performing steps i through k.		
		i. Slowly rotate turbopump one revolution minimum, and supply a minimum of 5 gallons of preservative oil to turbopump bearings.	80 ±10 psig	One revolution of the turbopump shaft requires 5 revolutions of the torque pinion gear. The locking pin and torque pinion gear must be fully extended after turbopump rotation is completed.
		j. Discontinue turbopump rotation, and stop oil flow to turbopump bearings.		
		k. Vacuum fluid from turbine bearing lube drain hose until fluid flow ceases.		
		l. Disconnect vacuum system, and reconnect turbine bearing lube drain hose to fuel drain manifold.		
		lA. Disconnect preservative supply, and connect a gaseous nitrogen purge line to bearing coolant control valve PRESERVATIVE IN port.		
		m. Slowly increase pressure and purge turbopump bearings through bearing coolant control valve PRESERVATIVE IN port for 5 minutes.	5-10 psig	Re-preserve turbopump if gaseous nitrogen pressure exceeds 50 psig at any time.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.22.2 (cont)		n. Record turbopump represervation date in Engine Log Book.		
1.5.23 and 1.5.24	(Deleted)			
1.5.25	<u>FUEL FEED SYSTEM DRAIN SUBSEQUENT TO STATIC TEST ABORT</u>	a. Connect drain hoses to the following quick-disconnects: (1) Turbopump fuel inlet No. 1 (2) No. 1 and No. 2 fuel high-pressure duct (3) Gas generator ball valve fuel inlet drain		Perform prior to draining thrust chamber fuel jacket and gas generator combustor. The F-1 Fuel Drain Vent Adapter Kit 99-9012908 must be installed during this activity if stage fuel pre-valves are closed. Prior to draining fuel, verify that the following conditions exist: (1) (Deleted) 902 (2) Hydraulic control system is pressurized within limits of section II. (3) Engines are in a null position. CAUTION During removal of the gas generator ball valve fuel inlet drain quick-disconnect cap, the quick-disconnect body must not be allowed to turn.
		b. Allow all fuel to drain.		
		c. Remove drain hoses and reinstall and torque caps on quick-disconnects.		Use care while draining fuel to prevent spillage on other engine systems.
1.5.26 through 1.5.29	(Deleted)			920

Pages 1-96A through 1-96D deleted.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6	HANDLING			
1.6.1	ENGINE INSTALLATION AT MAF	a. Verify that the following gimbal wrap-around lines are installed, installed within limits of alinement tool T-5041233, and supported with F-1 wrap-around lines support set T-5046440 to preclude line movement: (1) Helium supply duct (2) Helium return duct (3) GOX return duct (4) Hydraulic supply duct (5) Hydraulic return duct (6) LOX dome purge hose (7) Turbopump LOX seal purge hose (8) Thrust chamber jacket prefill hose (9) Cocoon purge hose		CAUTION Foreign matter must not be allowed to enter turbopump LOX and fuel inlets since foreign matter will contaminate the turbopump and contamination may necessitate extensive turbopump repair.
		b. Remove covers, and inspect turbopump oxidizer and fuel inlets for foreign matter. Remove desiccant from covers, and store desiccant as specified in section II.	No foreign matter is allowable in inlets.	
		c. Immediately after inspection of inlets, cover inlets with Aclar No. 33C film (0.002-inch minimum thickness) (Allied Chemical Corp) and secure with pressure-sensitive tape RB0195-002 (Rocketdyne), or equivalent.		
		d. Before installing engine, remove gimbal boot cover and make sure that 4 Gimbal Bearing Locks G4059 and electrical cable support post (outboard engines only) are installed.		CAUTION The engine must be immobilized with Stage Contractor supplied gimbal actuator locks.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.1 (cont)		e. After installing engine, remove 4 Gimbal Bearing Locks G4059. f. Reinstall gimbal boot on gimbal bearing. g. Remove Aclar film from turbopump LOX and fuel inlets, and connect stage ducting to inlets. h. Connect interface electrical connectors. i. Connect stage pressure switch checkout supply line to fitting on engine interface panel. j. Connect the following gimbal wrap-around ducts and hoses to stage using Stage Contractor supplied installation criteria: (1) Helium supply duct (2) Helium return duct (3) GOX return duct (4) Hydraulic supply duct (5) Hydraulic return duct (6) LOX dome purge hose (7) Turbopump LOX seal purge hose (8) Thrust chamber jacket prefill hose (9) Cocoon purge hose		
1.6.2	THRUST CHAMBER NOZZLE EXTENSION INSTALLATION	a. Using Engine Vertical Installer G4049, position nozzle extension beneath thrust chamber exit and aline index mark on nozzle extension with index mark on thrust chamber exhaust manifold flange.		Perform after completion of exhaust system leak test. Engine must be in null position. Prior to installation, verify that thrust chamber nozzle extension serial number is same as that listed in Engine Log Book.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.2 (cont)		b. Clean nozzle extension attach flange seal groove and flange boltholes with drycleaning solvent, or equivalent.		WARNING Drycleaning solvent is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury to personnel. 902
		c. On engines incorporating MD135 change, inspect seal for joint overlap.	0.060- to 0.090-inch free-state thickness for square-cut lap joints having approximately one inch of overlap.	
		d. Install and visually determine that nozzle extension seal is seated in nozzle extension seal groove.		CAUTION Nozzle extension flange must not be allowed to contact thrust chamber exit flange during elevation of nozzle extension since flange damage may result.
		e. Elevate nozzle extension so that flange is between 1/8 and 1/4 inch of thrust chamber attach flange.		
		f. Install and torque nozzle extension to thrust chamber exit flange fasteners.		Start bolt installation at index mark hole and continue around periphery on both sides or either side of index mark. Use Nozzle Extension Alinement Tool G4070 to aline boltholes or drift pins, if necessary.
		g. On engines incorporating MD135 change, retorque all fasteners an additional 2 times at one-hour intervals after initial torquing.		
		h. Lower Engine Vertical Installer G4049.		
		i. Install oxidizer, nitrogen purge, and fuel overboard drain lines.		915
1.6.3	IGNITER HARNESS INSTALLATION	a. Route and clamp harness to thrust chamber.		Perform prior to igniter installation and igniter harness checkout.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.3 (cont)		b. Connect igniter harness plug P47 to receptacle J47. Torque and safetywire plug to receptacle.		
1.6.4	<u>THERMAL INSULATION INSTALLATION</u>	a. Perform torque check of nozzle extension flange fasteners just prior to installing thermal insulation, which restricts access to flange. Record results.	Torque-check every tenth fastener. If any fastener is not within limits, retorque all 240 fasteners.	Perform after completion of all other listed requirements for vehicle checkout at VAB except engine environmental cover installation.
		b. Remove protective covers from propellant high-pressure ducts.		
		c. Remove all engine covers and closures that will be enclosed by thermal insulation.		
		d. Install thermal insulation.		
1.6.5	<u>ENGINE ENVIRONMENTAL COVER INSTALLATION</u>	Install cover on engine with silver-colored side of cover on inside so that overboard drain lines are exposed through holes provided in cover and access to igniter ports on nozzle extension is not restricted.		Install cover after thermal insulation installation and before vehicle movement to launch complex.
1.6.6	<u>HYPERGOL CARTRIDGE WEIGHT CHECK</u>	a. Wipe hypergol protective plastic bag free of contaminants with a lint-free cloth moistened with trichloroethylene; then remove hypergol cartridge from plastic protective packaging.	Torn protective packaging (both bags if double packaged) is not allowable. Restoration of hypergol cartridge to a serviceable condition must meet requirements of section II.	
		b. Compare current gross weight of hypergol cartridge with gross weight recorded on hypergol cartridge. Record results.	Current gross weight must be within 15 grams of recorded gross weight noted on hypergol cartridge.	Perform prior to hypergol cartridge installation. CAUTION The hypergol cartridge must be protected from damage and contamination until installed in hypergol container.

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Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.6 (cont)				**WARNING** Fluid leakage from a damaged hypergol cartridge can result in serious injury to personnel and damage to equipment.
		c. Verify that expiration date noted on hypergol cartridge is not exceeded.	Use of hypergol cartridge that has exceeded expiration date is not allowable.	
		d. Verify (by hand-torquing in tightening direction) that hypergol cartridge is tight to its plug. Inspect packings for chipping, cracking, or improper fit, and verify that downstream ring is not tucked under packing.	Damage to packings is not allowable. Restoration of hypergol cartridge to a serviceable condition must meet requirements of section II.	912
		e. Repackage and store hypergol cartridge as specified in section II until ready for installation.		
1.6.7	<u>IGNITER INSTALLATION FOR STATIC TEST AND LAUNCH</u>	a. Visually inspect that gas generator and nozzle extension igniter ports are clean of carbon and other loose particles.	No contamination is allowable.	
		b. Verify that igniters have been tested as specified in paragraph 1.2.9.		
		c. Visually inspect each igniter prior to installation for:		
		(1) Closure damage	No damage is allowable.	
		(2) Thread damage	No damage is allowable.	
		(3) Bent or loose receptacle pins	No damage is allowable.	916
		(4) Nicked or scratched gasket or gasket seating surfaces	No damage is allowable.	
		(5) Six-month time exceeded since igniter was removed from container		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.7 (cont)		(6) Service life expired	Service life must meet requirements of section II.	
		d. Install igniters.		No lubrication is allowable on igniter threads.
		e. Visually examine connectors for moisture prior to connection.	No moisture is allowable.	
		f. Connect igniter harness electrical connectors to each igniter.		
		g. Verify igniter link continuity.		
1.6.8	<u>INERT IGNITER INSTALLATION FOR COUNTDOWN DEMONSTRATION TEST</u>	a. Visually inspect that gas generator and nozzle extension igniter ports are clean of carbon and other loose particles.	No contamination is allowable.	
		b. Verify that inert igniters have been tested as specified in paragraph 1.2.10.		
		c. Visually inspect each inert igniter prior to installation for:		
		(1) Closure damage	No damage is allowable.	
		(2) Thread damage	No damage is allowable.	
		(3) Bent or loose receptacle pins	No damage is allowable.	
		(4) Nicked or scratched gasket or gasket seating surfaces	No damage is allowable.	
		d. Install inert igniters.		No lubrication is allowable on inert igniter threads.
		e. Visually examine connectors for moisture prior to connection.	No moisture is allowable.	
		f. Connect igniter harness electrical connectors to each inert igniter.		
		g. Verify igniter link continuity.		
1.6.9	(Deleted)			

916

Paragraph	Activities		Requirements	Limits	Special Constraints and Remarks
1.6.10	<u>HYPERGOL CARTRIDGE INSTALLATION</u>	a.	Verify that hypergol cartridge plastic protective packaging is not torn.	Torn protective packaging (both bags if double packaged) is not allowable. Restoration of hypergol cartridge to a serviceable condition must meet requirements of section II.	Perform after hypergol cartridge weight check. CAUTION The hypergol cartridge must be protected from damage and contamination until installed in the hypergol container. 912
		b.	Check that hypergol cartridge expiration date is not exceeded.	Use of hypergol cartridge that has exceeded expiration date is not allowable.	
		c.	Verify (by hand-torquing in tightening direction) that hypergol cartridge is tight to its plug. Inspect packings for chipping, cracking, or improper fit, and verify that downstream ring is not tucked under packing.	Damage to packings is not allowable. Restoration of hypergol cartridge to a serviceable condition must meet requirements of section II.	912
		d.	Lubricate hypergol cartridge packings and bore of hypergol cartridge container with FS1281 grease (Dow Corning Corp).		912
		e.	Verify that hypergol installed switch is deactuated.		CAUTION If the switch is not deactuated, the cam follower may be damaged during cartridge installation.
		f.	Carefully insert cartridge into container, and verify that there is no evidence of binding, scuffing, or any irregular resistance that may indicate an incorrect-size packing or damage as hypergol cartridge cap is screwed onto container.		912
		g.	Aline hole in cap with hole in container; then install lockpin in hole.		
		h.	Verify that hypergol installed switch actuates.		If hypergol installed indication is not received, damage to hypergol cartridge must be assumed.
		i.	If damage to hypergol cartridge is suspected, remove cartridge as specified in paragraph 1.6.39.		
1.6.11	(Deleted)				

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.12	<u>ENGINE ENVIRONMENTAL COVER REMOVAL</u>	Remove engine environmental cover from engine using care not to damage cover. Fold and store cover.		Perform prior to LOX admittance to engine for launch.
1.6.13	<u>EXPENDED HYPERGOL CARTRIDGE REMOVAL</u>	a. Connect a drain hose to hypergol manifold drain quick-disconnect, and drain fuel from manifold.		Perform prior to thrust chamber fuel jacket flush and LOX dome and gas generator LOX injector flush, if performed.
		b. Remove drain hose when drainage stops.		CAUTION The thrust chamber exit and throat closures and the overboard drain line closures must be off for this activity.
		c. Connect a gaseous nitrogen supply to hypergol manifold purge quick-disconnect.	Purge must meet requirements of section II.	
		d. Turn on operational low-level LOX dome and gas generator LOX injector purge.	Purge must meet requirements of section II.	Steps in Requirements column must be performed in sequence listed. 902
		e. Turn on hypergol purge and allow purge to flow a minimum of 3 minutes.	Purge must meet requirements of section II.	
		f. Turn off hypergol purge; then turn off operational low-level LOX dome and gas generator LOX injector purge.		902
		g. Unscrew cap from hypergol container, remove spent cartridge, and verify that both diaphragms, both packings, and the ring are still with cartridge; then package cartridge in a shipping container.		902
		h. Install hypergol manifold and closure plug.		
		i. Disconnect hypergol manifold purge supply from manifold quick-disconnect.		
1.6.14	<u>EXPENDED IGNITER REMOVAL</u>	a. Disconnect igniter harness connectors P43 and P44 from gas generator igniters and connectors P45 and P46 from nozzle extension igniters.		Perform prior to LOX dome and gas generator LOX injector flush, if performed.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.14 (cont)		b. Remove igniters.		
		c. Visually inspect each igniter to verify that igniter tube is not separated from igniter body.		
		d. Dispose of spent igniters as specified in section II.		
1.6.15	INERT IGNITER REMOVAL	a. Disconnect igniter harness connectors P43 and P44 from gas generator inert igniters, and P45 and P46 from nozzle extension inert igniters.		
		b. Remove inert igniters.		
		c. Visually inspect each inert igniter for damage.	No damage is allowable.	
		d. Install protective cap and cover on inert igniter and place in storage container.		
1.6.16	THRUST CHAMBER NOZZLE EXTENSION REMOVAL	a. Remove oxidizer, nitrogen purge, and fuel overboard drain lines.		Perform after thrust chamber fuel jacket drain and propellant fuel feed system drain. 915
		b. Elevate Vertical Engine Installer G4049 to within approximately 1/8 inch of nozzle extension exit.		Engine must be in null position. CAUTION The installer must not be allowed to contact the extension during elevation of the installer.
		c. Remove nozzle extension to thrust chamber flange bolts, and lower nozzle extension onto installer.		
		d. Lower installer.		
1.6.17	IGNITER HARNESS REMOVAL	a. Verify that power is removed from engine; then remove harness.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.18	<u>THRUST CHAMBER THROAT SECURITY CLOSURE INSTALLATION</u>	a. Remove thrust chamber exit closure, if installed.		Thrust chamber throat closure RX20700 is an acceptable alternate for thrust chamber throat closure G4089. 921
		b. Clean threaded hole in center of injector.		
		c. Retract and secure pin in detent on security closure shaft.		
		d. Install shaft in threaded hole in center of injector until shaft bottoms aline pin between extensions on injector face; then release pin from detent position.		
		e. Install desiccant in closure as specified in section II.	48 units. Closure humidity indicator must be blue within 24 hours after installation of desiccant.	NOTE Desiccant must not be removed from its airtight container until just prior to installation.
		f. Install closure on shaft. Aline hole in closure extension with hole in shaft, and install combination padlock 9026900 through closure and shaft.		908
		g. Inflate closure tube with gaseous nitrogen.	5-7 psig	
		h. Reinstall thrust chamber exit closure, if required.		
1.6.19	<u>THRUST CHAMBER THROAT SECURITY CLOSURE REMOVAL</u>	a. Remove thrust chamber exit closure, if applicable.		Thrust chamber throat closure RX20700 is an acceptable alternate for thrust chamber throat closure G4089. 921 915
		b. Deflate security closure tube.		
		c. Remove padlock, and remove closure from shaft.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.19 (cont)		d. Place shaft pin in detent position, and unscrew shaft from injector.		
		e. Remove desiccant from security closure and store as specified in section II.		
		f. Package security closure for storage by enclosing in a clean plastic bag and cushioning in a box with polyurethane material.		
		g. Reinstall thrust chamber exit closure, if applicable.		
1.6.20	<u>THRUST CHAMBER THROAT PLUG INSTALLATION</u>	a. Inspect and clean threaded hole in center of thrust chamber injector.		
		b. Lubricate throat plug shaft threads.		
		c. Install spacer on shaft. Hold spacer against thrust chamber injector, and screw shaft into thrust chamber injector. Make sure that clearance is maintained between spacer and shaft collar.		CAUTION The spacer must not be allowed to bottom against the shaft collar since damage to the injector may result.
		d. Measure axial spacing between shaft and collar.	0.020 to 0.115 inch	
		e. If axial spacing is less than 0.020 inch, perform the following: (1) Unscrew shaft from injector and insert washer T-5046431 over shaft threads; then holding spacer against injector, screw shaft into injector. Make sure that clearance is maintained between spacer and shaft collar.		CAUTION The spacer must not be allowed to bottom against the shaft collar since damage to the injector may result.
		(2) Measure axial spacing between spacer and shaft collar.	0.020 to 0.115 inch	

921

915

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.20 (cont)		f. Torque shaft into injector hole.		
		g. Apply petrolatum (Federal Specification VV-P-236) to tubes in thrust chamber throat.		
		h. Install support on shaft, alining support keyhole slot with shaft pin, and rotate support clockwise to lock.		
		i. Inspect seal for cleanliness, and install seal on support with valve stem facing outboard and ridge of seal periphery alined with tube contours.		
		j. Install retainer on shaft, alining retainer keyhole slots with studs on support, and rotate retainer clockwise to secure.		
		k. Install washer and nut on shaft and tighten firmly. Make sure that washer contacts retainer.		
		l. Install a quick-disconnect and a burst diaphragm in support.		
		m. Pressurize throat plug seal with gaseous nitrogen through valve stem.	50 (+5, -10) psig	
1.6.21	<u>THRUST CHAMBER THROAT PLUG REMOVAL</u>	a. Depressurize throat plug seal; then remove throat plug.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.21 (cont)		b. Clean petrolatum from thrust chamber tubes and throat plug parts.		
1.3.22	<u>TURBINE EXHAUST EXIT PRESSURE TEST FIXTURE INSTALLATION</u>	a. Apply a thin coat of petrolatum (Federal Specification VV-P-236) to ends of all segment seals where they overlap.		
		b. Remove knurled thumbnuts from internal wrenching screws on each clamp.		
		c. Attach one clamp, with quick-release pin, to any lug on inner wall of thrust chamber exit. Omit 3 lugs and attach a second clamp, with quick-release pin, to the fourth lug in either direction from first clamp.		
		d. Place segment on thrust chamber, and aline holes in segment with 2 clamps.		
		e. Insert internal wrenching screws through holes in thrust chamber exit ring, segment, and clamp. Attach knurled thumbnuts to internal wrenching screws. Do not tighten.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.22 (cont)		f. Aline outer curvature of segment with curvature of thrust chamber exit ring. Hand-tighten the 4 thumbnuts.		
		g. To install segments No. 2 through 7, repeat steps b through f, proceeding clockwise.		
		h. To install segment No. 8, loosen thumbnuts on first segment installed and repeat steps b through f. Place tapered seal on end of segment No. 8 under segment No. 1.		
		i. Adjust alinement of all segments.		
		j. Install previously omitted clamps. Hand-tighten all knurled thumbnuts.		
		k. Inflate each seal with gaseous nitrogen, proceeding clockwise.	35 ±2 psig	
		l. Visually verify that rubber of each seal has expanded to meet overlapping backup plate of junction of each segment.		
1.6.23	<u>TURBINE EXHAUST EXIT PRESSURE TEST FIXTURE REMOVAL</u>	a. Depressurize each seal segment; then remove turbine exhaust test fixture.		
		b. Clean petrolatum from thrust chamber exit flange and from test fixture.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.24	COVER AND CLOSURE INSTALLATION FOR UNINSTALLED ENGINES	Install protective covers and closures on engines at the following locations. (1) Engine gimbal joint bellows (2) High-pressure ducts (3) Drain line bellows and exits (4) Thrust chamber exterior (5) Thrust chamber throat (6) Thrust chamber exit (7) Fuel pump inlets (8) LOX pump inlet (9) Wrap-around ducts and lines (10) Electrical connectors and fluid interface joints		If engine is going into storage in accordance with criteria in Standard S-IC Stage Storage Specification MSFC-STD-500, installation of all engine exterior protective covers must be in accordance with the specification.
1.6.25	COVER AND CLOSURE INSTALLATION FOR INSTALLED ENGINES	Install protective covers and closures on engines at the following locations: (1) Engine gimbal joint bellows (2) High-pressure ducts (3) Drain line bellows and exits (4) Thrust chamber exterior (5) Thrust chamber exit (6) Thrust chamber throat		If engine is going into storage in accordance with criteria in Standard S-IC Stage Storage Specification MSFC-STD-500, installation of all engine exterior protective covers must be in accordance with the specification.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.26	COVER AND CLOSURE REMOVAL FOR UNINSTALLED ENGINES	Remove protective covers and closures, as applicable, from engines at the following locations: (1) Engine gimbal joint bellows (2) High-pressure ducts (3) Drain line bellows and exits (4) Thrust chamber exterior (5) Thrust chamber throat (6) Thrust chamber exit (7) Fuel pump inlets (8) LOX pump inlet (9) Wrap-around ducts and lines (10) Electrical connectors and fluid interface joints		
1.6.27	COVER AND CLOSURE REMOVAL FOR ENGINE INSTALLATION IN STAGE	Remove protective cover and closures from engines at the following locations: (1) Electrical interface connectors (2) Wrap-around line interface joints (3) Fuel inlets (4) LOX inlet		
1.6.28	COVER AND CLOSURE REMOVAL FOR INSTALLED ENGINES	Remove protective covers and closures from engines, as applicable, at the following locations: (1) Engine gimbal joint bellows (2) High-pressure ducts		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.28 (cont)		(3) Drain line bellows and exits (4) Thrust chamber exterior (5) Thrust chamber exit (6) Thrust chamber throat		
1.6.29	(Deleted)			
1.6.30	<u>HORIZONTAL ENGINE REMOVAL AT MAF</u>	a. Support wrap-around lines with F-1 wrap-around lines support set T-5046440; then disconnect the following wrap-around lines from stage interface, and install covers or closures, as applicable, on all open ports: (1) Helium supply duct (2) Helium return duct (3) GOX return duct (4) Hydraulic supply duct (5) Hydraulic return duct (6) LOX dome purge hose (7) Turbopump LOX seal purge hose (8) Thrust chamber jacket prefill hose (9) Cocoon purge hose		CAUTION Fluid must not be spilled from hydraulic lines on engine since contamination of LOX system may result.
		b. Disconnect electrical cable support post (applicable on outboard engines only).		
		c. Disconnect stage pressure switch checkout supply line from fitting on engine interface panel.		
		d. Disconnect interface electrical connectors.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.30 (cont)		e. Clean exterior of turbopump oxidizer and fuel inlets of foreign matter, remove fasteners that secure stage propellant ducts to inlets, and remove moisture from turbopump inlet flange fastener holes.		
		f. Immediately after disconnecting stage propellant ducts from turbopump LOX and fuel inlets, cover inlets with Aclar No. 33C film (0.002-inch minimum thickness) (Allied Chemical Corp) and secure with pressure-sensitive tape RB0195-002 (Rocketdyne), or equivalent.		
		g. Remove gimbal boot from gimbal bearing.		
		h. Before removing engine after gimbal bearing disconnection, install Gimbal Bearing Locks G4059 on engine gimbal, and install gimbal boot cover.		
		i. After engine is removed from stage and placed on Engine Handler G4069, remove Aclar film from turbopump LOX and fuel inlets, and install covers as specified in paragraphs 1.6.18 and 1.6.24.		Prior to installing LOX and fuel inlet closures, inlets must be inspected for contamination and LOX inducer for damage.
		j. Remove wrap-around lines from engine, and install closures on all engine openings.		CAUTION The level of the fuel pump must not exceed that of the LOX pump by more than 7 degrees during engine removal since LOX pump contamination can result.
		k. Utilizing Engine Rotating Sling G4050, install engine on Engine Handler G4058, or equivalent.		
		l. (Deleted)		901
1.6.31	<u>VERTICAL ENGINE REMOVAL</u>	a. Remove nozzle extension, if installed, as outlined in paragraph 1.6.15.		Perform after thrust chamber fuel jacket drain and propellant fuel feed system drain, if applicable.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.31 (cont)		b. Remove the following gimbal wrap-around lines, and install covers or closures, as applicable, on all open ports.		CAUTION Fluid must not be spilled from hydraulic lines on engine since contamination of LOX system may result.
		(1) Helium supply duct		
		(2) Helium return duct		
		(3) GOX return duct		
		(4) Hydraulic supply duct		
		(5) Hydraulic return duct		
		(6) LOX dome purge hose		
		(7) Turbopump LOX seal purge hose		
		(8) Thrust chamber jacket prefill hose		
		(9) Cocoon purge hose		
		c. Disconnect electrical cable support post (applicable on outboard engines only).		
		d. Remove thrust OK pressure switch checkout line from fitting on engine interface panel.		
		e. Disconnect interface electrical connectors.		
		f. Clean exterior of turbopump oxidizer and fuel inlets of foreign matter, remove fasteners that secure stage propellant ducts to inlets, and remove moisture from turbopump inlet flange fastener holes.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.31 (cont)		g. Immediately after disconnecting stage propellant ducts from turbopump LOX and fuel inlets, cover inlets with Aclar No. 33C film (0.002-inch minimum thickness) (Allied Chemical Corp) and secure with pressure-sensitive tape RB0195-002 (Rocketdyne), or equivalent.		
		h. Remove gimbal boot from gimbal bearing.		
		i. Support engine with Engine Vertical Installer G4049; then remove gimbal bearing to stage gimbal bearing attach point bolts and gimbal actuator from stage fittings or stiff-arm fasteners from engine fittings.		
		j. Using Engine Vertical Installer G4049, lower engine from stage.		CAUTION The level of the fuel pump must not exceed that of the LOX pump by more than 7 degrees during engine removal since LOX pump contamination can result.
		k. Remove Aclar film from turbopump LOX and fuel inlets, and install covers as specified in paragraphs 1.6.18 and 1.6.24.		Prior to installing LOX and fuel inlet closures, inlets must be inspected for contamination, and LOX inducer for damage. 901
		l. (Deleted)		
		m. Connect a purge supply, meeting requirements specified in section II, to turbopump LOX seal purge interface connect point, and turn purge on.		Requirement steps m, o, and q may be omitted if fuel has not been introduced into the turbopump lubrication system since turbopump preservation.
		n. Install Gimbal Bearing Locks G4059 on engine gimbal, and install gimbal boot cover.		
		o. Using Engine Rotating Sling G4050, rotate engine to horizontal position, then return engine to vertical position and perform fuel feed system drain (paragraph 1.5.15).		CAUTION The level of the fuel pump must not exceed that of the LOX pump by more than 7 degrees since LOX pump contamination can result.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.31 (cont)		p. Using Engine Rotating Sling G4050, rotate engine to horizontal position and install on Air Transport Engine Handler G4044.		
		q. Maintain purge to LOX pump seal for a minimum of 30 minutes prior to securing purge.		
1.6.32	(Deleted)			
1.6.33	<u>VERTICAL ENGINE INSTALLATION</u>	a. Remove covers, and inspect turbopump oxidizer and fuel inlets for foreign matter. Remove desiccant from covers, and store desiccant as specified in section II.	No foreign matter is allowable in inlets.	CAUTION Foreign matter must not be allowed to enter the turbopump LOX and fuel inlets since foreign matter will contaminate the turbopump and contamination may necessitate extensive turbopump repair.
		b. Immediately after inspection of inlets, cover inlets with Aclar No. 33C film (0.002-inch minimum thickness) (Allied Chemical Corp) and secure with pressure-sensitive tape RB0195-002 (Rocketdyne), or equivalent.		
		c. Remove gimbal boot cover and 4 Gimbal Bearing Locks G4059 from engine gimbal.		
		d. Install engine with Engine Vertical Installer G4049, or equivalent, in applicable stage position, and secure gimbal bearing to stage gimbal bearing attach point, and gimbal actuators to stage attach points or stiff arms to engine attach points.		CAUTION The engine must be immobilized with Stage Contractor supplied gimbal actuator locks.
		e. Reinstall gimbal boot on gimbal bearing.		
		f. Remove Aclar film from turbopump LOX and fuel inlets, and connect stage ducting to inlets.		
		g. Connect interface electrical connectors.		
		h. Connect stage pressure switch checkout supply line to fitting on engine interface panel.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.33 (cont)		i. Install and aline the following gimbal wrap-around duct and hoses using alinement tool T-5041233: (1) Helium supply duct (2) Helium return duct (3) GOX return duct (4) Hydraulic supply duct (5) Hydraulic return duct (6) LOX dome purge hose (7) Turbopump LOX seal purge hose (8) Thrust chamber jacket prefill hose (9) Cocoon purge hose	Vertical and lateral alinement of ducts and hoses must be within limits of alinement tool.	
		j. Connect electrical cable support post (applicable on outboard engines only).		
		k. Connect the following gimbal wrap-around ducts and hoses to stage, using Stage Contractor supplied installation criteria: (1) Helium supply duct (2) Helium return duct (3) GOX return duct (4) Hydraulic supply duct (5) Hydraulic return duct (6) LOX dome purge hose (7) Turbopump LOX seal purge hose		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.33 (cont)		(8) Thrust chamber jacket prefill hose		
		(9) Cocoon purge hose		
		l. Install thrust chamber nozzle extension. Refer to paragraph 1.6.2 for requirements.		
1.6.34	(Deleted)			
1.6.35	<u>THERMAL INSULATION REMOVAL</u>	a. Remove thermal insulation from engine.		
		b. Install protective covers and closures on engine components.		
1.6.36	<u>LIVE IGNITER REMOVAL</u>	a. Verify absence of electrical power to engine.		Perform prior to LOX dome and gas generator LOX injector flush, if applicable.
		b. Disconnect igniter harness electrical connectors P43 and P44 from gas generator igniters and electrical connectors P45 and P46 from nozzle extension igniters.		
		c. Install shorting caps on each igniter.		
		d. Remove igniters, and install protective caps on igniters.		
		e. Repackage and store igniters as specified in section II.		
		f. Plug gas generator and nozzle extension igniter ports.		
1.6.37 and 1.6.38	(Deleted)			

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.39	LIVE HYPERGOL CARTRIDGE REMOVAL	a. Perform the following when damage to hypergol cartridge is suspected:		Perform after thrust chamber fuel jacket drain and prior to LOX dome and gas generator LOX injector flush and thrust chamber fuel jacket flush, if applicable. Steps in Requirements column must be performed in sequence listed.
		(1) Remove pressure cap from, and connect a gaseous nitrogen supply to, hypergol purge quick-disconnect.	Purge must meet requirements of section II.	
		(2) Remove pressure cap from, and connect a pneumatic system to, fuel jacket purge quick-disconnect on each main fuel valve.	Purge must meet requirements of section II.	
		(3) Disconnect vent line from, and connect a pneumatic system to, igniter fuel valve vent port.	Purge must meet requirements of section II.	
		(4) Turn on operational high-level LOX dome and gas generator LOX injector purge, and audibly verify operation of purge.	Purge must meet requirements of section II.	
		(5) Pressurize fuel jacket purge system.	Purge must meet requirements of section II.	
		(6) Pressurize igniter fuel valve cap vent port.	Purge must meet requirements of section II.	
		(7) Clear engine area of personnel, and increase hypergol purge port pressure until hypergol cartridge diaphragms burst.		
		(8) Allow purges to continue until all vapor ceases to be emitted from thrust chamber.		
		(9) Depressurize igniter fuel valve cap.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.39 (cont)		(10) Depressurize fuel jacket purge system.		
		(11) Turn off operational high-level LOX dome and gas generator LOX injector purge.		
		(12) Disconnect pneumatic system from igniter fuel valve vent port, and re-install vent line.		
		(13) Disconnect pneumatic system from, and install pressure cap on, fuel jacket purge quick-disconnect on each fuel valve.		
		(14) Disconnect pneumatic system from hypergol purge quick-disconnect.		
		(15) Remove pin that secures cartridge in hypergol cartridge container installation port.		
		(16) Remove hypergol cartridge, verify that both diaphragms and all O-rings are still with the cartridge, and dispose of the cartridge as specified in section II.		
		(17) Inspect hypergol container closure plug for chipping and cracking, and then screw plug into hypergol cartridge container. Aline hole in plug with hole in container, and insert pin through alined holes.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.39 (cont)		b. Perform the following procedures when removing a nondamaged live hypergol cartridge:		
		(1) Remove pin that secures hypergol cartridge in cartridge container installation port.		
		(2) Unscrew hypergol cartridge cap from container; then carefully remove cartridge container.		
		(3) Wipe excess lubricant from hypergol cartridge O-rings and from exterior of cartridge.		
		(4) Repackage hypergol cartridge and store as specified in section II.		
		(5) Clean bore of hypergol cartridge manifold with drycleaning solvent (Federal Specification P-D-680), or equivalent cleaning solvent.		WARNING Drycleaning solvent is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.
		(6) Inspect hypergol container closure plug for chipping and cracking; then insert plug into hypergol cartridge container. Aline hole in plug with hole in container and insert pin through alined holes.		

Condition	Limits
THRUST CHAMBER	
Tube dents (external)	Up to 0.150 inch in depth is acceptable.
Tube dents (internal)	Up to 0.075 inch in depth or 12 inches in length is acceptable.
Tube crown burning	Up to 0.005 inch in depth, 3/16 inch in width, or 5 inches in length is acceptable.
Tube nicks and scratches	Up to 0.005 inch in depth, 0.010 inch in width, or 5 inches in length is acceptable.
Tube nickel plate peeling	Acceptable condition
Tube leakage (internal or external)	No leakage is allowable.
Tube to exit end ring braze joint leakage	No leakage is allowable.
Tube 3:1 expansion ratio plane splice braze joint leakage	No leakage is allowable.
Tube-to-tube joint hot-gas leakage	No leakage is allowable.
Pinholes in side wall of tubes	No pinholes are allowable.
Dome injector or thrust chamber instrumentation, prefill, drain, or purge boss cracks	No cracks are allowable.
Braze washout between tubes	No braze washout is allowable.
Exhaust manifold thermal deformation	Acceptable condition
Exhaust manifold mechanical deformation due to handling	Mechanical deformation is not allowable.
Omega joint attach weld or exhaust manifold shell cracked	No cracks are allowable.
Thrust chamber to nozzle extension flange deformation at 10:1 ratio plane	No deformation is allowable.
Exhaust manifold tension tie deformation	Up to 2 inches above or below horizontal plane is acceptable.
Exit and attach lug erosion	No less than 0.028 inch of remaining lug area is acceptable.
Thrust chamber to injector O-ring extruded	No extrusion is allowable.
INJECTOR	
Baffle separation	No separation is allowable.
Baffle deformation	Up to 0.250 inch maximum is acceptable.
Baffle erosion	No erosion is allowable.
Baffle bulges	Zero leakage up to 0.100 inch and within limits of T-5044956 is acceptable.
Baffle orifice distortion	Acceptable condition
Baffle to baffle braze joint cracks	No cracks are acceptable except where braze joint nuggets meet parent metal of baffle system.
Ring orifices distorted	Acceptable condition

Figure 1-3. Engine Damage Limits (Sheet 1 of 3)

Condition	Limits
INJECTOR (cont)	
Orifices obstructed	No obstruction is allowable.
Injector face eroded	No erosion is allowable.
NOZZLE EXTENSION	
Shingle thermal buckling	Acceptable condition
Slot locally opened or closed due to thermal buckling	Acceptable condition
Shingle axial overlap opened	Acceptable condition
Shingle overlap eroded	Remaining overlap must exceed 0.030 inch.
Shingle erosion	Up to 0.375 inch as measured across major dimension is acceptable.
Shingles pulled away from Z-bars	Up to 2 adjacent Z-bars are acceptable.
Outer shell distortion	Acceptable condition
External reinforcing bands buckles or local distortion in outer surface (parallel to centerline of thrust) greater than 0.200 inch from nominal surface contour within a circumferential span of 3 inches.	No buckles or distortion is allowable.
Cracks in outer band at outer shell	No cracks are allowable.
Cracks in outer shell	No cracks are allowable.
Elongation of attach flange boltholes	Acceptable condition
Nut plate damaged	No damage is allowable.
Blind nut loose	Loose blind nuts are not allowable.
Blind nuts damaged	No damage is allowable.
Gasket damaged	No damage is allowable.
FLEX HOSES	
Broken or chafed wires within one inch of braid retaining collar	No broken wires are allowable. Chafed wires with more than 30 percent of material worn away are not allowable.
Broken wires in a carrier	Up to one broken wire in a carrier is acceptable.
Broken wires in adjacent parallel carriers	No broken wires in adjacent parallel carriers are allowable.
Broken wires in entire flex hose	Up to 6 broken wires is maximum allowable.
Bulges	Bulges that extend beyond outside diameter or the hex flat dimension of braid retaining collar are not allowable.
Braid damage from impact	No damage is allowable.

Figure 1-3. Engine Damage Limits (Sheet 2 of 3)

Condition	Result
RIGID DUCTS AND COMPONENTS	
External damage	No damage is allowable.
ELECTRICAL HARNESS	
Connector pins bent or length incorrect	No damage to pins is allowable.
Connector pins and sockets corroded	No corrosion is allowable.
Connector socket contacts bent or misalined	No damage to socket contact is allowable.
Connector inserts cracked or split	No damage to insert is allowable.
Connector shells cracked, bent, or broken; threads damaged; or anodic coating damaged	No damage to connector is allowable.
Connector shells corroded	No corrosion is allowable.
Armored braid abrasions	Up to one inch of continuous linear length in any one area is acceptable.
Raised braid	Up to 5 percent maximum increase in harness diameter with braid unbroken is acceptable.
Braid separated	Up to 0.150 inch or one percent of rubber tubing visible in any one linear foot of harness is acceptable.
Broken strands	Up to 2 maximum at any one point and not more than 5 points within any 2-foot length is acceptable.
Voids or gouges in green or black overmold	Up to 1/4 inch in diameter (maximum) is acceptable.
Blisters, holes, scratches, or gouges in heat-shrinkable overmold	Up to 1/8 inch in diameter (maximum) is is acceptable.
920 Surface scratches, nicks, or gouges in plug protective boot	Up to 1/8 inch in diameter and less than 0.030 inch deep is acceptable.
TURBOPUMP	
Fuel inlet damage	No damage is allowable.
LOX inlet damage	No damage is allowable.
LOX inducer damage	No damage is allowable.

902 For additional information on damage disposition, refer to paragraph 2.4.3A.

Figure 1-3. Engine Damage Limits (Sheet 3 of 3)

Condition	Limits
INSULATORS, GENERAL	
Fuel-wetted or -soaked foil-batt panels, asbestos blankets, or fiberglass cloth assemblies	Not acceptable
Water-wetted or -soaked insulators	Acceptable condition
Cracked or torn insulators	Not acceptable
Deformed insulators	Deformed insulators without cracks or tears are acceptable.
Damaged or missing nut plates, blind nuts, threaded studs, or helicoil inserts	Not acceptable
Loss of texturized finish of foil skins	Loss of texturized finish is acceptable.
Loss of aluminum tape from insulator edges	Acceptable condition
Loose lacing studs	Lacing studs that are free to rotate are acceptable.
Missing lacing studs	Acceptable condition if two or more adjacent lacing studs are not missing.
Discoloration	Acceptable condition
INSULATORS, FOIL-BATT	
Holes through outer foil skins in batt areas	Not acceptable
Holes through inner foil skins in batt areas	Holes up to 0.062 inch in diameter are acceptable if there is a minimum of 12 inches between holes.
Elongated boltholes in standing flanges	Up to 0.625 inch in length parallel to flange and/or 0.322 inch in diameter horizontal to flange is acceptable.
Loss of Teflon tape vent hole covers	Acceptable condition
Damaged or missing access door lanyard	Acceptable condition
Missing retaining washer or snapring for access door attaching screw	Acceptable condition
Bent or creased folding edges of standing flanges	Acceptable condition

919

Figure 1-4. Thermal Insulation Damage Limits (Sheet 1 of 2)

Condition	Limits
INSULATORS, ASBESTOS	
Scuffed or scratched aluminized coating	Acceptable condition
Frayed edges	Up to 0.25 inch from original edge is acceptable.
Holes through asbestos cloth	Up to 0.25 inch in diameter are acceptable if wire in yarn is not broken.
INSULATORS, SILICONE	
Scratches, nicks, or gouges	Up to 50 percent of thickness in depth and not larger than 0.50 inch in diameter is acceptable.
INSULATORS, GLASS CLOTH	
Frayed edges of single layers	Up to 0.25 inch from original edge is acceptable.
Frayed, broken, or torn outer glass cloth layer(s)	Individual damage spots up to 0.25 inch in length are acceptable if there is a minimum of 1.50 inches between spots and the damage is confined to the outer glass cloth.
Blisters in inner elastomer coating	Acceptable condition
919 Loss of grommets and/or sheet metal doublers	Acceptable condition if two or more adjacent grommets or doublers are not missing.
INSULATORS, LOX	
Loss of foam filling and elastomer coating in foam-loss area	Up to 20 percent of surface area when void extends through to foil skin is acceptable. Up to 40 percent of surface area is acceptable when the remaining foam in the void area averages at least 0.12 inch in thickness.
Separation of foam filling from the foil skin	Acceptable condition along edges for the thickness of the insulator.
Soft blisters in the elastomer coating	Acceptable condition
Swollen foam	Up to 0.12 inch in height above the average foam thickness is acceptable.
Gaps between edges of adjacent insulators	Acceptable condition
Separated spot welds between foil skins and hose clamps	Acceptable condition

Figure 1-4. Thermal Insulation Damage Limits (Sheet 2 of 2)

SECTION II

GENERAL REQUIREMENTS

SCOPE. This section contains general F-1 engine requirements in terms of external input and output, environment, maintenance, operational test, and documentation criteria, to support the scheduled and nonscheduled authorized activities specified in section I.

2.1 FLUID INPUT/OUTPUT REQUIREMENTS.

2.1.1 Input/output requirement acceptability for the F-1 engine interface is as specified in paragraphs 2.1.2 through 2.1.9 and as delineated in F-1 Engine Interface Document R-6749 and F-1 Engine Model Specification R-1420.

2.1.2 PURGE REQUIREMENTS.

2.1.2.1 Turbopump LOX Seal Purge System Requirements.

a. Fluid specification: gaseous nitrogen (MIL-P-27401)

b. Fluid supply filtration requirement: 40-micron (or finer) filter having a maximum pore size of 100 microns

c. Fluid temperature: 0° to 130° F

d. Nominal flowrate:

(1) 0.005 lb/sec at 80 psig (turbopump shaft not rotating)

(2) 0.029 lb/sec at 30 psig (turbopump shaft rotating)

e. Pressure: 60-100 psig

f. Transient pressure surges: 30-100 psig

g. Maximum allowable pressure during stage or facility checkout: 125 psig

h. Sequencing: required prior to admitting LOX to the engines, anytime LOX is in the
902 engines, when an engine is rotated from vertical
to horizontal, and for 30 minutes minimum after engine rotation to the horizontal position.

2.1.2.2. Operational High-Level LOX Dome and Gas Generator LOX Injector Purge System Requirements.

a. Fluid specification: gaseous nitrogen (MIL-P-27401)

b. Fluid supply filtration requirement: 40-micron (or finer) filter having a maximum pore size of 100 microns

c. Fluid temperature: 0° to 130° F

d. Nominal pre-start and cutoff flowrate: 1.75 lb/sec at 600 psig

e. Flowrate during static test: 0.16 lb/sec at 950 psig

f. Pre-start and cutoff pressure: 600-1,000 psig

g. Maximum lockup pressure: 1,200 psig

h. Transient pressure surges: within range of 600-1,200 psig

i. Sequencing:

(1) Engine starting: sequenced on, and system primed prior to engine start. The time of primed purge system flow must not exceed 4 minutes prior to engine start.

(2) Engine shutdown: engine cutoff signal plus 30 seconds for engine static test and launch abort

(3) Servicing: required for LOX dome and
gas generator LOX injector flush, LOX dome 902
flush, gas generator LOX injector flush, and live hypergol cartridge removal.

NOTE 915

The operational low-level LOX dome and gas generator LOX injector purge is interchangeable with the high-level LOX dome and gas generator LOX injector purge for these sequence requirements.

2.1.2.3 Operational Low-Level LOX Dome and Gas Generator LOX Injector Purge System Requirements.

a. Fluid specification: gaseous nitrogen (MIL-P-27401)

b. Fluid supply filtration requirement: 40-micron (or finer) filter having a maximum pore size of 100 microns

c. Fluid temperature: 0° to 130° F

d. Nominal flowrate: 0.68 lb/sec at 220 psig

e. Pressure: 120-600 psig 915

eA. Nominal pressure: 220 psig

f. Transient pressure surges: with a range of 120-1,200 psig

g. Sequencing:

915 (1) Must be on whenever the hydraulic control system pressure is cycled from zero psig to nominal, and back to zero psig with fuel and/or prefill in the engine.

(2) Must be sequenced on at engine cutoff signal during an engine static test or launch abort. Must not be sequenced off for a minimum of one hour after cutoff if mainstage was obtained.

(3) Required prior to and during gimbaling with prefill in the thrust chamber.

(4) Required while admitting prefill to the thrust chamber.

(5) Required anytime the gas generator ball valve, oxidizer valves, and fuel valves are cycled after completion of thrust chamber LOX dome and gas generator LOX injector flush.

(6) Required during fluid transfer for the thrust chamber liquid leak test, for thrust chamber fuel jacket drain, for thrust chamber fuel jacket flush, and for expended hypergol cartridge removal.

(7) Must be sequenced on and system primed prior to engine start.

902

NOTE

The operational high-level LOX dome and gas generator LOX injector purge is interchangeable with the low-level LOX dome and gas generator LOX injector purge for these sequence requirements.

2.1.2.4 Cocoon Purge System Requirements.

a. Fluid specification: gaseous nitrogen (MIL-P-27401)

b. Fluid supply filtration requirement: 40-micron (or finer) filter having a maximum pore size of 100 microns

c. Temperature, pressure, and flowrate must meet criteria specified in figure 2-1.

d. Sequencing:

(1) A heated purge must be cycled on between 15 minutes (minimum) and 30 minutes
907 (maximum) after LOX is admitted to the engine propellant feed system and remain on until launch commit.

(2) (Deleted)

(3) (Deleted) 907

(4) (Deleted)

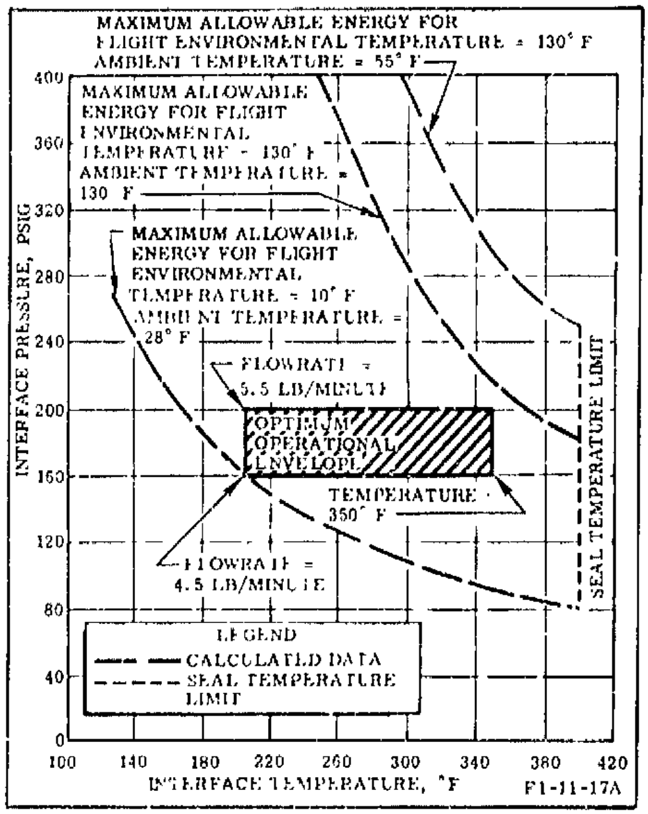


Figure 2-1. Cocoon Thermal Conditioning Requirements

2.1.2.5 G2030 LOX Dome and Gas Generator LOX Injector Purge System Requirements.

a. Fluid specification: gaseous nitrogen (MIL-P-27401)

b. Fluid supply filtration requirement: 40-micron (or finer) filter having a maximum pore size of 100 microns

c. Fluid temperature: 0° to 130° F

d. Nominal flowrate: 1.26 lb sec at 175 psig

e. Pressure: 150-200 psig

002 f. Sequencing: required for LOX dome and gas generator LOX injector flush, LOX dome
015 flush,and gas generator LOX injector flush.

2.1.2.6 Thrust Chamber Fuel Jacket Purge System Requirements.

a. Fluid specification: gaseous nitrogen (MIL-P-27401)

b. Fluid supply filtration requirement: 40-micron (or finer) filter having a maximum pore size of 100 microns

c. Fluid temperature: 0° to 130° F

d. Pressure: 300-400 psig

e. Nominal flowrate: 0.37 lb/sec at 350 psig

f. Sequencing: required for LOX dome and
015 002 gas generator LOX injector flush, LOX dome flush, thrust chamber fuel jacket flush, and live hypergol cartridge removal.

2.1.2.7 Hypergol Servicing Purge System Requirements.

a. Fluid specification: gaseous nitrogen (MIL-P-27401)

b. Fluid supply filtration requirement: 40-micron (or finer) filter having a maximum pore size of 100 microns

c. Fluid temperature: 0° to 130° F

d. Pressure: 100-200 psig

e. Nominal flowrate: 0.16 lb/sec at 150 psig

f. Sequencing: required for spent hypergol
015 002 cartridge removal, LOX dome and gas generator LOX injector flush, and LOX dome flush.

2.1.2.8 Hypergol Malfunction Purge System Requirements.

a. Fluid specification: gaseous nitrogen (MIL-P-27401)

b. Fluid supply filtration requirement: 40-micron (or finer) filter having a maximum pore size of 100 microns

c. Fluid temperature: 0° to 130° F

d. Pressure: 700-800 psig

e. Sequencing: required for live hypergol
002 cartridge removal.

2.1.2.9 Igniter Fuel Valve Lockup Requirements.

a. Fluid specification: gaseous nitrogen (MIL-P-27401)

b. Fluid supply filtration requirement: 40-micron (or less) filter having a maximum pore size of 100 microns

c. Fluid temperature: 0° to 130° F

d. Pressure: 725-775 psig (static pressure, no flow)

e. Sequencing: required for live hypergol cartridge removal.

2.1.2.10 Turbopump Preservation Servicing Purge System Requirements.

a. Fluid specification: gaseous nitrogen (MIL-P-27401)

b. Fluid supply filtration requirement: 40-micron (or finer) filter having a maximum pore size of 100 microns

c. Fluid temperature: 0° to 130° F

d. Pressure:

(1) Engines not incorporating MD145 change: 25-45 psig

(2) Engines incorporating MD145 change: 5-10 psig 014

e. Flowrate:

(1) Engines not incorporating MD145 change: 0.01 lb/sec at 35 psig

(2) Engines incorporating MD145 change: 0.003 lb/sec at 7.5 psig 014

f. Sequencing: required for turbopump preservation. 002

2.1.3 HEAT EXCHANGER REQUIREMENTS.

2.1.3.1 Heat Exchanger Helium Inlet System Requirements.

a. Helium specification: Bureau of Mines, Grade A

b. Helium supply filtration requirement: 40-micron (or finer) filter having a maximum pore size of 100 microns

c. Helium inlet pressure-temperature: -400° to +130° F at a pressure not exceeding 400 psig

d. Flowrate: 1.00 lb/sec maximum

e. Sequencing: Stage Contractor responsibility

2.1.3.2 Heat Exchanger Helium Outlet System Conditions.

a. Helium outlet pressure-temperature: -400° to +500° F at a pressure not exceeding 325 psig

b. Helium flowrate: 1.00 lb/sec maximum

c. Helium transient pressure surges: surges not exceeding 400 psig

d. Sequencing: Depends on paragraph 2.1.3.1 sequencing.

2.1.3.3 Heat Exchanger GOX Output Conditions.

a. Fluid specification: heated GOX (MIL-P-25508)

b. Fluid cleanliness:

(1) Maximum particulate matter size: 200 microns

(2) Maximum soluble hydrocarbon content: 75 ppm

(3) Maximum acetylene content: 1-1/2 ppm

c. GOX flowrate: 3-15 lb/sec

d. GOX throttle limits: Flowrate must not be throttled below 3 lb/sec.

e. GOX temperature: 400° to 500° F at engine interface with flowrate at 4 lb/sec

f. GOX pressure: 1,360 psig nominal discharge pressure

g. Sequencing: Heated GOX is supplied within one second after engine control valve start signal, and flow terminates 0.75 second maximum after engine control valve stop signal.

2.1.4 OXIDIZER FEED REQUIREMENTS.

a. Fluid specification: liquid oxygen (MIL-P-25508)

b. Fluid cleanliness:

(1) Supply filtration requirement: 70-micron (or finer) filters having a maximum pore size of 200 microns

(2) Maximum soluble hydrocarbon content: 75 ppm

(3) Maximum acetylene content: 1-1/2 ppm

c. Nominal fluid flowrate: 3,950 lb/sec

d. Fluid pressure-temperature: within limits specified in figures 2-2 and 2-3

e. Supply transient pressures: Maximum allowable static pressure surge must not exceed 335 psig.

f. Pressurizing media: The following fluids may be used to prepressurize and to pressurize the oxidizer propellant:

(1) Gaseous nitrogen (MIL-P-27401)

(2) Gaseous oxygen (MIL-P-25508)

(3) Helium (Bureau of Mines, Grade A)

g. Sequencing: Liquid oxygen must be supplied to the oxidizer pump inlet a minimum of 90 minutes prior to engine control valve start signal. The stage-provided oxidizer prevalve must be sequenced to the closed position after a time delay that allows the engine oxidizer valves to reach the closed position.

2.1.5 FUEL FEED REQUIREMENTS.

a. Fluid specification: RP-1 fuel (MIL-R-25576)

b. Fluid supply filtration requirement: 70-micron (or finer) filters having a maximum pore size of 200 microns

c. Nominal fluid flowrate: 1,750 lb/sec

d. Fluid pressure-temperature: within limits specified in figures 2-3 and 2-4

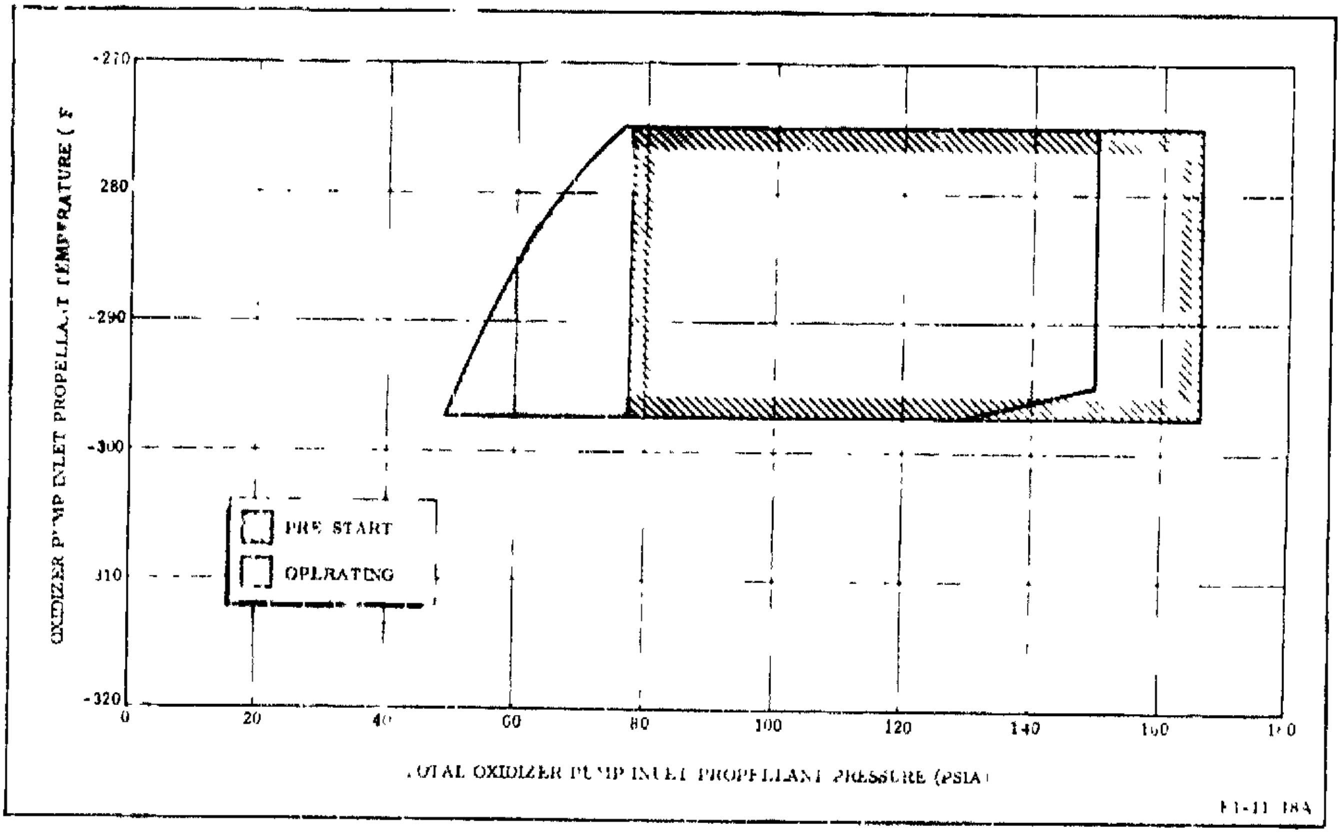


Figure 2-2. LOX Pump Inlet Conditions

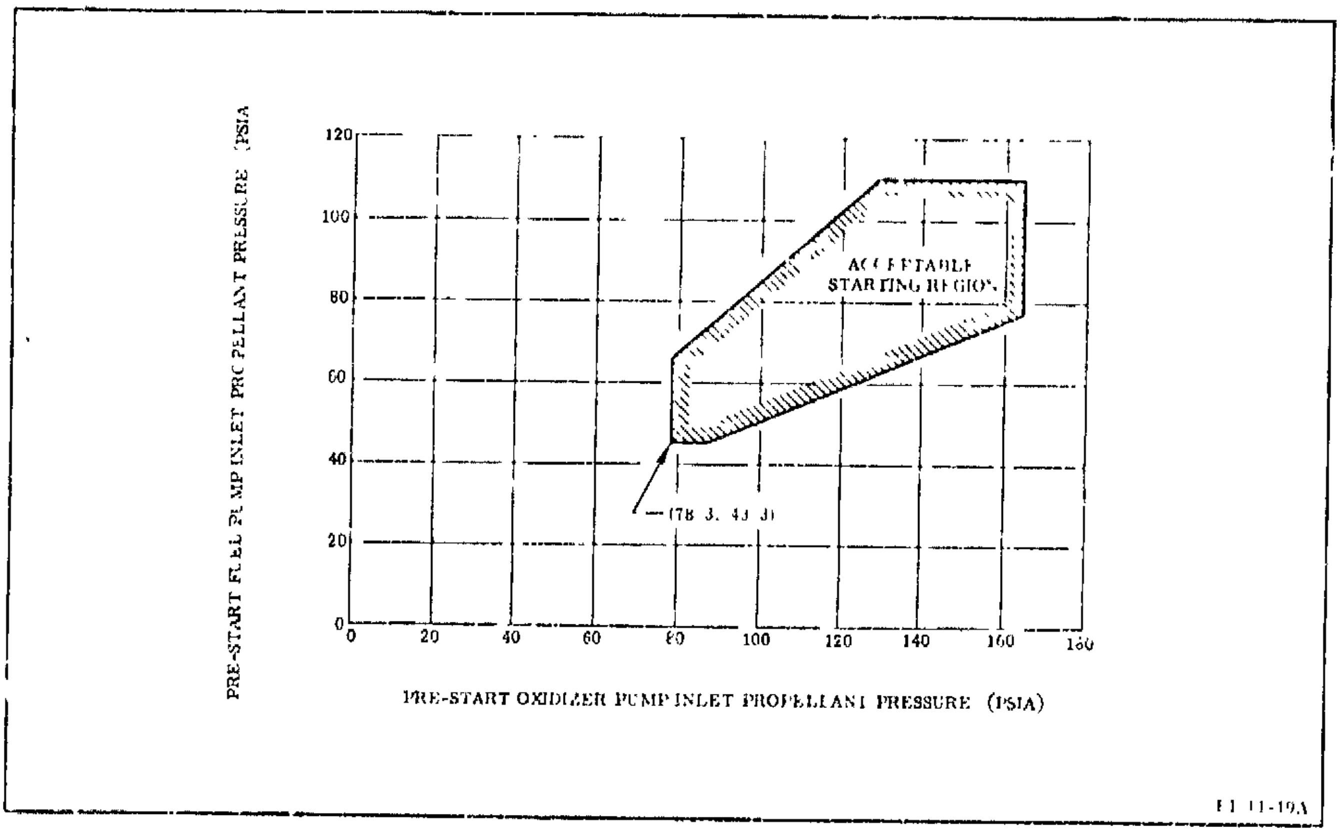


Figure 2-3. Acceptable Pump Inlet Pressures

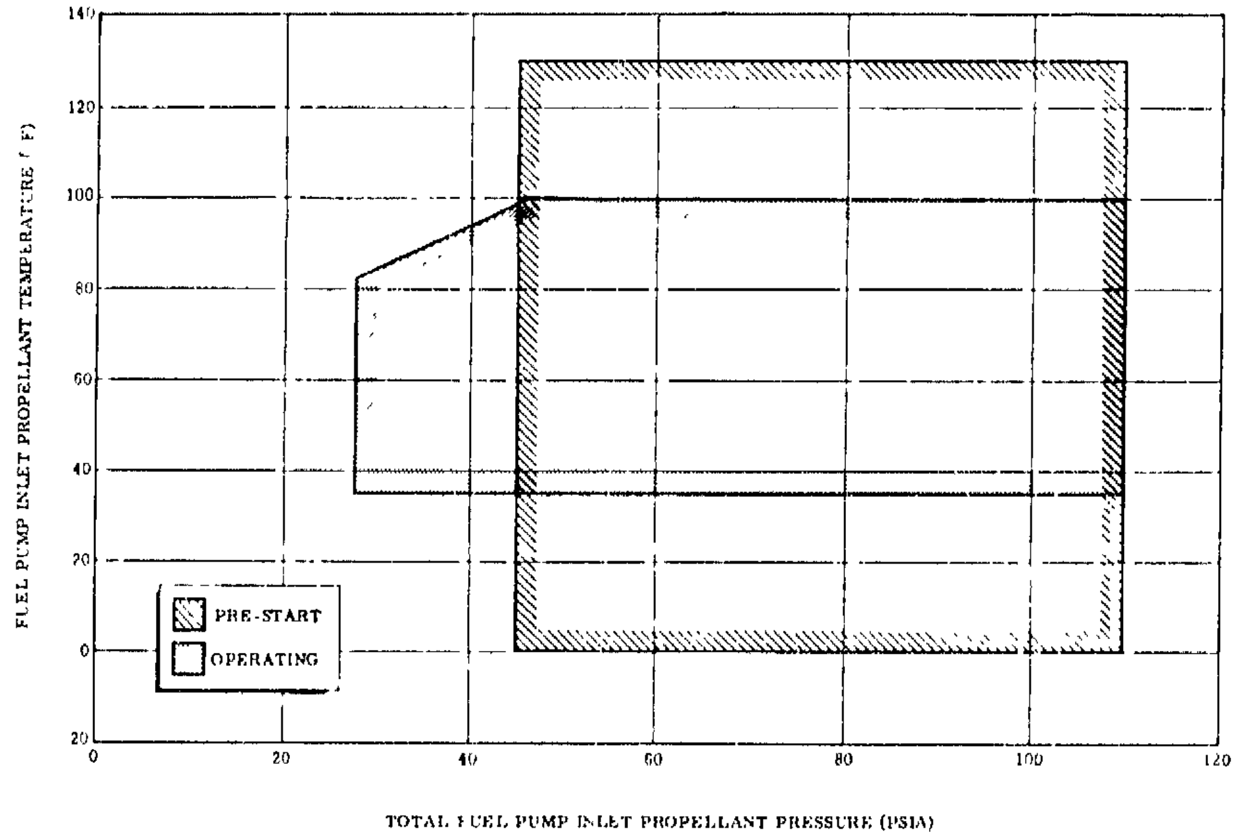


Figure 2-4. Fuel Pump Inlet Conditions

e. Supply transient pressures: Maximum allowable static pressure surge must not exceed 360 psig.

f. Pressurizing media: Gaseous nitrogen (MIL-P-27401) or helium (Bureau of Mines, Grade A) may be used for prepressurization and pressurization of the fuel propellant.

g. Sequencing: Fuel must be supplied to the fuel pump inlets a minimum of 60 minutes prior to the engine control valve start signal. The stage-provided fuel pre-valves must be sequenced to the closed position after a time delay that allows the engine fuel valves to reach the closed position and after the stage-provided oxidizer pre-valve has reached the closed position.

2.1.6 HYDRAULIC GROUND SUPPLY REQUIREMENTS.

a. Fluid specification: RP-1 fuel (MIL-R-25576) or RJ-1 fuel (MIL-F-25558)

b. Fluid supply filtration requirements: 10-micron (or finer) filter having a maximum pore size of 25 microns

c. Fluid flowrate: Fluid must be supplied to the engine connect point at a nominal steady-state flowrate of 12 gpm with a transient flowrate of 35 gpm.

d. Fluid temperature: 35° to 130° F with no liquid oxygen in engine propellant feed system and 60° to 130° F with liquid oxygen in engine propellant feed system.

e. Bleeding: The engine hydraulic control system must be bled of entrapped air before energizing the engine control valve start solenoid after initial application of hydraulics
909 to the engine and any time thereafter that hydraulic system is invalidated by drainage. Entrapped air can be removed by circulating hydraulic fluid through the system at 1,000 psig (minimum) for a period 15 minutes (minimum).

f. Operating pressures: The hydraulic control system pressure must be supplied to and removed from the engine in such a manner as to preclude the possibility of the return pressure exceeding the supply pressure. Pressures are as follows:

(1) If fuel valve leakage occurs without the hydraulic control system pressurized, hydraulic pressure steady-state limits must be maintained between 415 and 1,850 psig, and pressure tran-
902 sient limits (including surges resulting from gimbaling) between 415 and 3,000 psig must be maintained at all times fuel or prefill is in the engine without drain hoses installed on thrust chamber fuel inlet manifold drain quick-disconnects.

(2) During and after LOX admittance to the engine but prior to checkout valve actuation to the engine position during engine starting, hydraulic pressure steady-state limits must be maintained between 1,450 and 1,850 psig, and transient pressure surges (including surges resulting from gimbaling) between 415 and 2,000 psig.

(3) During engine starting prior to checkout valve actuation to the engine position, hydraulic pressure steady-state limits must be maintained between 1,450 and 1,650 psig.

(4) During engine starting, hydraulic pressure as measured at the engine control valve must not decrease below 900 psig or remain below 1,200 psig for a time period in excess of 40 milliseconds.

g. In the event fuel is loaded on the stage with the stage prevalves closed, and a minimum of 415 psig hydraulic control pressure is not applied to the engine, drain lines must be installed on either the No. 1 and/or No. 2 fuel pump inlet drain quick-disconnect and the drain line must be monitored for fuel pre-valve leakage.

2.1.7 PREFILL SUPPLY REQUIREMENTS

a. Fluid specification: ethylene glycol RB0210-017 (Rocketdyne)

b. Fluid cleanliness: The solution must be colorless, clear, and free of sediment.

c. Fluid flowrate: 10-20 gpm

d. Fluid pressure: 20-40 psig

e. Fluid temperature: 0° to 130° F

f. Composition: distilled or deionized water containing 50 ±1 percent by weight of ethylene glycol

g. Acidity: pH of solution, 6.5 ±1.5

h. Specific gravity: 1.0640 ±0.0015 at 26° C

i. Flash point: must not flash

j. Gallons required: approximately 105 gallons not including overflow

2.1.8 FLUSHING SOLVENT SUPPLY REQUIREMENTS.

2.1.8.1 LOX Dome and Gas Generator LOX Injector Flushing System Requirements.

a. Solvent specification: trichloroethylene RB0210-003 (Rocketdyne) free of sediment and suspended matter. Alternate solvents that may be used are as follows:

(1) Trichloroethylene (MIL-T-27602) or MB0210-003 (North American Rockwell Corp, Space Division) may be used as a LOX dome and gas generator LOX injector flushing agent provided a minimum of 48 hours is allowed to elapse between engine flushing and engine firing.

(2) Trichloroethylene (Federal Specification O-T-634, Type I) may be used as a LOX dome and gas generator LOX injector flushing agent provided it has passed the residue-soluble-in-carbon-tetrachloride test of MIL-T-27602 or RB0210-003 (Rocketdyne) and a minimum of 48 hours is allowed to elapse between engine flushing and engine firing.

(3) Trichloroethylene (MSFC-SPEC-217) may be used as a LOX dome and gas generator LOX injector flushing agent provided it has passed the residue-soluble-in-carbon-tetrachloride test of MIL-T-27602 or RB0210-003 (Rocketdyne) and a minimum of 18 hours is allowed to elapse between engine flushing and engine firing.

b. Solvent must be supplied to Oxidizer Dome Flushing Kit G2030 installed on the engine as shown in figure 2-5 and as follows:

(1) Flowrate: 9.9 gpm nominal

(2) Pressure: 80-100 psig

(3) Temperature: 0° to 130° F

2.1.8.2 Thrust Chamber Fuel Jacket Flushing Requirements.

a. Solvent specification:

(1) Trichloroethylene RB0210-003 (Rocketdyne)

(2) Trichloroethylene MB0210-003 (North American Rockwell Corp, Space Division)

(3) Trichloroethylene (Federal Specification O-T-634, Type I)

(4) Trichloroethylene (MSFC-SPEC-217)

(5) Trichloroethylene (MIL-T-27602)

b. Fluid cleanliness: free of sediment and suspended matter

c. Solvent must be supplied to the two thrust chamber fuel inlet manifold quick-disconnects for thrust chamber fuel jacket flushing as follows:

(1) Flowrate: 10 gpm nominal

(2) Pressure: 80-100 psig

(3) Temperature: 0° to 130° F

2.1.9 PRESERVATION FLUID SUPPLY REQUIREMENTS. A system must be provided to supply a minimum of 5 gallons of preservative fluid for turbopump preservation meeting the following requirements:

a. Fluid specification. corrosion preventive MIL-C-14201, Grade 2. The only acceptable alternate is corrosion preventative RB0210-016 (Rocketdyne).

b. Fluid cleanliness: supply filtration requirement of a 75-micron (or finer) filter during recirculation and a 40-micron (or finer) in-line filter during delivery to the turbopump.

c. Nominal fluid flowrate: 4.7 gpm at 200 psig (on engines incorporating MD145 change,
614 1.5 gpm at 80 psig)

d. Fluid pressure (monitored at instrumentation tap LB1b): 175-225 psig (on engines incorporating MD145 change, 70-90 psig)

e. Fluid temperature: 70° to 95° F during fluid recirculation and delivery to turbopump

f. Mixing requirement: fluid recirculated a minimum of 10 minutes prior to fluid delivery to turbopump bearings

g. On engines incorporating MD145 change, a suction pump is required with a flow capability of 2-8 gpm.

2.1.10 CORROSION-PREVENTIVE REQUIREMENTS.

a. Fluid specifications:

(1) Unpainted working surfaces: lubricating oil (Federal Specification VV-L-800)

(2) Unpainted stationary surfaces: corrosion-preventive compound (MIL-C-16173, Grade 1) or corrosion preventative RB0210-016 (Rocketdyne)

b. Mixing requirement: Corrosion preventative RB0210-016 (Rocketdyne) must be thoroughly mixed at 70° to 95° F immediately prior to each application.

2.2 ELECTRICAL INPUT REQUIREMENTS.

2.2.1 AC POWER REQUIREMENTS.

a. Control system requirements:

(1) Turbopump heater No. 1: 190-220 vac, 60 cps, 1,500 watts maximum load

(2) Turbopump heater No. 2: 190-220 vac, 60 cps, 1,500 watts maximum load

(3) Igniters: 500-750 vac, 60 cps, 10,000 watts maximum load

b. Instrumentation system requirements:

(1) Turbopump rpm transducer: 5 to 7.5 vac, 200 cps, 0.2 watt maximum load for ground checkout

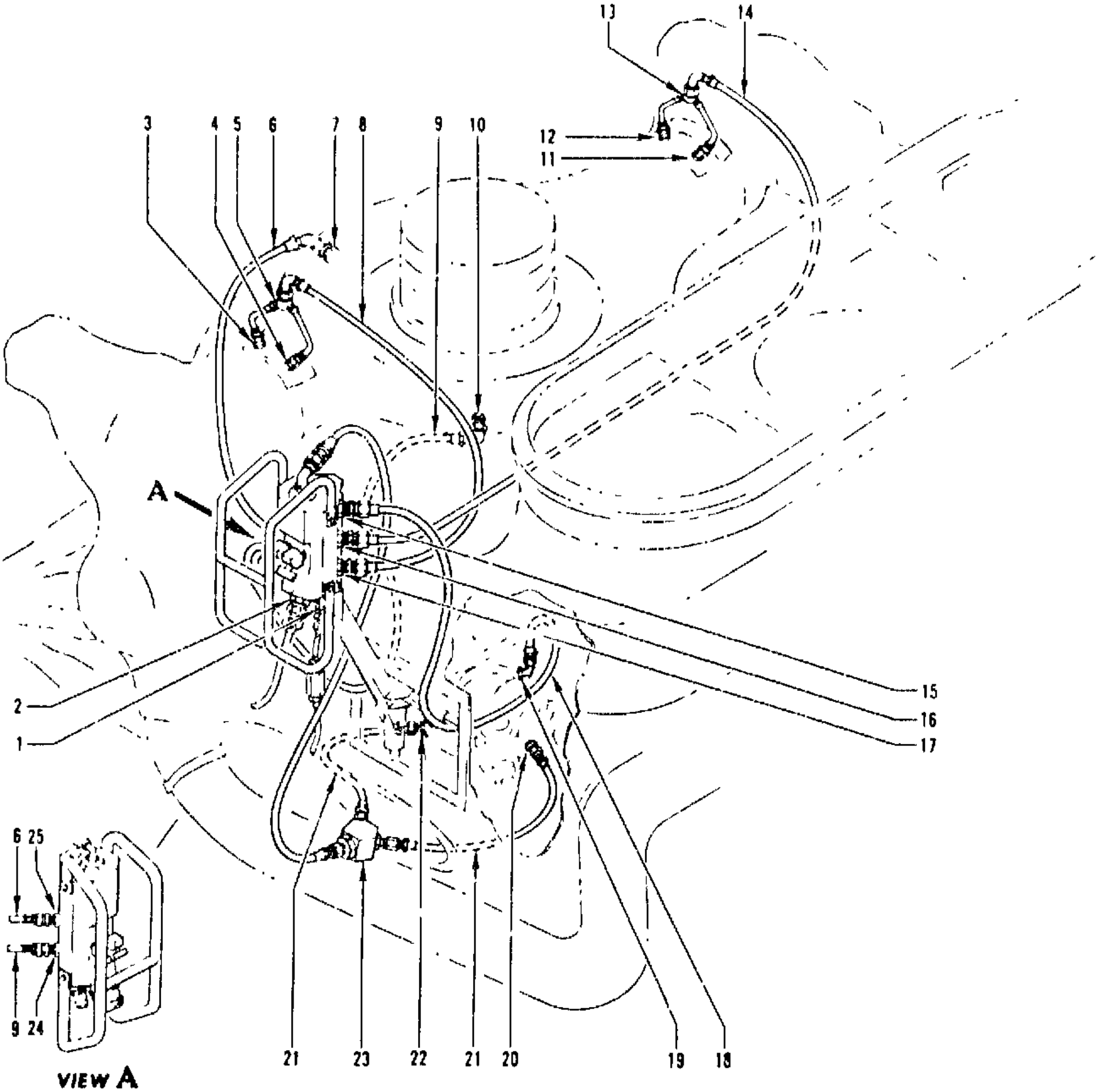
(2) Oxidizer flowmeter: 5 to 7.5 vac, 200 cps, 0.2 watt maximum load for ground checkout.

2.2.2 DC POWER REQUIREMENTS.

a. Control system requirements:

(1) Voltage level: 24-30 vdc under load conditions until 0.5 second after completion of
start sequence, and 20-30 vdc thereafter pro- 906
viding a maximum of 80 watts for 0.100 second and 65 watts thereafter for engine shutdown.

(2) Ripple voltage: 1.5 volts maximum when measured with a peak reading vacuum tube voltmeter connected in series with a 40-microfarad capacitor. The higher of the two values measured when the voltmeter is successively connected for each of the two polarities is defined as ripple voltage.



LEGEND

1 TRICH PORT
2 GN_2 PORT
3 PURGE 1B PORT
REDUCER AN919-15C
SEAL 12100CR8
4 PURGE 1A PORT
REDUCER AN919-15C
SEAL 12100CR8
5 ADAPTER 9024153
6 HOSE R3806-12-1080
7 PURGE NO. 4 PORT
UNION AN833-12D
SEAL 12100CR12
8 HOSE R3806-12-0500
9 HOSE R3806-12-0600
10 PURGE NO. 3 PORT
UNION AN815-12C
SEAL 12100CR12
11 PURGE 2B PORT
REDUCER AN919-15C
SEAL 12100CR8
12 PURGE 2A PORT
REDUCER AN919-15C
SEAL 12100CR8
13 ADAPTER 9024153
14 HOSE R3806-12-1000
15 NO. 5 0800 PORT
16 NO. 2 1000 PORT
17 NO. 1 0500 PORT
18 HOSE R3806-12-0800
19 ADAPTER 9022103
20 TAP GF2A
DIFFUSER 9023934
21 HOSE 19-9014938-11
22 TAP GF2B
DIFFUSER 9023934
23 ADAPTER 9025254
24 NO. 3 0600 PORT
25 NO. 4 1080 PORT

F1-11-23A

Figure 2-5. Oxidizer Dome Flushing Kit Installation

(3) Maximum voltage transient limits: 50-volt positive pulse with a time width of 10 microseconds and a repetitive rate of 20 pulses per second

(4) DC control system power requirement:
932 290 watts maximum

b. Instrumentation system requirements:

(1) Circuit separation: Separate circuits must be provided for pressure transducer power, valve position power, electrical simulation circuits (except for turbopump speed and heat exchanger flows), and all resistance-type temperature transducers.

(2) Pressure transducer and simulation circuit voltage level: 24-32 vdc. Continuous maximum application of 30-32 vdc must not exceed 60 seconds.

(3) Pressure transducer and simulation circuit ripple voltage: 0.1 volt maximum when measured with a peak reading vacuum tube voltmeter in series with a 4.0-microfarad capacitor. The higher of the two values measured when the voltmeter is successively connected for each of the two polarities is defined as the ripple voltage.

(4) Pressure transducer and simulation circuit maximum voltage transient limits: 50-volt positive pulse with a time width of 10 microseconds and a repetitive rate of one pulse per second

(5) Temperature transducer power requirement: 100 microwatts maximum for each transducer

(6) Valve potentiometer voltage and power levels: 4.99 to 5.01 vdc, 0.50 watts maximum

(7) Valve position switches voltage and current levels: 24-32 vdc, one ampere maximum

(8) Potentiometer circuit ripple voltage. 0.025 volt maximum when measured with a peak reading vacuum tube voltmeter connected in series with a 4.0-microfarad capacitor. The higher of the two values measured when the voltmeter is successively connected for each of the two polarities is defined as ripple voltage.

2.2A <u>ENGINE REQUIREMENTS ON STANDBY STATUS.</u>

2.2A.1 <u>STANDBY STATUS DEFINITION.</u> Standby status is defined as the time period that uninstalled flight spare or installed engines wait for the next authorized activity to start. These engines are not in storage, per MSFC-STD-500.

2.2A.2 <u>PREPARATION OF UNINSTALLED ENGINE FOR STANDBY STATUS.</u>

a. Visually verify that all exposed and accessible portions of engine are not damaged. Damage, if any, must be within limits specified in section I.

b. Coat all machined areas of thrust chamber outrigger arms, turbopump mounts, and inside and outside diameter of engine handler bearing with corrosion preventative.

c. Repaint all turbopump and outrigger arm surfaces that contain scratches.

d. Remove any corrosion from gas generator
feed line gimbal joint yokes; then coat yokes with 930
corrosion preventative.

e. Remove any corrosion from gas generator fuel and oxidizer feed line bellows.

f. Verify or install 425 aluminum-foil tape (Minnesota Mining and Mfg) over space between thrust chamber exhaust manifold and thrust chamber tubes, and white sealant RTV-102 (General Electric) between thrust chamber tubes and bands. White sealant is only required on engines where sealant was installed during engine manufacture.

g. Replace or install any broken lockwire, and plug any open engine taps.

h. Refill any void in turbopump housing cavity material.

i. Determine if turbopump requires re-preservation; re-preserve turbopump (if required) and enter date in Engine Log Book. Refer to paragraph 2.4.11 for re-preservation limits and to Engine Log Book for date of last turbopump preservation.

j. Verify that LOX pump and fuel inlet closures are installed and that desiccant in closures is as specified in paragraph 2.3.6.2.

k. Verify that thrust chamber throat closure is installed and that desiccant in closure is as specified in paragraph 2.3.6.2.

l. Install Gimbal Bearing Locks G4059.

m. Visually verify that oxidizer overboard drain and nitrogen purge overboard drain line exits are free of fluid.

n. Install all protective closures except for fuel overboard drain line exit.

o. Install suitable drainage line on fuel overboard drain line exit, or drain bag, and route line exit so that leakage flows externally from engine.

p. Install engine on Air Transport Engine Handler G4044, Engine Handler G4069, or Engine Handling Dolly G4058, or equivalent.

930
q. Cover engine with Engine Cover G4047, or equivalent.

r. Place engine in an environmentally controlled area meeting criteria specified in paragraph 2.3.1. Do not place engine in a position where LOX pump elevation is below fuel pump elevation by more than 7 degrees.

2.2A.3 PREPARATION OF INSTALLED ENGINES FOR STANDBY STATUS.

a. Visually verify that all exposed and accessible portions of engine are not damaged. Damage, if any, must be within limits specified in section I.

b. Coat all exposed machined areas of thrust chamber outrigger arms, turbopump mounts, and inside and outside diameter of engine handler bearing with corrosion preventative.

c. Repaint all turbopump and outrigger arm surfaces that contain scratches through paint.

d. Remove any corrosion from gas generator feed line gimbal joint yokes; then coat yokes with corrosion preventative.

e. Remove any corrosion from gas generator fuel and oxidizer feed line bellows.

f. Verify or install 425 aluminum-foil tape (Minnesota Mining and Mfg) over space between thrust chamber exhaust manifold and thrust chamber tubes and thrust chamber, and white sealant RTV-102 (General Electric) between thrust chamber tubes and bands. White sealant is only required on those engines in which sealant was installed during engine manufacture.

g. Replace or install any broken lockwire, and plug any open engine taps.

h. Refill any voids in turbopump housing cavity filler material.

i. Determine if turbopump requires re-preservation; re-preserve turbopump, if required, 930
and enter date in Engine Log Book. Refer to paragraph 2.4.11 for re-preservation limits. Refer to Engine Log Book for date of last turbopump preservation.

j. Install desiccant in thrust chamber throat security closure as specified in paragraph 2.3.6.2.

k. Install thrust chamber throat security closure.

l. Visually verify that oxidizer overboard drain and nitrogen purge overboard drain line exits are free of fluid.

Change - see [illegible] No 69

m. For engines installed in a horizontal stage, perform the following:

(1) Install all protective closures.

(2) Remove and replace fuel overboard drain system bags with drain hoses, and route hoses so that leakage flows externally from engine.

n. For engines installed in a vertical stage, install all protective closures except for fuel overboard drain line exit. Install suitable drainage line on fuel overboard drain line exit so that leakage flows externally from engine.

o. Lock engine to stage attachment gimbal
930 actuators to prevent engine movement. Do not lock actuators in positions that will cause LOX pump elevation to be below fuel pump elevation by more than 7 degrees.

p. Place stage in an environmentally controlled area meeting criteria specified in paragraph 2.3.1.

2.3 ENVIRONMENTAL REQUIREMENTS.

2.3.1 ENGINE ENVIRONMENTAL CONDITIONS. The engine must be stored to preclude
930 engine exposure to rain, sand, dust, etc. The ambient temperature of the engine environment must be within -20° to +140° F at a relative humidity of less than 95 percent except when the engine is stored in the environment specified by Standard S-IC Stage Storage Specification MSFC-STD-500. During engine handling, with the engine installed in authorized handling equipment, the engine must not be exposed to acceleration loads exceeding 4g in any direction. All parts of the engine that require protective closures or covers must be protected at all times unless otherwise indicated by the applicable procedures or requirements in this manual or by Standard S-IC Stage Storage Specification MSFC-STD-500.

a. Install suitable protective closures and/or covers on components and assemblies immediately after removal from engine.

b. Install suitable protective closures and/or covers on joints of engine where a component or assembly is removed, immediately after removal.

c. Transport components or assemblies requiring rework or inspection to an environmentally controlled area before removing protective closures and/or covers.

d. Do not remove protective closures and/or covers from components, assemblies, or engine joints until immediately prior to installation of components and assemblies on engine.

e. Inspect humidity indicators of engines in storage and standby status in accordance with
section I requirements within a minimum of 910
one-calendar-month intervals and as follows:

(1) Engines stored in accordance with Standard S-IC Stage Storage Specification MSFC-STD-500: If the 40-percent storage
environment is exceeded, the humidity indi- 930
cators must be inspected following correction of the environmental conditioning problem.

(2) Engines in standby status: The humidity indicators must be inspected following exposure of the engine to an environment outside limits specified in paragraph 2.3.1.

f. (Deleted) 901

g. Closures that require desiccant are as follows:

Closure Use	Units Required
LOX inlet	16[a]
Fuel inlet	16 (each inlet)[a]
Thrust chamber throat	48

h. Replace desiccant each time desiccated closures are removed for more than 5 minutes unless desiccant or closure with installed desiccant is immediately placed in a desiccant storage container as outlined in paragraph 2.3.6.1

2.3.2 NOZZLE EXTENSION ENVIRONMENTAL CONDITIONS. The nozzle extension must be stored horizontally or vertically on approved handling equipment or pallets and covered to prevent exposure to rain, sand, dust, etc.

2.3.3 PYROTECHNIC IGNITER ENVIRONMENTAL CONDITIONS. The order of usage for pyrotechnic igniters is (1) earliest date of manufacture and (2) earliest date of removal from container.

2.3.3.1 Pyrotechnic Igniter Storage. The storage area for pyrotechnic igniters must be a structure specifically designed, located, and designated for storage of ordnance. If pyrotechnic igniters containing one microcurie of radium are stored in excess of 100 units (either live or spent), the storage area should display a radiation identification and should be separate from nonradiating igniters. A maximum of 1,500 units (live or spent) is recommended for storage without special shielding and packaging. The handling and storage of live and spent igniters that contain radiation material should be coordinated with the radiation safety officer at the using activity. Storage area traffic must be kept to a minimum, a high level of housekeeping must be maintained, and the general safety practices must be consistent with the best practices for explosive storage areas. Every effort must be made to maintain the storage area environment as constant as possible, keeping the relative humidity as low as possible and the temperature between 0° and 120° F.

(a) Only 12 units are required when using closures having single seals on the desiccant cover.

2.3.3.2 Pyrotechnic Igniter Service Life. The pyrotechnic igniter must be stored in its original shipping container (can) in an approved storage area until ready for use. Service life of a pyrotechnic igniter is as follows:

a. Twenty-four months maximum from date of manufacture when packaged and stored in its original container.

NOTE

The expiration date noted on the pyrotechnic igniter container is determined by adding 24 months to the date of manufacture.

- The "Install Igniter Before" date applies only to igniters that are installed in a ready-to-fire state for periods up to 6 months.

b. The shipping container must be tagged or labeled with the date the pyrotechnic igniter was first removed from the container. The "Date First Removed" tag or label provides information for establishing the issue/usage requirements.

c. A pyrotechnic igniter removed from its shipping container and not installed on an engine must be repackaged as outlined in paragraph 2.3.3.3.

CAUTION

The out-of-container uninstalled period must be held to a minimum to provide maximum protection from handling and environmental damage.

d. A pyrotechnic igniter removed from an engine due to cancellation of static test or launch is acceptable for reuse providing:

(1) The shipping container is labeled with date of removal from engine.

(2) The protective closure cap and shorting cap are installed immediately.

(3) The igniter is not visually damaged.

(4) The igniter gasket is discarded and replaced with a new gasket.

(5) The igniter is repackaged as outlined in paragraph 2.3.3.3.

(6) The repackaged igniter is returned to an approved storage area.

2.3.3.3 Pyrotechnic Igniter Repackaging. It is recommended that pyrotechnic igniters remain in the manufacturer's shipping container, undisturbed, until just prior to installation on the engine or other mandatory functions that require its removal. This will assure maximum packaging integrity and a minimum handling damage. During repackaging, the original shipping container must be used in order to retain information concerning dates, classification, etc. During installation of new desiccant, the elapsed time between removal of the desiccant from its container and installation in the igniter container must be held to a minimum. Repackage igniters as follows:

a. Make sure protective and/or shorting caps are installed. Install shorting cap when harness is disconnected from igniter.

b. Observe all safety precautions applicable at using organization, and wear recommended protective clothing.

c. Inspect original shipping container (can) and polyurethane foam wrap. If moisture is visually evident, dry container and replace polyurethane form with dry polyurethane foam.

d. Install 1/6 unit of new desiccant
934 RB0295-001 (Rocketdyne) in bottom of can.

e. Wrap igniter in polyurethane foam and place in can.

f. Install humidity indicator in can.

g. Secure lid or vaporproof barrier material (MIL-B-131) (0.002 inch thick minimum) to can with pressure-sensitive tape (Federal Specification PPP-T-60). Tape must extend over can end, and ends of tape must be secured by applying a layer of tape around periphery of can end.

NOTE

Vaporproof barrier material (MIL-B-131) may be replaced by a barrier material with equivalent moisture vapor transmission properties.

2.3.3.4 Pyrotechnic Igniter Disposal. Spent or used igniters should be collected and held for disposal in accordance with the instructions of the radiation safety officer of the using activity. Spent igniters should be treated as radioactive material in accordance with applicable Atomic Energy Commission regulations or in agreement with state regulations. The maximum number of igniters to be held for disposal is 1,500 (contains approximately 1.5 millicuries of radium).

2.3.4 HYPERGOL CARTRIDGE ENVIRONMENTAL CONDITIONS. The order of usage for the hypergol cartridge is (1) earliest date of manufacture and (2) earliest date of removal from container.

2.3.4.1 Hypergol Cartridge Storage. The storage area for hypergolic cartridges must be a structure specifically designed, located, and designated for storage of ordnance. Storage area traffic must be kept to a minimum, a high level of housekeeping must be maintained, and the general safety practices must be consistent with the best practices for flammable-liquid storage areas. Every effort must be made to maintain the storage area environment as constant as possible, keeping the relative humidity as low as possible and the temperature between 0° and 120° F.

2.3.4.2 Hypergol Cartridge Service Life. The hypergol cartridge must be stored in its original shipping container (can) in an approved flammable-liquids storage area until ready for use. Service life periods specified pertain to a hypergol cartridge that has not been mishandled or internally damaged in a manner that would not be readily visible. Service life is as follows:

a. Twenty-four months maximum from loading date when properly packaged and stored.

NOTE

The expiration date noted on the hypergol cartridge is determined by adding 24 months to the loading date.

b. The shipping container must be taped or 912
labeled with date hypergol cartridge was first removed from container. The "Date First Removed" tag or label provides information for establishing the issue/usage requirements.

bA. If the polyethylene bag (both bags if double
packaged) is noted to be torn after removing the 91
hypergol cartridge from the shipping container, the hypergol cartridge must be restored for service as outlined in paragraph 2.3.4.2A.

c. A hypergol cartridge removed from its shipping container must be immediately installed in an engine or repackaged as outlined in paragraph 2.3.4.3.

CAUTION

The out-of-container/uninstalled period must be held to a minimum to provide maximum protection from handling and environmental damage.

d. An unexpended hypergol cartridge removed from an engine due to cancellation of static test or launch is acceptable for reuse providing:

(1) The hypergol cartridge is repackaged as outlined in paragraph 2.3.4.3.

(2) The hypergol cartridge is not damaged during removal from engine or during repackaging.

(3) The shipping container is labeled with date of removal from engine and the container returned to an approved flammable-liquids storage area.

2.3.4.2A Hypergol Cartridge Restoration. A hypergol cartridge will be returned to a serviceable condition when the following requirements are met:

a. The existing packings and ring are removed from the hypergol cartridge.

b. The hypergol cartridge is thoroughly cleaned of all contaminants.

c. The hypergol cartridge is visually inspected and found to be free of contaminants and/or damage.

912 d. New packings are lubricated and packings and ring are installed on the hypergol cartridge.

2.3.4.3 Hypergol Cartridge Repackaging. The hypergol cartridge should remain installed in the manufacturer's shipping container undisturbed until just prior to installation in the engine, or any any other mandatory procedure requiring its removal. This will assure maximum packaging integrity and minimum handling damage. A hypergol cartridge is repackaged when the following requirements are met:

a. The hypergol cartridge is visually inspected and found to be free of contaminants and/or damage.

b. The hypergol cartridge shipping container and cushions are inspected and found to be free of moisture.

c. The hypergol cartridge is double packaged in individually sealed polyethylene bags before wrapping the hypergol cartridge in a cushion. The hypergol cartridge is wrapped in the cushion before inserting the hypergol cartridge into the shipping container with cushions positioned at each end of the hypergol cartridge. 912

d. The hypergol cartridge is repackaged in the original shipping container with the original information (concerning dates, classification, etc) retained.

e. Covers and gaskets are installed on each end of the shipping container and secured with locking rings.

2.3.4.4 Hypergol Cartridge Disposal. Spent or over-aged hypergol cartridges must be returned to Rocketdyne.

2.3.5 MISCELLANEOUS LOOSE EQUIPMENT ENVIRONMENTAL CONDITIONS. Miscellaneous loose equipment is defined as those items of engine equipment shipped with the engine and required for engine installation in the stage. Accountability of the equipment must be maintained and the equipment must be properly packaged. Storage environment must be within the 930
limits required for engine storage as outlined in paragraph 2.3.1.

2.3.6 DESICCANT ENVIRONMENTAL CONDITIONS. The F-1 engine closures require desiccant RB0295-001 (Rocketdyne) packaged in 934
dust-free, high-burst-and-tear-strength plastic bags. Desiccant used in engine closures must 934
not be reactivated. Packaged desiccant may be obtained in various unit sizes ranging from fractional units of 1/16, 1/3, and 1/2 to sizes of 1, 2, 4, 8, and 16 units and may be utilized in any combination.

2.3.6.1 Desiccant Storage. Desiccant must be stored in a sealed metal container (20- or 30-gallon size) having an airtight, gravity, self-locking door and an externally mounted humidity indicator with a three-spot indicating element for 20, 30, and 40 percent relative humidity ranges. A caution must be stenciled directly on the exterior of the container stating: "This container contains moisture-absorbent desiccant. Do not open container except to remove desiccant. Reseal immediately. Take only the quantity required for immediate use." If more than one size of desiccant is stored in a container, segregate units by packaging each size in separate plastic bags. The plastic bags may be closed in any manner that will provide ready access to the desiccant and that will eliminate the possibility of physical damage to desiccant bags. The relative humidity in the storage container must be maintained at less than 20 percent relative humidity. If the 20-percent spot on the storage container turns a color other than blue, the entire contents of the storage container must be replaced with a new supply of desiccant. Desiccant removed from the storage container and not installed and sealed in a closure within a maximum of 5 minutes, may be stored outside the container for a maximum of one hour if the desiccant is placed in a polyethylene bag (6-mil minimum thickness). Excess air must be squeezed from the bag and the open end of the bag must be folded, closed, and sealed with tape before the 5 minutes lapses.

2.3.6.2 Desiccant Installation. Desiccant must be stored as outlined in paragraph 2.3.6.1 until immediately prior to installation. The time phase between removal of desiccant from storage until sealing in a protective closure must not exceed 5 minutes, or desiccant must be
934 discarded. Desiccant bags must always be handled in a manner that will prevent tearing or rupturing of the bags. Immediately prior to installing desiccant in a closure, the desiccant bag must be wiped with a clean, hemmed, nylon cloth moistened with cleaning compound (MIL-C-81302). The quantity of desiccant used in a particular closure is as stated on the closure or as specified in this manual. Specific requirements for desiccant in relation to the engine are as follows:

WARNING

Cleaning compound (MIL-C-81302) is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

a. After engine receipt or during a receiving inspection, replace desiccant if 40-percent relative humidity indicator shows color other than blue.

b. During engine storage, make sure fuel closure, oxidizer closure, and thrust chamber
910 security closure 30-percent relative humidity indicators show blue color. If color other than blue is noted, change closure desiccant.

c. When desiccant is replaced, inspect
910 humidity indicator after 24 hours. If 30-percent relative humidity range shows color other than blue, replace desiccant and repeat inspection after 24 hours.

d. If relative-humidity indicator colors overrun their borders due to excessive moisture, replace indicator.

e. When desiccated protective closures are removed from engine, compare number of bags and units with number recorded and account for all desiccant before processing hardware. Note condition of bags. If hardware contamination is suspected as result of discrepant bags, verify condition of processing hardware.

2.4 MAINTENANCE REQUIREMENTS.

2.4.1 SEAL USAGE Seals from connections that have been disassembled must be replaced with like-serviceable items whenever a visual inspection reveals contaminants, nicks, scratches, or any other defect that may impair sealing capability. A new K-seal must be installed whenever a K-seal joint, except for seal monitoring port plugs, is loosened or opened. Pressure-actuated (Naflex) seals, except for the seal used at the oxidizer overboard drain line flange (at thrust chamber to nozzle extension 902 joint during static test at MTF), must be replaced and returned to the Engine Contractor for disposition whenever a joint is loosened or opened.

2.4.2 FASTENER USAGE. Bolts removed from the engine or components must be replaced whenever a visual inspection reveals damage to the bolthead, grip, threads, plating, or dry-film lubricant. Undamaged bolts may be reused unless otherwise specified. Nuts may be reused if threads and wrench flats are not damaged. Self-locking nuts may be reused if the locking feature still provides positive torque drag. Washers are reusable as long as the plating is not damaged and the surfaces are not deformed. Any engine fastener disturbed during performance of authorized activities must be retorqued to its applicable torque value at the completion of that activity.

2.4.3 FASTENER CROSS-TORQUE REQUIREMENT. The cross-torquing method must be used for multifastener application of flanges or joints, to apply evenly distributed axial loads to seals and gaskets. Torque must be applied in increments of one third of the total torque to be applied until all fasteners are evenly torqued to the desired torque value.

2.4.3A. DAMAGE DISPOSITION. All damage to the engine, regardless of magnitude or nature of discrepancy, must be considered as either one of the following conditions:

a. Acceptable without repair if within the acceptable damage limits specified in figure 1-3.

b. Not acceptable without repair or further evaluation to determine an appropriate disposition. This type of damage is identified by the entry "No damage allowable" in the Limits column of figure 1-3. Generally, this applies to damage for which no acceptable damage limits have been formulated. Each damage occurrence must be evaluated on an individual basis in accordance with the authorized site discrepancy reporting system.

2.4.4 COMPONENT REMOVAL, INSTALLATION, REPAIR, MODIFICATION, AND INSPECTION CONSTRAINTS. Component removal, replacement, and reinstallation must be accomplished using authorized and approved procedures and equipment. Field modifications of approved ECP's and inspections by FFIR's may be accomplished at any field location. See figures 2-6 for detail requirements on component replacement, reinstallation, and adjustment.

Component Nomenclature	When Component is Replaced	When Component Is Adjusted, Disturbed, or Reinstalled
Thrust chamber body	(a) (b) (c)	(c)
Thrust chamber injector	(a) (b) (c)	(a) (b) (c)
Thrust chamber dome	(a) (b) (c) (d)	(a) (c) (d)
Turbopump	(b) (c)	(b) (c)
LOX pump inlet	(b)	(b)
Heat exchanger	(e)	(e)
No. 1 or No. 2 main LOX orifice plate	(c)	
No. 1 or No. 2 main fuel orifice plate	(c)	
Interface panel	(b)	(b)
Gimbal	(a)	(a)
No. 1 or No. 2 fuel pump inlet duct	(b)	(b)
Adjustment of brackets and associated lines:		
Heat exchanger helium outlet	(e)	(e)
Heat exchanger helium inlet	(e)	(e)
Heat exchanger GOX outlet	(e)	(e)
Hydraulic ground supply	(e)	(e)
Hydraulic ground return	(e)	(e)
High-pressure ducts	(c)	(c)

(a) Adjust gimbal X_G and Z_G axes using Gimbal Bearing Locks G4059, holding fixture T-5037454, and check fixture T-5037452 so that dimensions from gimbal center to outer diameter surface of 4 thrust chamber injector alinement pins are within 0.010 inch. Record new gimbal settings in Engine Log Book.
(b) Verify that interface location dimensions are within limits specified in F-1 Engine Interface Document R-6749.
(c) Reaffirm that propellant duct fit check and alinement are within limits of figure 2-7.
(d) A torque check of the outer dome bolts is required at completion of second firing (first if only one is performed).
(e) Using appl cable holding fixture T-5037454; alinement tools T-5039113, T-5041233, and T-5040948; and Gimbal Bearing Locks G4049, adjust bracketry and/or associated lines to correct locations.

Figure 2-6. Component Replacement, Reinstallation, and Adjustment Requirements (Sheet 1 of 2)

Component Nomenclature	When Component is Replaced	When Component Is Adjusted Disturbed, or Reinstalled
High-pressure duct spacers	(c)	(c)
No. 1 and/or No. 2 oxidizer valves	(c)	(c)
No. 1 and/or No. 2 fuel valves	(c)	(c)
Hydraulic control system lines	(f)	(f)
Cocoon conditioning purge line	(f)	(f)
LOX dome and gas generator LOX injector purge line	(f)	(f)
LOX pump seal purge line	(f)	(f)
Bearing coolant control valve	(g)	(g) 902

(c) Reaffirm that propellant duct fit check and alinement are within limits of figure 2-7.
(f) Reaffirm that line alinement is within limits of figure 2-8.
902 (g) Orifice size must be the same as that specified in the Engine Log Book.

Figure 2-6. Component Replacement, Reinstallation, and Adjustment Requirements (Sheet 2 of 2)

Joint Location	Maximum Axial Gap at Largest Space (Inches)	Maximum Differential Gap[(a)] (Inches)
No. 1 oxidizer duct to turbopump volute	0.040	0.020
No. 1 oxidizer duct to valve	0.040	0.020
No. 2 oxidizer duct to turbopump volute	0.040	0.020
No. 2 oxidizer duct to valve	0 040	0.020
No. 1 fuel duct to turbopump volute	0.040	0.020
No. 1 fuel duct to valve	0.180 (0.110 for horizontal assembly)	0.020
No. 2 fuel duct to turbopump volute	0.040	0.020
No. 2 fuel duct to valve	0.060 (0.040 for horizontal assembly	0.020

(a) The "Maximum Differential Gap" is the difference between the gap obtained at the largest space and the gap obtained at the smallest space.

Figure 2-7. Propellant Duct Fit-Check and Alinement Requirements (Sheet 1 of 2)

Joint Location	Maximum Axial Gap at Largest Space (Inches)	Maximum Differential Gap[a] (Inches)
No. 1 oxidizer valve to LOX dome inlet[b]	0.065	0.015
No. 2 oxidizer valve to LOX dome inlet[b]	0.065	0.015
No. 1 fuel valve to fuel manifold inlet [b]	0.065	0.015
No. 2 fuel valve to fuel manifold inlet[b]	0.065	0.015

(a) The 'Maximum Differential Gap" is the difference between the gap obtained at the largest space and the gap obtained at the smallest space.
(b) These allowable gap dimensions are applicable only for the following fit-check cases:
  (1) Removal and reinstallation or replacement of the LOX dome and injector with the oxidizer ducts remaining attached to the turbopump and the oxidizer valves.
  (2) Disconnection of fuel valves from fuel manifold with fuel ducts remaining attached to the fuel valves and turbopump.

Figure 2-7. Propellant Duct Fit-Check and Alinement Requirements (Sheet 2 of 2)

Line	Joint Location	Maximum Allowable Limits		
		Offset (Inch)	Gap (Inch)	Angulation[a] (Inch)
No. 1 fuel valve open control tube	No. 1 fuel valve	0.30	±0.30	0.017
Propellant valves close tube	No. 1 fuel valve	0.02	±0.10	0.009
No. 2 fuel valve open control tube	No. 2 fuel valve	0.05	±0.20	0.017
Propellant valves close tube	No. 2 fuel valve	0.10	±0.20	0.017
No. 1 oxidizer valve dome purge line	No. 1 oxidizer dome purge check valve	0.10	±0.05	0.009
Sequence valve to sequence valve line	No. 1 oxidizer valve sequence valve	0.15	±0.30	0.017
Propellant valves open tube	No. 1 oxidizer valve	0.05	±0.15	0.011
No. 2 oxidizer valve dome purge line	No. 2 oxidizer dome purge check valve	0.10	±0.05	0.009
Propellant valves open tube	No. 2 oxidizer valve sequence valve	0.10	±0.15	0.017

918

(a) Angulation is determined after line is alined within offset and gap requirements.

Figure 2-8. Tube Alinement Requirements (Sheet 1 of 2)

Line	Joint Location	Maximum Allowable Limits		
		Offset (Inch)	Gap (Inch)	Angulation[a] (Inch)
Propellant valves open tube	No. 2 oxidizer valve	0.07	±0.15	0.011
Propellant valves open tube	Ignition monitor valve inlet	0.05	±0.02	0.012
Ignition monitor valve sense tube	Thrust chamber fuel manifold	0.03	±0.10	0.014
Propellant valves close tube	No. 2 oxidizer valve	0.15	±0.20	0.024
Igniter fuel supply tube 918	No. 1 fuel high-pressure duct or hypergol manifold	0.10	+0.100 +0.001	0.022
Engine supply tube	No. 2 fuel high-pressure duct or engine control valve	0.05	+0.100 +0.001	0.020
Gas generator system close tube	Gas generator	0.10	±0.20	0.017
Gas generator system open tube	Gas generator	0.10	±0.40	0.054

(a) Angulation is determined after line is alined within offset and gap requirements.

Figure 2-8. Tube Alinement Requirements (Sheet 2 of 2)

2.4.4A <u>COMPONENT REPLACEMENT EFFECTS ON ENGINE PERFORMANCE AT SEA LEVEL.</u> Component replacement effects on engine performance at sea level are tabulated in figure 2-9. The deviations presented are the maximum expected effects on sea-level engine thrust and mixture ratio when the listed components are replaced. The following procedure is to be used for determining the maximum expected performance deviations for individual engines:

a. The deviations listed in figure 2-9, corresponding to hardware replaced on the engine, are to be tabulated and included with the Engine Log Book. This tabulation is necessary for future reference and continuous updating when additional replacements are made.

b. The combination of deviations due to the replacement of each individual component determines the expected maximum performance deviation. The combination is accomplished by calculating the square root of the sum of the squares of the deviations listed in figure 2-9, corresponding to each component replaced. Components replaced a second time are treated as a single replacement of the item. (No additional variation is added besides the variation for the component being replaced a second time.)

Component Being Replaced	Reason For Test	Maximum Expected Performance Uncertainty		
		Sea-Level Thrust (K lb)	Sea-Level Mixture Ratio	
Fuel pump	(a) (b)	26.9	0.044	
No. 1 inlet elbow		9.0	0.014	
No. 2 inlet elbow		9.0	0.014	
Inlet assembly	(a) (b)	9.0	0.014	
Inducer	(a) (b)	9.0	0.014	
Volute	(a) (b)	18.9	0.029	
Impeller	(a) (b)	12.0	0.019	
Turbine assembly	(a) (b)	35.6	0.005	
Nozzle (manifold)	(a) (b)	19.1	0.001	
First-stage wheel	(a) (b)	17.6	0.002	
Per blade	(a)	0.2	0.0	
Second-stage wheel	(a) (b)	8.8	0.001	
Per blade	(a)	0.1	0.0	
Stator	(a)	17.6	0.002	
Per segment	(a)	1.8	0.0	
Honeycomb seal	(a)	17.6	0.002	
Gas generator oxidizer bootstrap line scoop		6.0	0.001	
Gas generator oxidizer bootstrap line (upstream)		12.0	0.002	
Gas generator oxidizer upstream orifice	(a)	1.9	0.0	921
Gas generator oxidizer bootstrap line (downstream)		12.0	0.002	

(a) Replacement of this component requires reorificing and/or retest for performance uncertainty and redline value acceptability as mutually agreed by Engine Contractor and NASA.
(b) Component hot-fire test required for functional integrity verification

Figure 2-9. Deviations in Engine Performance Due to Component Replacement (Sheet 1 of 3)

Component Being Replaced	Reason For Test	Maximum Expected Performance Uncertainty	
		Sea-Level Thrust (K lb)	Sea-Level Mixture Ratio
Gas generator oxidizer downstream orifice	(a)	1.9	0.0
Gas generator fuel bootstrap line		7.8	0.001
Gas generator fuel orifice	(a)	1.1	0.0
Gas generator ball valve		21.2	0.004
Gas generator injector	(a)	31.6	0.005
Gas generator combustor body		11.7	0.001
Thrust chamber	(a)	21.5	0.054
Thrust chamber	(a) (c)	11.5	0.043
Main injector	(a)	6.5	0.029
Oxidizer dome		17.0	0.016
Turbine exhaust system duct with heat exchanger		27.0	0.003
Nozzle extension		15.0	0.0
No. 1 main LOX orifice	(a)	0.1	0.0
No. 2 main LOX orifice	(a)	0.1	0.0
No. 1 main fuel orifice	(a)	0.0	0.0
No. 2 main fuel orifice	(a)	0.1	0.0
No. 1 main oxidizer valve		13.0	0.019
No. 2 main oxidizer valve		20.1	0.012
No. 1 main fuel valve		1.1	0.022
No. 2 main fuel valve		9.6	0.018
No. 1 turbopump oxidizer outlet line		1.3	0.002
No. 2 turbopump oxidizer outlet line		4.1	0.003
No. 1 turbopump fuel outlet line		0.2	0.003
No. 2 turbopump fuel outlet line		1.4	0.003

(a) Replacement of this component requires reorificing and/or retest for performance uncertainty and redline value acceptability as mutually agreed by Engine Contractor and NASA.
(c) Single engine hot-fire test required for functional integrity verification

Figure 2-9. Deviations in Engine Performance Due to Component Replacement
(Sheet 2 of 3)

Component Being Replaced	Reason For Test	Maximum Expected Performance Uncertainty	
		Sea-Level Thrust (K lb)	Sea-Level Mixture Ratio
Turbopump	(a)	55.0	0.071
Oxidizer pump	(a) (b)	30.2	0.055
Inlet assembly		7.3	0.014
Inducer	(a)	7.3	0.014
Volute	(a) (b)	15.8	0.028
Impeller	(a) (b)	24.6	0.043

(a) Replacement of this component requires reorificing and/or retest for performance uncertainty and redline value acceptability as mutually agreed by Engine Contractor and NASA.
(b) Component hot-fire test required for functional integrity verification

NOTE

Component hot-fire test is required after removal and reinstallation or replacement of turbopump internal components from the No. 3 fuel seal to the first-stage turbine wheel.

Figure 2-9. Deviations in Engine Performance Due to Component Replacement (Sheet 3 of 3)

2.4.5 LOCKWIRE REPLACEMENT. Lockwire removed to accomplish authorized activities must be replaced at the completion of those activities.

2.4.6 COVER AND CLOSURE REQUIREMENT. All parts of the engine requiring protective covers or closures must be protected at all times unless covers are required to be off for performance of an authorized activity.

2.4.7 ENGINE SOFT GOODS VERIFICATION. An age control log for components that contain soft goods is provided in each Engine Log Book If it becomes necessary to replace a component that contains soft goods, the Engine Log Book age control log must be updated to reflect the new replacement date. The replacement date is the installation date of the soft goods in the
9 component plus 32 quarters.

2.4.8 ENGINE ORIFICE VERIFICATION. In case of conflict between orifice diameters, as recorded in the Engine Log Book, and the external identification of an orifice, the orifice must be removed from the engine and the orifice diameter measured. If the actual orifice diameter differs from that recorded in the Engine Log Book, notify Engine Contractor for disposition.

NOTE

The actual orifice diameter and the orifice diameter recorded in the Engine Log Book may differ by the allowable machining tolerance of the individual orifice.

2.4.9 CLEANLINESS REQUIREMENT FOR EXTERNAL CONNECTIONS. All components and lines that transfer fluids to engine systems must meet cleanliness requirements of engine system hardware prior to connection to the engine system.

2.4.10 SYSTEM INTERCONNECTION CONSTRAINTS. Systems that transfer fluids to the engine must be plumbed, unless otherwise specified, so that fluids cannot intermix.

2.4.11 TURBOPUMP PRESERVATION REQUIREMENTS. Preservation of the turbopump is required at the following times:

a. Within 4 hours after:

(1) An engine test that introduced fuel into
928 the turbopump lubrication system.

(2) A launch abort.

(3) Lubrication system purge in excess of 50 psig.

937 b. Every 10 years.

c. If a preserved turbopump is exposed to fuel while horizontal, the engine shall be rotated to vertical within 6 months of the event and the turbopump bearings representing within an additional 4 months.

921

2.4.12 HARDWARE ATTACHMENT CONSTRAINTS. Engine Contractor Design Review and concurrence of applicable Stage Contractor installation documents must be obtained before attaching any additional lines, harnesses, brackets, clamps, or other hardware to the engine. Attaching hardware to the engine in locations other than those agreed upon during Design Review by the Engine Contractor may result in reduced engine reliability. Unless
902 otherwise specified, constraints for installation of attaching hardware and minimum clearance between attaching hardware and engine components are as follows:

a. Minimum clearance between attaching hardware and engine lines:

(1) Static conditions: A minimum clearance of 1/8 inch must be maintained between rigid lines and adjacent surfaces.

(2) Dynamic conditions (independent of vibration): A minimum clearance of 1/2 inch must be maintained between the maximum clearance envelope of rigid lines and adjacent surfaces.

(3) A minimum clearance of 1/2 inch must be maintained between flexible lines and adjacent surfaces.

b. Rigid line support requirements:

(1) Lines 1/4 inch through 3/8 inch in diameter must be supported every 18 inches (maximum).

(2) Lines 1/2 inch through 3/4 inch in diameter must be supported every 25-1/2 inches (maximum).

(3) Lines one inch and over must be supported every 30 inches (maximum).

(4) One-third of distance specified in substeps 1 through 3 is maximum spacing between unsupported line fittings or to bends of more than 75 degrees. 902

c. Attaching hardware must not be clamped to line flexible sections.

d. Clamping between attaching hardware and engine lines must not stress engine lines. Under no circumstances shall any hardware be attached to engine hydraulic control lines.

e. Components must not be mounted on engine lines.

f. Clearance of 1/2 inch minimum must be maintained between attaching conventional electrical harnesses and any line carrying a flammable fluid, including liquid oxygen.

g. Clearances must be maintained as specified in step a between attaching flexible armored harnesses and engine lines.

h. Attaching flexible armored harness must not be in direct contact with any component that contains or flows hot-gas products, other than the normal connecting of a harness plug to a component. Contact by a support attached to a hot-gas component is acceptable.

2.5 OPERATIONAL TEST REQUIREMENTS.

2.5.1 SAFETY REQUIREMENTS WHEN WORKING WITH THERMAL INSULATION.

a. Wear leather gloves and arm protection to prevent injury from sharp edges and corners of insulators.

b. Do not force-fit brackets.

c. Use enough personnel when handling insulators to prevent buckling or distortion of panels.

CAUTION

Because of the extreme lightness of insulators in comparison with their surface area, they must not be placed where winds or drafts could blow them about.

d. Use extreme care when handling insulators in windy areas.

e. Leave protective packaging on insulators until ready for installation.

f. Do not stack or pile insulators on work platform.

g. Use tiedowns to secure insulators; do not use weights.

h. Protect insulators from punctures or tears when handling near sharp projections or tools.

i. Do not place equipment against insulators or use them for hand or foot holds.

j. Do not bend flange tabs of insulators to a sharp radius.

k. Do not expose insulators to liquids or moisture. The insulation between foil sheets cannot be conveniently dried. Insulation damaged by fuel absorption must be replaced prior to engine firing.

l Make sure that vent covers on inner foils of cocoon and thrust chamber and nozzle extension insulators are not distorted and are free of obstructions.

m. Insulators must not be alined with drift pins engaging nut plates of brackets.

n. Do not wear clothing containing sharp objects that may damage engine finishes.

o. Exercise extreme care to prevent damage to engine equipment.

p. Insulators are not rigid components until installed. If misalinement of attaching features occurs due to deformation of insulators from handling, it may be necessary to use hand-force to effect installation. To prevent damage to insulators, apply hand-force to large areas either by pushing or striking with the heel of the hand. Wear gloves to prevent injury to hands.

2.5.2 SAFETY SHIELDING AND SAFE OPERATING TEST PRESSURES.

F-1 engine system safe operating test pressures for personnel safety are as listed in figure 2-10. Safety shielding must be used on engine/components during performance of authorized activities in this manual that specify pressures in excess of the values listed.

2.5.3 SAFETY REQUIREMENTS WHEN WORKING WITH PNEUMATIC AND HYDRAULIC SYSTEMS.

a. Prior to pressurization of any system, verify that all connections on the system are fully engaged, and safety precautions, such as warning signs and warning lights, are displayed.

b. Do not tighten or loosen any fitting on a pressurized system.

c. Do not leave pressurization controls unattended when pressure is applied to a system.

d. Verify that test equipment hoses or lines are depressurized prior to disconnection.

e. Secure all test hoses connected between test equipment or facility and/or engine, to prevent whipping in event of accidental disconnection or line failure.

f. Wear safety glasses or face shield when working in areas where systems are pressurized.

g. If any fitting or line is loosened or any part removed, protect opening against entry of foreign material.

h. In the event LOX propellant feed system is depressurized with fuel propellant feed system pressurized, make certain nitrogen overboard drain is not plugged.

i. If closures are to remain on overboard drain lines when LOX and fuel propellant feed systems are pressurized, closure fasteners must be loosened to prevent possible pressure buildup in drain lines.

2.5.4 SAFETY REQUIREMENTS WHEN WORKING WITH ELECTRICAL SYSTEMS.

a. Deenergize circuits before working on electrical components or electrical cables.

b. Place circuit breakers controlling the power source and all switches on the electrical equipment in the off or deenergized position prior to connecting a power source to electrical equipment.

c. Do not leave electrical controls unattended when electrical power is supplied to an electrical system.

d. Ground engine and electrical consoles to a common ground with separate ground cables.

2.5.5 SAFETY REQUIREMENTS WHEN WORKING WITH SOLVENTS. The hazard associated with a solvent is specified in the requirement or procedure by a warning note since improper use of a solvent can cause injury to personnel or damage to equipment. The following steps list the solvents used, their particular hazard, and the safety precautions that should be followed when using that solvent.

a. Observe the following safety precautions when using trichloroethylene (MIL-T-27602), or equivalent:

(1) Avoid excessive inhalation of vapors from trichloroethylene. Trichloroethylene gives off vapors even at room temperature, and prolonged inhalation can produce narcotic effects on the nervous system.

(2) Do not allow trichloroethylene to contact skin for prolonged periods since it can be absorbed through the skin. The liquid chemically dries the skin, leaving it susceptible to infection.

(3) Wear safety glasses or face shield while using trichloroethylene.

(4) Wear a breathing apparatus while working with trichloroethylene in confined or unventilated areas.

(5) Do not expose trichloroethylene to excessive heat.

b. Observe the following safety precautions when using cleaning compound (MIL-C-81302), or equivalent:

(1) Avoid excessive inhalation of vapors of cleaning compound as it may cause headaches, dizziness, sleepiness, or unconsciousness due to the oxygen-deficient atmosphere.

(2) Do not allow cleaning compound to contact skin for prolonged periods. The liquid chemical dries the skin, leaving it susceptible to infection.

(3) Wear safety glasses or face shield when using cleaning compound.

Information will follow at a later date.

Figure 2-10. Safe Operating Pressure Requirements

(4) Wear a breathing apparatus when using cleaning compound in confined or unventilated areas.

(5) Do not subject cleaning compound to excessive temperatures.

c. Observe the following safety precautions when using isopropyl alcohol (Federal Specification TT-I-735), or equivalent:

(1) Avoid excessive inhalation of vapors of isopropyl alcohol since prolonged inhalation may cause slight intoxication.

(2) Wear breathing apparatus when using isopropyl alcohol in confined or unventilated areas.

(3) Because of its low vaporizing qualities, use the least amount of isopropyl alcohol consistent with performing the task.

(4) Wear safety glasses or face shield when using isopropyl alcohol.

(5) Do not use isopropyl alcohol near source of ignition heat or open flame.

d. Observe the following safety precautions when using drycleaning solvent (Federal Specification P-D-680), or equivalent.

(1) Do not use drycleaning solvent near source of ignition, heat, or open flame.

(2) Wear safety glasses or face shield when using drycleaning solvent.

2.5.6 SAFETY REQUIREMENTS FOR THRUST CHAMBER ENTRY. The minimum safety requirements that must be followed when personnel enter the thrust chamber are as follows:

a. The man lift, if employed, must be capable of operation from the work platform or from ground level.

b. Breathing apparatus must be worn when entering the thrust chamber.

c. The buddy system must be used when personnel enter the thrust chamber. The standby personnel must be qualified in facility operation, operation of the breathing apparatus, and operation of the lift equipment. The standby personnel must always remain in line-of-sight of the person in the thrust chamber.

d. Isolate thrust chamber assembly in such a manner that inadvertent pressurant or propellant admission is impossible.

e. Verify with an explosimeter that combustible vapors in thrust chamber are less than 20 percent of lower explosive limit of combustibles prior to allowing personnel entry into thrust chamber to make spark-producing repairs. A list of combustible materials that might be used in the thrust chamber and their explosive limits is as follows:

Material	Lower Limit (Percent by Volume in Air)	20 Percent of Lower Limit (Percent by Volume in Air)
Alcohol (isopropyl)	2.0	0.4
Ethylene glycol	3.2	0.6
Fuel (RJ-1 and RP-1)	1.6 to 6	0.3 to 1.2
Freon (cleaning compound)	none	none
Solvent (stoddard)	1.1	0.2
Trichloroethylene	12.0	2.4

2.5.7 SAFETY REQUIREMENTS FOR HANDLING IGNITERS AND HYPERGOL CARTRIDGE. Wear the following protective clothing:

a. Fire-resistant body-length open-back asbestos smock with snap-on straps for rapid removal. Smock should hang about 6 inches from the floor.

b. Heat-resistant gloves, fitted oversize so that they can be rapidly shaken from the hands.

c. Face shield with a full-view plastic window. Shield must cover from the crown of the head to below the chin including part of the neck.

d. Knee-length neoprene boots.

2.5.8 GROUND SUPPORT EQUIPMENT AND SPECIAL TOOL REQUIREMENTS. The ground support equipment and special tools used in conjunction with the authorized activities in this manual must meet their respective test and inspection requirements prior to usage.

2.5.9 ENGINE SERVICE LIFE. The total service life of the engine, in terms of operating time and number of starts, is 2,250 seconds of operation within 20 engine starts. An engine start is defined as attainment of site thrust equal to 90 percent of rated thrust.

2.5.9.1 Component Service Life. A torque check of the oxidizer dome bolts is required at 1,350 seconds of engine firing.

2.5.10 COMPONENT CYCLE LIFE LIMITS. Record component cycles during engine checkouts for the listed components on data forms contained in the Engine Log Book. Contact Rocketdyne representative for an engineering recommendation as to hardware disposition when the cycle limits, as defined in figure 2-11, are exceeded.

Name	Cycle Definition	Cycle Limit
Fuel valve	Anytime the valve leaves the closed position, reaches the open position, and returns to the closed position, as indicated by the valve position switches, independent of the fluid or pressure used.	900
Oxidizer valve	Anytime the valve leaves the closed position, reaches the open position, and returns to the closed position, as indicated by the valve position switches, independent of the fluid or pressure used.	900
Gas generator ball valve	Anytime the valve leaves the closed position, reaches the open position, and returns to the closed position, as indicated by the valve position switches, independent of the fluid or pressure used.	900
Engine control valve	Anytime the valve is actuated and subsequently deactuated as a result of the application of the required electrical power to the start solenoid and stop solenoid, respectively.	900
Ignition monitor valve	Anytime the valve poppet is unlocked and is unseated as a result of the application of the required actuation pressure to the control port, followed by return of the poppet to the normally closed position, independent of the fluid used.	400
Igniter fuel valve	Anytime the piston is unseated as a result of the application of sufficient actuation pressure to the fuel inlet port, followed by return of the piston to the normally closed position, independent of the fluid used.	450

Figure 2-11. Component Cycle Definition and Limits (Sheet 1 of 2)

Name	Cycle Definition	Cycle Limit
Bearing coolant control valve	Anytime the coolant poppets and/or preservative poppet are unseated as a result of the application of the required actuation pressure, followed by return of the coolant poppets and/or the preservative poppet to the normally closed position, independent of the fluid used.	900
Redundant shutdown valve	Anytime the valve is actuated and subsequently deactuated as a result of the application and removal, respectively, of the required electrical power to the redundant shutdown valve solenoid.	1,900
Gimbal bearing	Anytime one gimbal actuator is extended or retracted from its nominal position and returns to its nominal position is defined as half a cycle, or anytime the thrust chamber centerline is displaced from its null position, travels in one square or circle pattern, and returns to its null position, is defined as one cycle.	See figure 2-12.
Gimbal wrap-around lines	Anytime one gimbal actuator is extended or retracted from its nominal position and returns to its nominal position is defined as half a cycle, or anytime the thrust chamber centerline is displaced from its null position, travels in one square or circle pattern, and returns to its null position, is defined as one cycle.	See figure 2-12.
Thrust OK pressure switch	Anytime the diaphragm is provided sufficient pressure so that electrical continuity is switched from the normally closed contact to the normally open contact, followed by sufficient decrease in pressure so that electrical continuity is switched from the normally open contact back to the normally closed contact.	3,400
Checkout valve	Anytime the checkout valve actuator is supplied with sufficient electrical power to cause the checkout valve ball to leave the "ground" position, reach the "engine" position, and subsequently return to the "ground" position, as indicated by the valve position switches.	900

Figure 2-11. Component Cycle Definition and Limits (Sheet 2 of 2)

2.5.10.1 GIMBAL CYCLE LIMITATIONS. Cycle limitations for the gimbal bearing and for wrap-around lines are presented in figure 2-12. In order to make sure that cycle limitations are not exceeded, a cycle ratio is computed to determine total cycles. A cycle ratio is defined as the ratio of the number of gimbaling cycles to the limiting number of gimbal cycles at a particular gimbal angular excursion. A formula to compute total cycle ratio for a particular gimbal excursion is provided as follows:

$$\Sigma \frac{M_i}{N_i} = \frac{M_1}{N_1} + \frac{M_2}{N_2} + \frac{M_3}{N_3} + \frac{M_n}{N_n} < 1$$

where

M_i = number of cycles at X_i degrees (Refer to Engine Log Book.)

N_i = limiting number of cycles at X_i degrees

$\frac{M_i}{N_i}$ = cycle ratio

2.5.11 ENGINE CHECKOUT CONSTRAINTS.

a. The term "no leakage is allowable" is defined as bubble-tight for gas, and an unmeasurable amount of leakage over a 5-minute period when liquid is used.

b. Unless otherwise specified, 2-5 minutes must be allowed for leakage observation on all tests that specify no leakage is allowable.

c. Fuzz leakage is defined as a formation of bubbles that do not increase in size over a 5-minute period.

d. Leakage rates specified in this manual are at standard conditions of 70° F and 29.92 inches of mercury.

e. Leak-test compound must not be applied to open ports or drain lines during leak tests.

f. Leak-test compound must be removed from engine surface at completion of leak tests.

g. In the event a system is disturbed or opened subsequent to completion of an authorized leakage test, the leakage test must be repeated on the disturbed or open joints. Whenever the GG combustor to turbine manifold inlet flange
929 has been disturbed or opened, an external leakage test of the joint shall be conducted.

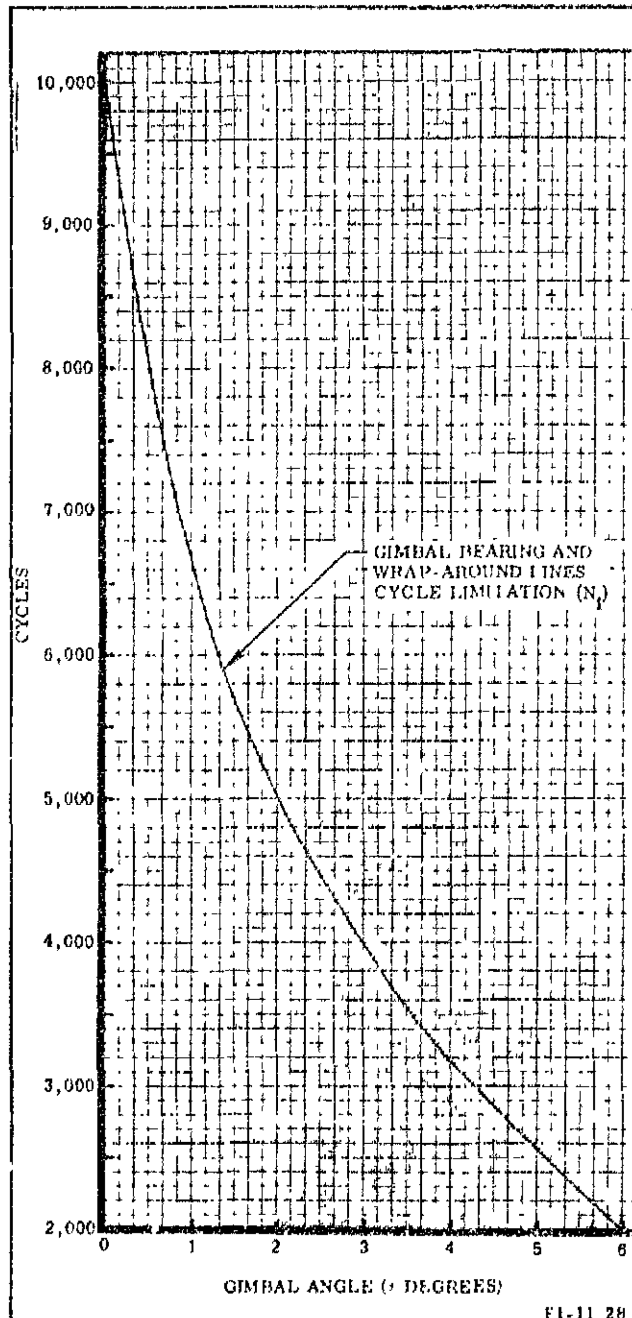


Figure 2-12. Gimbal Bearing and Wrap-Around Line Cycle Limitations

h. Electrical receptacles and plugs must be inspected for damage, wear, and contamination before connections are made.

i. When accomplishing authorized leakage isolation requirements, engine joints may be opened, as required, to isolate the specified component.

j. The moisture content of the engine oxidizer propellant feed system and the heat exchanger GOX and helium discharge systems must not exceed 26.3 ppm by volume of water vapor corrected to standard conditions.

k. If engine systems are opened, the openings must be protected against entry of foreign material, and the moisture content of the system must be minimized to satisfy requirements of step j.

kA. When reinstalling a joint, verify that
902 all joint protective closures are removed prior to reconnecting the joint.

l. The engine must be electrically grounded to a facility ground and any test equipment used, during all tests.

m. Acceptable leakage rates as specified in test criteria are confined to those using Engine Contractor-provided or equivalent Stage Contractor test equipment.

n. Leak testing of engine joints should be accomplished by completely covering fittings, seams, or joints with leak-test compound (MIL-L-25567). If a leak is detected using a leak detector, verify leakage using leak-test
913 compound (MIL-L-25567) or by system isolation.

o. When using a G3104 Flowtester to check leakage of joints incorporating seal monitoring ports and no leakage is specified, use the smallest tube of the flowtester. The ball may move off the stop but must not rise above the lowest graduation on the scale, which is less than 0.25 scim when testing with gaseous nitrogen or 0.29 scim when testing with helium.

p. When a leak detector is used to detect leakage, refrigerant, Type 12 (Federal Specification BB-F-1421), must be added to the system prior to the application of gaseous nitrogen.

2.5.11.1 ENGINE CHECKOUT REQUIREMENTS AFTER STORAGE. When an engine is removed from storage after being stored in accordance with Standard S-IC Stage Storage Specification MSFC-STD-500 for time periods in excess of 6 months, checkout of the engine is required. See figure 2-13 for checkout requirements.

2.5.11.2 ENGINE CHECKOUT REQUIREMENTS AFTER STANDBY STATUS. Uninstalled flight spare and installed engines that are in standby 930
must be checked out as outlined in figure 2-13A before engine hot-fire operation.

2.5.12 ENGINE STARTING ATTITUDE CONSTRAINTS. For starting, the engine must be in the thrust-chamber-nozzle-down position with the thrust chamber centerline not exceeding a cant of 2 degrees, 30 minutes, from the true vertical.

Engine Status When Placed in Storage	Next Planned Engine/Stage Operation	Requirements (Figure 1-1)
Completed Rocketdyne checkout.	Installation in stage.	Activities in event columns A and B.
Completed single-engine receiving inspection.	Installation in stage.	Activities in event columns A and B.
Completed single-engine checkout.	Installation in stage.	Activities in event columns A and B.
Completed engine installation in stage.	Stage static test.	Activities in event columns H and J.
Completed stage static test.	Post-static test checkout.	Activities in event columns N and O.
Completed stage receiving inspection.	Post-static test checkout.	Activities in event columns N and O.
Completed stage post-static test checkout.	Shipment to KSC.	Activities in event columns Q, R, and T through W.

Figure 2-13. Engine Checkout Requirements After Storage in Accordance With MSFC-STD-500 930

Engine Standby Status	Next Planned Stage Operation	Requirements (Figure 1-1)
Completed single engine checkout.	Stage static test.	Activities in event columns H, J, and K.
	Vehicle launch.	Activities in event columns R, T, and W.
Completed stage post-static checkout.	Stage static test.	Activities in event columns H, J, and K.
	Vehicle launch.	Activities in event columns R and T through W.
Completed vehicle checkout at VAB.	Stage static test.	Activities in event columns H, J, and K.
	Vehicle launch.	Activities in event columns U through W.

Figure 2-13A. Engine Checkout Requirements After Standby Status

2.5.12A SLAVE HARDWARE USE DURING STATIC TESTING OF ENGINE AT MTF. During static testing of engine at MTF, slave hardware may be used in place of the standard hardware supplied with the engine. The slave hardware and the constraints for using the hardware are as follows:

a. New hardware consisting of a thermocore seal may be used in place of the delivered tadpole seal for the thrust chamber body to nozzle extension joint.

b. Slave hardware, maintained in a clean condition or cleaned to the requirements of delivered loose equipment, consisting of the nitrogen purge drain line and an AN fitting, oxidizer overboard drain line and seal, and fuel overboard drain line and seal, may be reused unless damaged or deteriorated as determined by visual inspection.

902 c. Slave attaching hardware, consisting of clamps, nuts, bolts, and washers for installation of nozzle extension and drain lines, may be reused a maximum of three times unless damage is indicated by visual inspection.

d. Slave hardware, maintained in a clean condition or cleaned to the requirements of the delivered propellant feed system, consisting of the No. 1 fuel valve position transducer vent drain tube for engines installed in the S-IC stage in positions 103 and 104 and the No. 2 fuel valve position transducer vent drain tube for engines installed in the S-IC stage in positions 101, 102, and 105, may be reused unless damaged or deteriorated as determined by visual inspection.

e. Slave attaching hardware, consisting of clamps, nuts, screws, and washers for installation of the No. 1 and No. 2 fuel valve position transducer vent drain tubes, may be reused unless damage is indicated by visual inspection.

2.5.13 GIMBAL LIMIT CONSTRAINTS. Engine gimbal displacement must be maintained within a square pattern of plus and minus 6 degrees in the actuation planes from the delivered, alined engine position. Gimbal acceleration must not exceed combined longitudinal and lateral acceleration of 0.5g lateral and 10g longitudinal, 1.0g lateral and 6g longitudinal, or 2.5g lateral and 3g longitudinal. Engine angular displacement is limited to the longitudinal acceleration with an allowable displacement of 2 degrees at 10g, 4 degrees at 6g, 6 degrees at 3g with maximum angular displacement limited to 30 radians/second^2.

2.5.14 HEAT EXCHANGER DRY-COIL TESTING CONSTRAINTS. If heat exchanger LOX or helium coils are to be run dry during engine testing, the coils must be provided with a 50 ±15 psig purge of gaseous nitrogen (MIL-P-27401).

2.5.15 COCOON PURGE STUB LINE STATIC TESTING CONSTRAINTS. The cocoon purge stub line must be removed for engine testing unless the complete purge system, consisting of the wrap-around duct and manifold lines, is installed on the engine.

2.5.16 FIREX CONSTRAINTS. A gaseous nitrogen or water system must be supplied to protect the engine in the event of fire and to control chamber afterfire following engine cutoff. In the event of fire, water should be directed on the engine only in an emergency.

2.5.17 THERMAL INSULATION REQUIREMENTS. Thermal insulation is provided for flight testing the F-1 engine. Engine static tests may be conducted without thermal insulation if the engine ambient temperature requirements for engine starting are met. An engine equipped with the bracketry for thermal insulation (figure 2-14) and/or equipped with LOX propellant feed system insulation may be static tested if the engine ambient temperature requirements for engine starting are met. Figure 2-15 lists and locates the thermal insulation access doors. Thermal insulation damage limits 619
are specified in figure 1-4.

2.5.18 CONTROL SYSTEM SEQUENCING AND ELECTRICAL SAFETY CIRCUIT REQUIREMENTS. The engine electrical control system sequencing and safety circuit requirements are shown in figure 2-16.

2.5.18A. FLIGHT INSTRUMENTATION SYSTEM VOLTAGE LIMITS. The flight instrumentation system voltage limits presented in figure 2-16A are used to determine initial pressure transducer data for those instruments for which no data is available in the Engine Log Book.

2.5.19 INSTRUMENTATION REQUIREMENTS. Instrumentation requirements for static test are outlined in figures 2-17 and 2-18. Instrumentation requirements for launch are outlined in figures 2-19 and 2-20. Definitions for interpretation of the instrumentation tables are as follows:

a. The category column letters M and HD on the instrumentation tables are defined as follows:

(1) The letter M is defined as mandatory. A mandatory item is an engine element or an operational support element essential for the accomplishment of test or launch, which includes pre-test, static test, prelaunch, and launch. If a mandatory item fails during countdown, it must be corrected prior to static test or launch.

(2) The letters HD are defined as highly desirable. A highly desirable item is an engine or operational support element that supports and enhances the accomplishment of the test or launch. Consideration must be given to the repair of any highly desirable item that fails, but in no case must the static test or launch be scrubbed for any single failed item.

b. Any function that is interlocked for an automatic sequencing device that will affect an automatic shutdown or will prevent static test or launch completion is defined as mandatory.

c. All redlines (minimum and/or maximum values or conditions) are mandatory. Verifications that the values or conditions remain within the limits of acceptable operation specified are mandatory.

(1) Minimum and/or maximum values are mandatory and are assigned to any engine element or operational support element required to meet a specified condition in order to gain maximum assurance of acceptable system performance. It is mandatory that at least one method exists for verifying each redline.

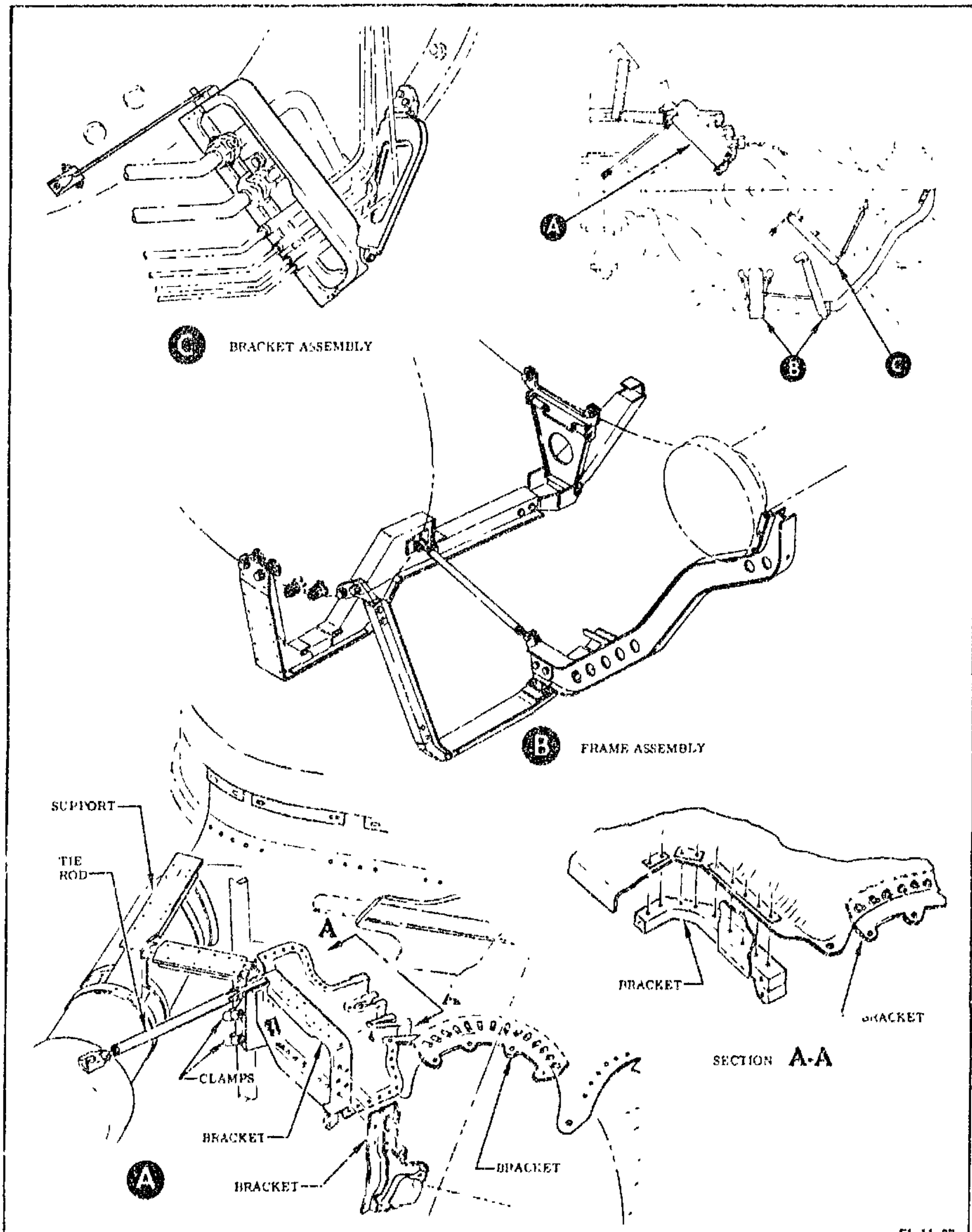


Figure 2-14. Thermal Insulation Installation Requirements Prior to Stage Shipment to KSC

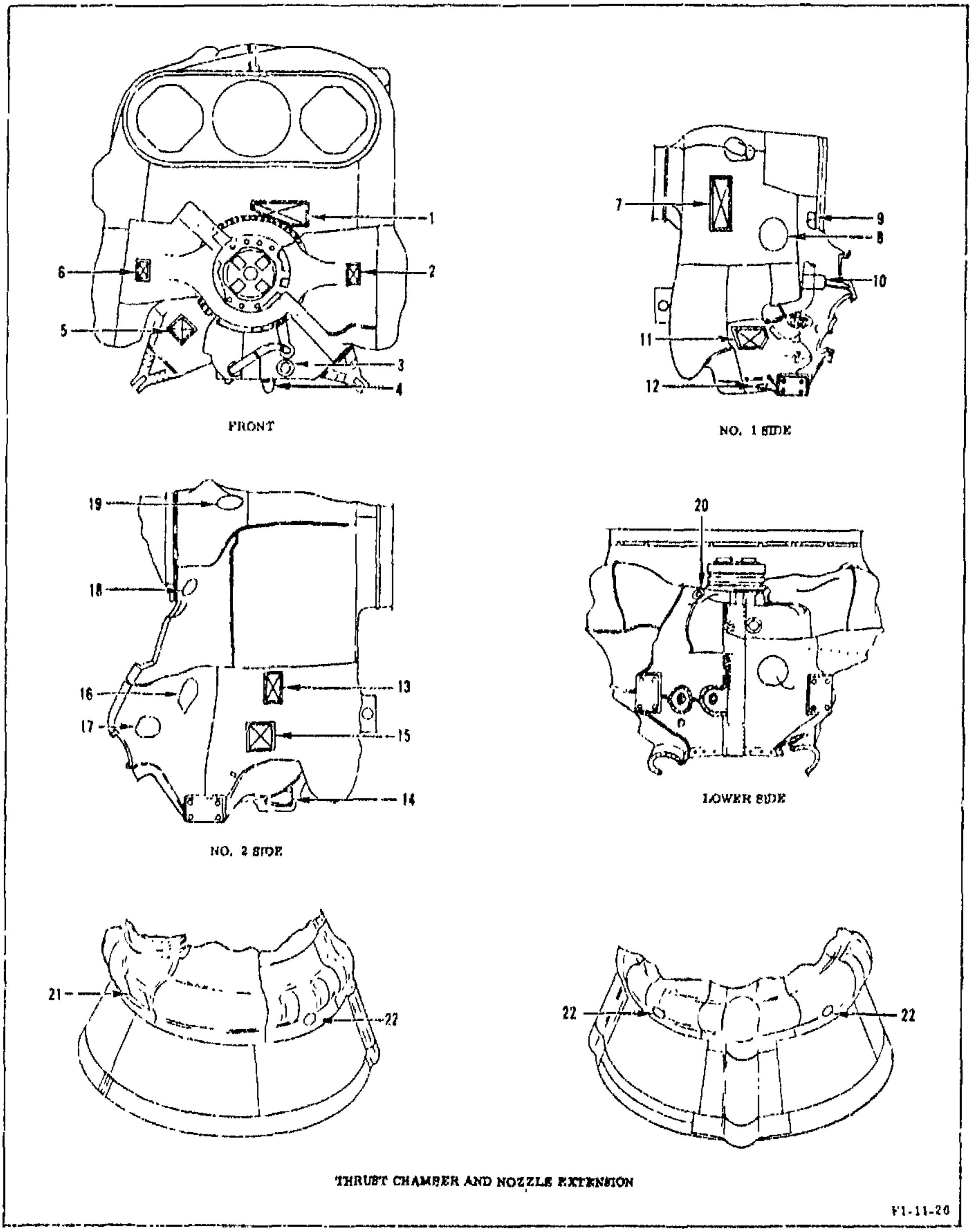
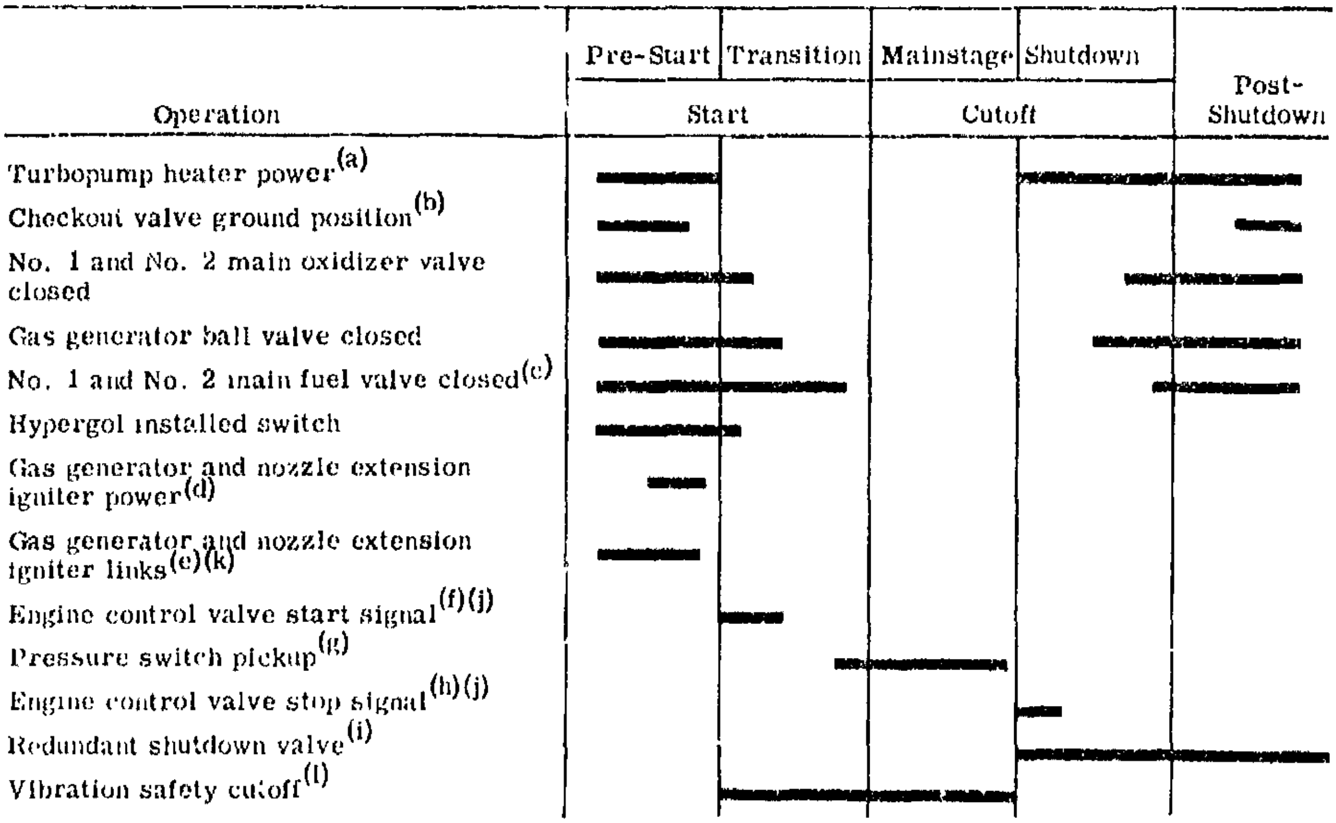


Figure 2-15. Thermal Insulation Insulator Access Doors (Sheet 1 of 2)

Index No.	Access to	Index No.	Access to
	COCOON AREA	12	Ignition monitor valve quick-disconnect
1[a]	Thrust OK pressure switches and oxidizer dome purge and flush port	13	No. 2 main fuel valve purge quick-disconnect
2	No. 1 oxidizer dome flush and purge ports	14	Hypergol cartridge container
3	Hypergol purge quick-disconnect	15	No. 2 thrust chamber fuel inlet manifold quick-disconnect
4	Hypergol drain quick-disconnect	16	Engine hydraulic supply and return line quick-disconnects
5	Checkout valve	17	No. 2 fuel high-pressure duct drain quick-disconnect
6	No. 2 oxidizer dome flush and purge ports	18	Instrumentation
7	Gas generator oxidizer purge check valve	19	Turbopump torque adapter and No. 2 fuel turbopump inlet drain quick-disconnect
8	Gas generator igniters	20	Oxidizer dome flush and purge port
9	Gas generator drain		THRUST CHAMBER AND NOZZLE EXTENSION AREA
10	No. 1 fuel high-pressure duct drain quick-disconnect	21	Thrust chamber drain and nozzle extension igniters
11	No. 1 thrust chamber fuel inlet manifold drain and No. 1 main fuel valve purge quick-disconnects	22	Thrust chamber drain (3 places)

(a) Thermal insulation sets 18-5 and subsequent

Figure 2-15. Thermal Insulation Insulator Access Doors (Sheet 2 of 2)



(a) During engine static testing or launch abort, heater power must be turned on at engine control valve stop signal and must remain on until all LOX has been removed from the engine. During engine start, heater power may remain on until static test or launch commit.

(b) Prior to the initiation of automatic sequence, the checkout valve must have been previously cycled to the engine position with fuel in the engine and a ground hydraulic supply pressure of 1,550 ±100 psig, for at least 20 seconds without subsequent drainage of the checkout valve to inlet elbow hydraulic return hose. During the automatic sequence, the checkout valve must be in the engine position for at least 20 seconds prior to engine start signal and the igniters must not be fired unless the checkout valve is in the engine position.

(c) An engine test must be terminated if: (1) both main fuel valves leave the closed position prior to loss of hypergol installed switch signal; (2) one main fuel valve reaches the open position while the other main fuel valve has not left the closed position; (3) both main fuel valves leave open position during a stage-static test.

(d) Gas generator and nozzle extension igniter power must be supplied for 0.100 ±0.050 second, and the engine control valve start signal must occur 1-5 seconds after igniter power has been initiated.

(e) A test must be terminated if at least one gas generator igniter link and one nozzle extension igniter link have not broken by the time the engine control valve start signal is initiated.

(f) The engine control valve start signal must be applied for 0.100 second minimum.

(g) An engine test must be terminated if at least 2 of 3 thrust OK pressure switches have not picked
902 up when checked after 5.5 seconds (at standard inlet conditions specified in F-1 Engine Interface Document R-6749) after engine control valve start signal has been initiated.

(h) The engine control valve stop signal must be applied for 0.100 second minimum.

(i) The redundant shutdown valve signal must be applied for a minimum of 2 minutes and a maximum of 15 minutes during engine static testing or in the event of launch abort. During flight, the signal must be applied simultaneously with engine cutoff signal and be maintained through stage separation. Power must also be applied to the redundant shutdown valve after cutoff if power is applied to the engine control valve start solenoid to prevent main engine valves from opening.

Figure 2-16. Electrical Control System Sequencing and Safety Circuits (Sheet 1 of 2)

(j) External control of the engine start and engine stop solenoids must be such that an engine start solenoid cannot be energized unless continuity to the stop solenoid connector exists.
(k) A test must be terminated any time the gas generator and nozzle extension igniter link indicate links open subsequent to attaining an igniter installed indication with 28 vdc power applied to the igniters and prior to high voltage application to fire the igniters.
(l) A stage-static test must be terminated any time 2 of 3 vibration safety cutoff units indicate vibration levels in excess of those specified in F-1 Engine Interface Document R-6749.

Figure 2-16. Electrical Control System Sequencing and Safety Circuits (Sheet 2 of 2)

		Voltage Limits[a]					
		Initial		Low Calibrate		High Calibrate	
Tap	Parameter	Low	High	Low	High	Low	High
	<u>Pressures</u>						
LB1a	LOX pump bearing jet	-0.125	0.275	0.875	1.275	3.875	4.275
GG1d	Gas generator chamber	-0.150	0.250	0.850	1.250	3.850	4.250
PF2a-2	Fuel pump discharge No. 2	-0.170	0.230	0.830	1.230	3.830	4.230
NH5c	Common hydraulic return	-0.050	0.350	0.950	1.350	3.950	4.350
CG1e	Combustion chamber	-0.150	0.250	0.850	1.250	3.850	4.250
PF2a-1[b]	Fuel pump discharge No. 1	-0.170	0.230	0.830	1.230	3.830	4.230
NH3a[b]	Engine control opening	-0.170	0.230	0.830	1.230	3.830	4.230
PO2a-1[b]	LOX pump discharge No. 1	-0.160	0.240	0.840	1.240	3.840	4.240
NH2a[b]	Engine control closing	-0.170	0.230	0.830	1.230	3.830	4.230
PO7a[b]	LOX pump seal cavity	1.150	1.750	2.150	2.750	5.150	5.750
HH3a[b]	Heat exchanger helium outlet	-0.050	0.350	0.950	1.350	3.950	4.350
HH2a[b]	Heat exchanger helium inlet	-0.050	0.350	0.950	1.350	3.950	4.350
HO1b[b]	Heat exchanger LOX inlet	-0.160	0.240	0.840	1.240	3.840	4.240
HO4a[b]	Heat exchanger GOX outlet	-0.160	0.240	0.840	1.240	3.840	4.240
KF6a-1	Fuel pump inlet No. 1	0.150	0.600	1.150	1.600	4.150	4.600
PO2a-2	LOX pump discharge No. 2	-0.160	0.240	0.840	1.240	3.840	4.240

(a) Voltage limits on pressure parameters are based on 14.7 ±1 psia applied to the transducer during ing test. Pressures outside these limits have a significant effect on the limits.
(b) Engines not incorporating <u>MD96</u> change

Figure 2-16A. Flight Instrumentation System Voltage Limits

(2) A category of mandatory assigned to a measurement associated with a redline indicates that the measurement is primary for monitoring the redline and must remain operational since no other means exists to verify that the redline is within the specified limits.

(3) Unless otherwise specified, the redlines as listed apply to each engine.

2.5.20 DETERMINING ACCEPTABILITY OF WETTED SURFACE LEAKAGE. In the event surface wetting is observed on any component in the engine hydraulic control system, determine if the condition is acceptable as follows:

a. Wipe wetted surface clean with a cloth dampened with cleaning compound (MIL-C-81302), or equivalent.

WARNING

> Cleaning compound (MIL-C-81302) is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

b. Pressurize engine hydraulic control system to 3-30 psig.

c. Observe surface for evidence of leakage. If surface wetting reappears within 5 minutes, wipe wetted surface clean and inspect surface after another 5-minute interval.

d. If necessary, repeat step c four more times (a total of 5 times). If surface wetting continues following the 5 inspection intervals, reject the component. If surface wetting does not appear following any 5-minute inspection interval, proceed to step e.

e. Increase hydraulic system pressure to 1,400-1,600 psig.

f. If no surface wetting appears within 5 minutes, the component is acceptable. If surface wetting appears within 5 minutes, wipe wetted surface clean and inspect after another 5-minute interval.

g. If necessary, repeat step f four more times (a total of 5 times). If surface wetting continues following the 5 inspection intervals, reject the component. If surface wetting does not appear following any 5-minute inspection interval, the component is acceptable.

2.5.21 FUEL OVERBOARD DRAIN SYSTEM ISOLATION REQUIREMENTS.

a. Unless otherwise specified, any time an uninstalled engine is in a vertical position, the fuel overboard drain line at the thrust chamber exit must be open to ambient environment.

b. Prior to engine rotation from the vertical to the horizontal position for installation in the S-IC stage, the fuel overboard drain system must be isolated as follows:

(1) The cross-to-lateral fuel overboard drain tube must be disconnected from the Y-fitting on the fuel overboard drain line.

(2) The No. 1 fuel valve position transducer vent drain tube must be removed between the fuel valve and the tee for engines to be installed in the S-IC stage in positions 103 and 104.

(3) The No. 2 fuel valve position transducer vent drain tube must be removed between the fuel valve and the tee for engines to be installed in the S-IC stage in positions 101, 102, and 105.

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(4) A clean polyethylene bag (one gallon minimum volume) must be installed on each side of the disconnections listed in substeps 1 through 3. The bags must allow free flow but prevent the entry of contaminants. Bags must be secured in a manner that allows rotation of the engine from horizontal to vertical with the bags filled with fluid

(5) The cover must be installed on the fuel overboard drain line at the thrust chamber exit.

c. Twenty-four hours after completion of installation of bags, the bags must be inspected for fluid collection. If fluid is evident, the bags must be removed and quantity of fluid measured. New bags must be installed on joints and inspection and fluid volumetric determination repeated 24 hours later. Determine subsequent inspection time (maximum intervals, 30 days) using the following formula:

$$\frac{\text{Day 1 vol (cc)} + \text{Day 2 vol (cc)}}{2} \text{(x days)} = 3{,}764 \text{ cc}$$

If fluid is not evident in the bags after the first 24-hour inspection, subsequent bag inspections must be performed at 30-day intervals.

d. During S-IC stage rotation from horizontal to the vertical position, the thrust chamber and exhaust manifold must be monitored for fluid drainage. Fluid drainage is not allowable.

e. After completion of S-IC stage rotation to the vertical position, the fuel overboard drain system must be restored as follows:

(1) The cover must be removed from the fuel overboard drain line at the thrust chamber exit.

(2) A clean polyethylene bag (one gallon minimum volume) must be installed on the fuel overboard drain line at the thrust chamber exit. The bag must allow free flow but prevent the entry of contaminants. The bag must be removed prior to engine static test or launch.

(3) The bags must be removed from the cross-to-lateral fuel overboard drain tube and the Y-fitting on the fuel overboard drain line, and the tube reconnected to the Y-fitting.

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(4) The bags must be removed from the tee and the fuel valve, and the No. 1 fuel valve position transducer vent drain tube reinstalled for engines installed in the S-IC stage in positions 103 and 104.

(5) The bags must be removed from the tee and the fuel valve, and the No. 2 fuel valve position transducer vent drain tube reinstalled for engines installed in the S-IC stage in positions 101, 102, and 105.

f. Prior to S-IC stage rotation from vertical to the horizontal position, or in the event an installed engine is in a horizontal stage and the fuel overboard drain system is not isolated, the fuel overboard drain system must be isolated as follows:

(1) The cross-to-lateral fuel overboard drain tube must be disconnected from the Y-fitting on the fuel overboard drain line.

(2) The No. 1 fuel valve position transducer vent drain tube must be removed between the fuel valve and the tee for engines installed in the S-IC stage in positions 103 and 104.

(3) The No. 2 fuel valve position transducer vent drain tube must be removed between the fuel valve and the tee for engines installed in the S-IC stage in positions 101, 102, and 105.

(4) A clean polyethylene bag (one gallon minimum volume) must be installed on each side of the disconnections in substeps 1 through 3. The bags must allow free flow but prevent the entry of contaminants. Bags must be secured in a manner that allows rotation of the engine from vertical to horizontal with the bags filled with fluid.

(5) The cover must be installed on the fuel overboard drain line at the thrust chamber exit.

g. Twenty-four hours after completion of installation of bags, the bags must be inspected for fluid collection. If fluid is evident, the bags must be removed and the quantity of fluid
measured. New bags must be installed on 901
joints, and inspection and fluid volumetric determination repeated 24 hours later. Determine subsequent inspection time (maximum intervals, 30 days) using the following formula.

$$\frac{\text{Day 1 vol (cc)} + \text{Day 2 vol (cc)}}{2}(\text{x days}) = 3{,}764 \text{ cc}$$

If fluid is not evident in the bags after the first 24-hour inspection, subsequent bag inspections must be performed at 30-day intervals.

2.5.22 FUEL FEED SYSTEM DRAIN REQUIREMENTS.

2.5.22.1 Uninstalled Engine, Vertical Position. Prior to opening engine propellant valves, drain hoses must be installed on the drain quick-disconnects of the No. 1 and No. 2 fuel high-pressure ducts, gas generator ball valve inlet, turbopump No. 1 and No. 2 fuel inlet elbows, engine control valve supply tube, and checkout valve engine return hose, and fuel allowed to drain. Drain hoses must be attached to the engine control valve supply tube and the checkout valve engine return hose quick-disconnects until after completion of all engine propellant valve actuations. If a gimbal system is installed on the engine, the drain hose must be attached to the No. 1 fuel high-pressure duct quick-disconnect until the hydraulic control system pressure is decreased to ambient.

2.5.22.2 Installed Engine, Vertical Position. Prior to each engine propellant valve actuation drain hoses must be installed on the drain quick-disconnects of the No. 1 and No. 2 fuel high-pressure ducts, checkout valve engine return hose, and gas generator ball valve fuel inlet, and fuel drained prior to valve actuation. Hoses must be left attached until after completion of valve actuations.

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2.5.22.3 Installed Engine, Horizontal Position. Prior to each engine propellant valve actuation, the plugs must be removed from the following engine instrumentation taps and fluid allowed to drain. The taps must be left open until after completion of engine valve actuations.

Instrumentation Taps	Engine Position Effectivity
KF6d-2	102
KF7a-1	103
IF2	101 and 104
PF3a-2	101 and 105

NOTE

A suction pump must be used to remove residual fluid from PF3a-2.

2.5.23 ENGINE REQUIREMENTS AFTER A LIGHTNING STRIKE. Engine requirements after a lightning strike are predicated on data from instrumentation that monitors stage and ground AC and DC voltage and current supplies to the engine; data anomalies noted during the lightning strike; and the engine condition after the lightning strike. For this requirement a data anomaly is defined as any fluctuation in voltage or current level that cannot be attributed to normal system operation. Paragraphs 2.5.23.1 and 2.5.23.2 contain engine requirements for the conditions specified.

2.5.23.1 Instrumentation Monitored and No Data Anomalies Noted During Lightning Strike. Visually inspect the engine for obvious lightning strike damage (eg, burned or heat-discolored thermal insulation). If damage is noted, perform maintenance, testing, and servicing tasks required to return the engine to a flight condition.

2.5.23.2 Instrumentation Not Monitored or Instrumentation Monitored and Data Anomalies Noted During Lightning Strike. Visually inspect the engine for obvious lightning strike damage (eg, burned or heat-discolored thermal insulation) and verify requirements, specified in steps a through d. If damage is noted or engine fails to meet the requirements, perform maintenance, testing, and servicing tasks required to return the engine to a flight condition. 936

NOTE

Measurements may be taken from easily accessible ground terminals.

a. Engine control valve:

(1) Start solenoid coil: 55 ±7 ohms.

(2) Stop solenoid coil: 55 ±7 ohms.

b. Redundant shutdown valve solenoid coil: 18.4 ±6 ohms.

c. Checkout valve:

(1) Actuator motor windings: 15 ohms maximum.

936 (2) Open switch: 15 ohms maximum.

(3) Closed switch: 15 ohms maximum.

d. Thrust OK pressure switch pickup and dropout values within limits specified in section I.

2.6 DOCUMENTATION REQUIREMENTS.

2.6.1 ENGINE LOG BOOK ENTRIES. An Engine Log Book must be maintained for each engine to provide accurate and current records of engine configuration, tests, operating time for engine and components, orifices sizes, engine maintenance, and serialized components as installed. The custodian of the engine must maintain the Engine Log Book and verify that entries are made for each serialized component replacement, variable orifice replacement, and other maintenance and test data. The Engine Log Book must accompany the engine whenever engine custody is transferred.

2.6.2 UNSATISFACTORY CONDITION REPORT SUBMITTAL. An Unsatisfactory Condition Report (UCR) must be prepared to report all unsatisfactory conditions on a part, component, engine, or technical document. Information detailing the failure and its test history that is required to complete the UCR should be provided, if applicable, by the Stage Contractor to the Engine Contractor. In the event the failed component is removed from an engine, the failed component must be returned to the Engine Contractor for failure analysis.

2.6.3 CHECKOUT DATA. During the performance of authorized tests specified in section I, the test results must be recorded and submitted to the Engine Contractor upon request.

2.6.4 STATIC AND FLIGHT TEST DATA.

2.6.4.1 Engine Redline Parameters. The engine test data on which engine redline parameters were recorded must be examined to determine whether any engine system is performing near its minimum or maximum established limit. If an engine system with an established operating limit is performing near its operating limit, Engine Contractor must be notified of this condition prior to the next test.

2.6.4.2 Test Instrumentation. All test instrumentation that monitors any engine parameter on a high-frequency, oscillograph, or scaled system must be examined for abnormalities, such as sudden shifts in any one or a combination of parameters, abnormal feed system oscillations, abnormal feed system oscillation amplitudes, or abnormal vibration levels. A discrepancy in any test parameter must be reported to Engine Contractor.

2.6.4.3 Data Reduction. Those engine test parameters that are recorded and used to establish engine calibration must be reduced to standard sea-level conditions, and the results must be submitted to Engine Contractor.

2.6.4.4 Data Interval Definition. The data interval is defined as a period of 3.0 to 3.2 seconds within the time interval of 35.0 to 40.0 seconds after attainment of mainstage (90 percent of thrust).

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Category M	Category HD	Time Period/Action/Notes
	PRIMARY FLIGHT INSTRUMENTATION					
KF6a-1	Fuel pump inlet No. 1	0.200 psig	±2.0	See notes.		Fuel pump inlet pressure measurement is also provided by stage-static-test instrumentation taps KF6b-1 and KF6d-2. One of the measurements must be classified as mandatory, and the other two classified as highly desirable.
TG5c	Turbine outlet	0-100 psig	±2.0		X	
PF2a-2	Fuel pump discharge No. 2	0-2,500 psia	±2.0	See notes.		Fuel pump discharge pressure measurement is also provided by auxiliary flight instrumentation tap PF2a-1 and stage-static-test instrumentation taps PF2b-1 and PF2b-2. One of the measurements must be classified as mandatory, and the other three classified as highly desirable.
CG1c	Combustion chamber	0-1,500 psia	±0.5		X	
GG1d	Gas generator chamber	0-1,500 psia	±1.0		X	

Figure 2-17. Static Test Instrumentation Category Requirements (Sheet 1 of 9)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent or Full Range)	Category M	Category HD	Time Period/Action/Notes
PRIMARY FLIGHT INSTRUMENTATION (cont)						
PO2a-2	LOX pump discharge No. 2	0-2,000 psia	±2.0	See notes.		LOX pump discharge pressure measurement is also provided by auxiliary flight instrumentation tap PO2a-1 and stage-static-test instrumentation taps PO2b-1 and PO2b-2. One of the measurements must be classified as mandatory, and the other three classified as highly desirable.
NH5c	Common hydraulic return	0-500 psia	±2.0		X	
LB1a	LOX pump bearing jet	0-1,000 psia	±2.0	See notes.		LOX pump bearing jet pressure measurement is also provided by stage-static-test instrumentation tap LB1b. One of the measurements must be classified as mandatory, and the other classified as highly desirable.
LS1	LOX pump bearing No. 1	0° to 400° F	±2.0	X		Measurement may be classified as highly desirable if turbopump bearing thermostat T3 is used as an interlock.
TG4a[a]	Turbine inlet (manifold)	0° to 2,000° F	±2.0	See notes.		Turbine inlet temperature is also provided by Stage-supplied measurement at tap GG2b. One of the measurements must be classified as mandatory, and the other classified as highly desirable.
K6	Gas generator ball valve limit switch	On-off (open-closed)	--	See notes.		Closed position is classified as mandatory, and open position is classified as highly desirable. Identification K6 is an MSFC number reference.
K7	Fuel valve No. 1 limit switch	On-off (open-closed)	--	X		Identification K7 is an MSFC number reference.
	Fuel valve No. 1 position	0-100%	--		X	

(a) Engines not incorporating MD176 change

Figure 2-17. Static Test Instrumentation Category Requirements (Sheet 2 of 9)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Category M	Category HD	Time Period/Action/Notes
	PRIMARY FLIGHT INSTRUMENTATION (cont)					
K8	Fuel valve No. 2 limit switch	On-off (open-closed)	--	X		Identification K8 is an MSFC number reference.
	Fuel valve No. 2 position	0-100%	--		X	
K9	Oxidizer Valve No. 1 limit switch	On-off (open-closed)	--	See notes.		Closed position is classified as mandatory, and open position is classified as highly desirable.
	Oxidizer valve No. 1 position	0-100%	--		X	Identification K9 is an MSFC number reference.
K10	Oxidizer valve No. 2 limit switch	On-off (open-closed)	--	See notes		Closed position is classified as mandatory, and open position is classified as highly desirable.
	Oxidizer valve No. 2 position	0-100%	--		X	Identification K10 is an MSFC number reference.
T1	Turbopump rpm No. 1	0-7,000 rpm	--		X	RPM No. 1 is an ac cycle count (0-234 cps). Identification T1 is an MSFC number reference.
	Turbopump rpm No. 2	0-7,000 rpm	--		X	RPM No. 2 is an ac cycle count (0-4,200 cps).
F44	Heat exchanger LOX inlet flow	20-100 gpm	±2.0		X	Identification F44 is an MSFC number reference.
CGT1	Engine environmental temperature	0° to 1,500° F	±2.0		X	Identification CGT1 is an MSFC number reference.
902		0° to 1,000° F (aA)				
	AUXILIARY FLIGHT INSTRUMENTATION					
						Auxiliary flight instrumentation is not applicable on engines incorporating MD96 change.
PF2a-1	Fuel pump discharge No. 1	0-2,500 psia	±2.0	See notes.		Fuel pump discharge pressure is also provided by primary flight instrumentation tap PF2a-2 and stage-static-test instrumentation taps PF2b-1 and PF2b-2. One of the measurements must be classified as mandatory, and the other three classified as highly desirable.

902 (aA) Engines incorporating MD159 change

Figure 2-17. Static Test Instrumentation Category Requirements (Sheet 3 of 9)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Category M	Category HD	Time Period/Action/Notes
	AUXILIARY FLIGHT INSTRUMENTATION (cont)					
PO2a-1	LOX pump discharge No. 1	0-2,000 psia	±2.0	See notes.		LOX pump discharge pressure measurement is also provided by primary flight instrumentation tap PO2a-2 and stage-static-test instrumentation taps PO2b-1 and PO2b-2. One of the measurements must be classified as mandatory, and the other three classified as highly desirable.
NH3a	Engine control opening	0-2,500 psia	±2.0		X	
NH2a	Engine control closing	0-2,500 psia	±2.0	See notes.		Control system supply pressure measurement provided by stage-static-test instrumentation tap NH1b may be used in lieu of engine control closing pressure. Engine control closing pressure is also provided by stage-static-test instrumentation tap NH2b. One of the measurements listed must be classified as mandatory, and the other classified as highly desirable. All measurements may be classified as highly desirable if a facility-supplied hydraulic pressure umbilical connection is operational.
HO1b	Heat exchanger LOX inlet	0-2,000 psia	±2.0		X	
HO4a	Heat exchanger GOX outlet	0-2,000 psia	±2.0		X	
HH2a	Heat exchanger helium inlet	0-500 psia	±2.0		X	
HH3a	Heat exchanger helium outlet	0-500 psia	±2.0		X	
PO7a	LOX pump seal cavity	0-50 psia	±2.0	See notes.		LOX pump seal cavity pressure measurement is also provided by stage-static-test instrumentation tap PO7b. One measurement must be classified as mandatory, and the other classified as highly desirable.

Figure 2-17. Static Test Instrumentation Category Requirements (Sheet 4 of 9)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Category M	Category HD	Time Period/Action/Notes
	AUXILIARY FLIGHT INSTRUMENTATION (cont)					
HO1a	Heat exchanger LOX inlet	-300° to -250° F	±2.0		X	
HO4b	Heat exchanger GOX outlet	-300° to +600° F	±2.0		X	
HH3b	Heat exchanger helium outlet	-300° F to +600° F	±2.0		X	
902 KF6a-2	Fuel pump inlet No. 2	0° to 130° F	±2.0		X	
	STAGE STATIC TEST INSTRUMENTATION					
KF6b-1	Fuel pump inlet No. 1	0-250 psia	±0.5	See notes.		Fuel pump inlet pressure measurement is also provided by primary flight instrumentation tap KF6a-1. One of the measurements must be classified as mandatory, and the other two classified as highly desirable.
902 KF6d-2	Fuel pump inlet No. 2					
PF2b-1[b][c]	Fuel pump discharge No. 1	0-2,500 psia	±0.5	See notes.		Fuel pump discharge pressure measurement is also provided by primary flight instrumentation tap PF2a-2 and auxiliary flight instrumentation tap PF2a-1. One of the measurements must be classified as mandatory, and the other three classified as highly desirable.
PF2b-2[b][c]	Fuel pump discharge No. 2					
PO2b-1[b][c]	LOX pump discharge No. 1	0-2,000 psia	±0.5	See notes.		LOX pump discharge pressure measurement is also provided by primary instrumentation tap PO2a-2 and auxiliary flight instrumentation tap PO2a-1. One of the measurements must be classified as mandatory, and the other three classified as highly desirable.
PO2b-2[b][c]	LOX pump discharge No. 2					
CG1b[b][c]	Combustion chamber No. 1	0-1,500 psia	±0.5		X	
CG1d[b][c]	Combustion chamber No. 2	0-1,500 psia	±0.5		X	

(b) Engines not incorporating MD141 change
(c) Engines incorporating MD150 and MD151 changes

Figure 2-17. Static Test Instrumentation Category Requirements (Sheet 5 of 9)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Category M	Category HD	Time Period/Action/Notes
	STAGE STATIC TEST INSTRUMENTATION (cont)					
GG1b	Gas generator chamber	0-1,500 psia	±0.5		X	
TG5a	Turbine outlet	0-100 psia	±0.5		X	
NH2b(b)(d)	Engine control closing	0-2,000 psia	±2.0	See notes.		Control system supply pressure measurement provided by stage-static-test instrumentation tap NH1b may be used in lieu of engine control closing pressure. Engine control closing pressure measurement is also provided by auxiliary flight instrumentation tap NH2a. One of the measurements listed must be classified as mandatory, and the other classified as highly desirable.
NH3b(b)(d)	Engine control opening	0-2,000 psia	±2.0		X	
NH8	Redundant shutdown valve supply pressure	0-2,000 psia	±2.0		X	902
LB1b	LOX pump bearing jet	0-1,000 psia	±2.0	See notes.		Two transducers are provided on engines incorporating MD150 and MD151 changes. LOX pump bearing jet pressure measurement is also provided by primary instrumentation tap LB1a. One of the measurements must be classified as mandatory, and the other classified as highly desirable.
PF10(b)(d)	Fuel impeller backcasing	0-500 psia	±2.0	See notes.		Two transducers are provided for this measurement. One must be classified as mandatory, and the other classified as highly desirable.
NH1b(b)(c)	Control system supply	0-2,000 psia	±2.0	See notes.		Engine control closing pressure provided by stage-static-test instrumentation tap NH2b or auxiliary flight instrumentation tap NH2a may be used in lieu of control system supply pressure. One of the measurements listed must be classified as mandatory, and the other classified as highly desirable.

(b) Engines not incorporating MD141 change
(c) Engines incorporating MD150 and MD151 changes
(d) Engines not incorporating MD151 change

Figure 2-17. Static Test Instrumentation Category Requirements (Sheet 6 of 9)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Category M	Category HD	Time Period/Action/Notes
	STAGE STATIC TEST INSTRUMENTATION (cont)					
PO7b[(b)(c)]	LOX pump seal cavity	0-50 psig	±2.0	See notes.		Two transducers are provided on engines incorporating MD150 and MD151 changes. LOX pump seal cavity pressure measurement is also provided by auxiliary flight instrumentation tap PO7a. One measurement must be classified as mandatory, and the other classified as highly desirable.
GC2a	Turbine inlet	0-1,500 psig	±0.5		X	
	ENGINE-MONITORED INSTRUMENTATION PARAMETERS					
PZA1-Y	LOX pump inlet flange	0-250g	--		X	0-3,500 cps filter
PZA2-Y	Fuel pump inlet elbow	0-250g	--		X	0-3,500 cps filter
PZA3-Z	Fuel pump inlet elbow	0-250g	--		X	Triaxial mounting pad 0-3,500 cps
PZA4-X	Fuel pump inlet elbow	0-250g	--		X	Triaxial mounting pad 0-3,500 cps
PZA8-Y	Fuel pump housing	0-250g	--		X	Triaxial mounting pad 0-3,500 cps
PZA9-Z	Fuel pump housing	0-250g	--		X	0-3,500 cps
--	Gas generator combustor	0-500g	--		X	Adapter block (Y) 0-3,500 cps
--	Gas generator combustor	0-500g	--		X	Adapter block (Z) 0-3,500 cps
CZA1-Y	LOX dome	0-707g	--	X		dc to 10 kc ±2db
CZA4-Y	LOX dome	0-707g	--	X		dc to 10 kc ±2db
CZA10-Y	LOX dome	0-707g	--	X		dc to 10 kc ±2db
--	LOX pump inlet	0-200 psia	--		X	dc to 10 kc ±2db
POad-1	LOX pump discharge No. 1	0-2,000 psia	--		X	dc to 10 kc ±2db

(b) Engines not incoporating MD141 change
(c) Engines incorporating MD150 and MD151 changes

Figure 2-17. Static Test Instrumentation Category Requirements (Sheet 7 of 9)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Category M	Category HD	Time Period/Action/Notes
	ENGINE-MONITORED INSTRUMENTATION PARAMETERS (cont)					
PO2c-2	LOX pump discharge No. 2	0-2,000 psia	--		X	dc to 10 kc ±2db
CO3h	LOX injection	0-3,000 psia	--		X	dc to 10 kc ±2db
KF7a-1	Fuel pump inlet No. 1	0-200 psia	--		X	dc to 10 kc ±2db
PF2d-1	Fuel pump discharge No. 1	0-2,500 psia	--		X	dc to 10 kc ±2db
CF1a	Fuel manifold	0-2,000 psia	--		X	dc to 10 kc ±2db
CF2a	Fuel injection	0-2,000 psia	--		X	dc to 10 kc ±2db
CG1a	Combustion chamber	0-3,000 psia	--		X	dc to 10 kc ±2db
GG1c	Gas generator chamber	0-1,500 psia	--		X	dc to 10 kc ±2db
See notes	LOX duct inlet temperature	-300° to -250° F	±1.0	See note.		Engine position 1 or 2 is mandatory, and one of engine positions 3, 4, or 5 is mandatory. Other positions are highly desirable. Temperature must be measured 90 inches or more above oxidizer inlet flange.
--	LOX suction line pressure	0-200 psia	±0.5	X		
GG2n	Turbine inlet temperature	0° to 2,500°F	±1.0		X	Turbine inlet manifold temperature is also provided as primary flight instrumentation system measurement at tap TG4a. One of the measurements must be classified as mandatory, and the other classified as highly desirable.
TG5b	Turbine outlet temperature	0° to 2,000° F	±1.0		X	
.	Engine control valve start signal	0-40 vdc	--		X	

Figure 2-17. Static Test Instrumentation Category Requirements (Sheet 8 of 9)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Category M	Category HD	Time Period/Action/Notes
ENGINE-MONITORED INSTRUMENTATION PARAMETERS (cont)						
--	Engine control valve stop signal	0-40 vdc	--		X	
--	Redundant shutdown valve signal	0-40 vdc	--		X	
--	Hypergol installed switch signal	0-40 vdc	--	X		
--	No. 1 thrust OK pressure switch pickup signal	0-40 vdc	--	See note.		Two of three thrust OK pressure switches are classified as mandatory, and the other classified as highly desirable.
--	No. 2 thrust OK pressure switch pickup signal	0-40 vdc	--	See note.		Two of three thrust OK pressure switches are classified as mandatory, and the other classified as highly desirable.
--	No. 3 thrust OK pressure switch pickup signal	0-40 vdc	--	See note.		Two of three thrust OK pressure switches are classified as mandatory, and the other classified as highly desirable.
--	LOX dome and gas generator LOX injector purge pressure	0-1,500 psia	±1.0	X		
--	Ground hydraulic supply temperature	0° to 200° F	±1.0	X		
--	DC voltage	0-40 vdc	±1.0	X		

Figure 2-17. Static Test Instrumentation Category Requirements (Sheet 9 of 9)

Instrumentation Tap	Description	Redline Values Minimum	Redline Values Maximum	Time Period/Action/Notes
	ENGINE PRE-START			
NH2a[(a)]	Control system supply pressure (engine position 1 only)	400 psig 415 psig[(b)]	1,800 psig 1,850 psig[(b)]	Measurements of engine positions 2 through 5 may be used as redline backups. Facility-supplied hydraulic umbilical connection pressure, when corrected for system delta P, is an acceptable alternate for this redline parameter. Required anytime hydraulic system is in operation prior to start of LOX loading.
		1,400psig 1,450psig[(b)]	1,800 psig 1,850 psig[(b)]	Required from start of LOX loading to checkout valve engine return position command.
		1,400psig 1,450psig[(b)]	1,600 psig 1,650 psig[(b)]	Required from checkout valve engine return position command to engine control valve start solenoid energized.
See notes	Turbopump LOX inlet temperature	--	-275° F	Temperature is measured at or below LOX pre-valve. Required at engine control valve start signal Applicable for engine position 1 or 2 and for engine position 3, 4, or 5.
LS1	Turbopump No. 1 bearing temperature	0° F	--	Required from start of LOX loading to engine control valve start signal. This parameter may be deleted if turbopump bearing thermostat T3 is used as an interlock.
Engine interface	Turbopump LOX seal purge pressure	60 psig	100 psig	Maximum allowable pressure during facility or stage system checkout is 125 psig. Required from start of admitting fuel or LOX to engine propellant feed system to engine control valve start signal and any time fuel or LOX is in engine propellant feed system. Common supply system pressure measurement to 5 engines is acceptable.
See notes.	Turbopump LOX seal leakage	--	See notes.	A visual inspection of oxidizer overboard drain line is required with LOX in engine system to verify no liquid leakage exists at engine control valve start signal.

(a) Engines not incorporating MD96 change. On engines incorporating MD96 change, a stage or facility instrumentation tap must be utilized to monitor control system supply pressure.
(b) These pressure values are applicable at the engine interface.

Figure 2-18. Static Test Operating Redline Instrumentation Requirements (Sheet 1 of 3)

Instrumentation Tap	Description	Redline Values Minimum	Redline Values Maximum	Time Period/Action/Notes
	ENGINE PRE-START (cont)			
Engine Interface	Turbopump LOX inlet pressure	78.3 psia		Required at engine control valve start signal. LOX pre-valves open must be interlocked to make sure that all LOX pre-valves are open at engine start. Minimum turbopump LOX inlet pressure is 75 psia if measured at or immediately below the stage LOX pre-valve.
KF6a-1	Turbopump fuel inlet pressure No. 1	43.3 psia		Required at engine control valve start signal. Fuel pre-valves open must be interlocked to make sure that all fuel pre-valves are open at engine start. Measurements of engine positions 2 through 5 or No. 2 fuel pump inlet pressure may be used as a backup.
Engine interface	Hydraulic supply temperature	60° F	130° F	Required from start of LOX loading to engine control valve start signal. Common supply system temperature measurement to 5 engines is acceptable.
Engine Interface	DC electrical voltage	24 vdc	32 vdc	From initial power application to checkout valve engine return position command. Common voltage measurement to 5 engines is acceptable.
		24 vdc	30 vdc	From checkout valve engine return position command to engine control valve start signal.
920 Engine Interface	LOX dome and gas generator LOX injector purge pressure	120 psig		Under flow conditions. From engine igniter firing signal to engine thrust OK pressure switch signal at a maximum lockup pressure of 1,200 psig. Common supply system measurement to 5 engines is acceptable. Sequence purge on so that system is primed at igniter firing signal.
	ENGINE START TO ENGINE SHUTDOWN			
PF10	Turbopump fuel impeller back-casing pressure	150 psig	350 psig 400 psig	Minimum value is applicable 6 seconds after engine control valve start signal; 400 psig is applicable 0-10 seconds after engine control valve start signal.

Figure 2-18. Static Test Operating Redline Instrumentation Requirements (Sheet 2 of 3)

Instrumentation Tap	Description	Redline Values Minimum	Redline Values Maximum	Time Period/Action/Notes
	ENGINE START TO ENGINE SHUTDOWN (cont)			
KF6a-1	Turbopump fuel inlet pressure No. 1	12 psig	--	Minimum value is applicable 6 seconds after engine control valve start signal. Other No. 1 or No. 2 turbopump inlet measurements are acceptable alternates for the parameter.
PF2a-1	Turbopump fuel discharge pressure No. 1	--	2,280 psig	Other No. 1 or No. 2 turbopump fuel discharge pressure measurements are acceptable alternates for this parameter.
Engine interface	Turbopump LOX inlet	30 psig	--	Minimum value is applicable 6 seconds after engine control valve start signal.
PO2a-1	Turbopump LOX discharge pressure No. 1	--	1,700 psig	This parameter may be used to limit turbopump speed to 5,800 rpm and may be adjusted to a maximum value of 2,010 psig. Other No. 1 or No. 2 turbopump LOX discharge pressure measurements are acceptable alternates for this parameter.
PO7a	Turbopump LOX seal cavity pressure	--	12 psig	Other turbopump LOX seal cavity pressure measurements are acceptable alternates for this parameter.
LB1a	Turbopump bearing jet pressure	200 psig	540 psig	Minimum value is applicable 8 seconds after engine control valve start signal. Other turbopump bearing jet pressure measurements are acceptable alternates for this parameter.
TG4a[(c)]	Turbine manifold temperature	--	1,775° F	Maximum value is applicale from engine control valve start signal. Turbine inlet temperature with maximum value of 1,575° F is an acceptable alternate for this parameter.
Engine interface	LOX pump seal purge pressure	30 psig	100 psig	Maximum and minimum values are applicable from engine control valve start signal. Common supply system measurement to 5 engines is acceptable.
CZA10-Y CZA4-Y CZA1-Y	Vibration safety cutoff	--	See notes.	100g rms for 45 milliseconds continuously from 2 of 3 accelerometers (applicable from engine control valve start signal).

(c) Engines not incorporating MD176 change

Figure 2-18. Static Test Operating Redline Instrumentation Requirements (Sheet 3 of 3)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Category M	Category HD	Time Period/Action/Notes
	PRIMARY FLIGHT INSTRUMENTATION					
KF6a-1	Fuel pump inlet	0-200 psia	±2.0	See notes.		One of five engine positions is mandatory unless fuel tank ullage pressure measurements are operational. If fuel tank ullage pressure is operational, these measurements are classified as highly desirable.
TG5c	Turbine outlet	0-100 psia	±2.0		X	
PF2a-2	Fuel pump discharge No. 2	0-2,500 psia	±2.0		X	
CG1e	Combustion chamber	0-1,500 psia	±0.5		X	
GG1d	Gas generator chamber	0-1,500 psia	±1.0		X	
PO2a-2	LOX pump discharge No. 2	0-2,000 psia	±2.0		X	
NH5c	Common hydraulic return	0-500 psia	±2.0		X	
LB1a	LOX pump bearing jet	0-1,000 psia	±2.0		X	
LS1	LOX pump bearing No. 1	0° to 400° F	±2.0	X		Measurement may be classified as highly desirable if turbopump bearing thermostat T3 is used as an interlock.
TG4a[(a)]	Turbine inlet	0° to 2,000° F	±2.0		X	
K6	Gas generator ball valve limit switch	On-off (open-closed)	--	See notes.		Identification K6 is an MSFC number reference. Closed position is mandatory, and open position is highly desirable.
K7	Fuel valve No. 1 limit switch	On-off (open-closed)	--	X		Identification K7 is an MSFC number reference.
	Fuel valve No. 1 position	0-100%	--		X	

(a) Engines not incorporating MD176 change

Figure 2-10. Launch Instrumentation Category Requirements (Sheet 1 of 5)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Category M	Category HD	Time Period/Action/Notes
	PRIMARY FLIGHT INSTRUMENTATION (cont)					
K8	Fuel valve No. 2 limit switch	On-off (open-closed)	--	X		Identification K8 is an MSFC number reference.
	Fuel valve No. 2 position	0-100%	--		X	
K9	Oxidizer valve No. 1 limit switch	On-off (open-closed)	--	See notes.		Identification K9 is an MSFC number reference. Closed position is mandatory; open position is highly desirable.
	Oxidizer valve No. 1 position	0-100%	--		X	
K10	Oxidizer valve No. 2 limit switch	On-off (open-closed)	--	See notes.		Identification K10 is an MSFC number reference. Closed position is mandatory, open position is highly desirable.
	Oxidizer valve No. 2 position	0-100%	--		X	
T1	Turbopump rpm No. 1	0-7,000 rpm	--		X	Identification T1 is an MSFC number reference. RPM No. 1 is an ac cycle count (0-234 cps).
	Turbopump rpm No. 2	0-7,000 rpm			X	RPM No. 2 is an ac cycle count (0-4,200 cps).
F44	Heat exchanger LOX inlet flow:					
	pickup	20-100 gpm	±2.0		X	Identification F44 is an MSFC number reference.
CGT1	Engine environmental temperature	0° to 1,500° F 0° to 1,000° F(b)	±2.0		X	Identification CGT1 is an MSFC number reference 567 902
	AUXILIARY FLIGHT INSTRUMENTATION					Engines not incorporating MD96 change.
PF2a-1	Fuel pump discharge No. 1	0-2,500 psia	±2.0		X	
PO2a-1	LOX pump discharge No. 1	0-2,000 psia	±2.0		X	

(b) Engines incorporating MD159 change 902

Figure 2-19. Launch Instrumentation Category Requirements (Sheet 2 of 5)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Category M	Category HD	Time Period/Action/Notes
	AUXILIARY FLIGHT INSTRUMENTATION (cont)					
NH3a	Engine control opening	0-2,500 psia	±2.0		X	
NH2a	Engine control	0-2,500 psia	±2.0	See notes.		One of five engine positions is mandatory. This measurement may be classified as highly desirable if the facility-supplied hydraulic umbilical connection pressure is operational.
HO1b	Heat exchanger LOX inlet	0-2,000 psia	±2.0		X	
HO4a	Heat exchanger GOX outlet	0-2,000 psia	±2.0		X	
HH2a	Heat exchanger helium inlet	0-500 psia	±2.0		X	
HH3a	Heat exchanger helium outlet	0-500 psia	±2.0		X	
PO7a	LOX pump seal cavity	0-50 psia	±2.0		X	
HO1a	Heat exchanger LOX inlet	-300° to -250° F	±2.0		X	
HO4b	Heat exchanger GOX outlet	-300° to +600° F	±2.0		X	
HH3b	Heat exchanger helium outlet	-300° to +600° F	±2.0		X	
902 KF6a-2	Fuel pump inlet No. 2	0° to 130° F	±2.0		X	
	ENGINE-MONITORED INSTRUMENTATION PARAMETERS					
PZA1-Y	LOX pump inlet flange	0-250g	--		X	0-3,500 cps filter
PZA2-Y	Fuel pump inlet elbow	0-250g	--		X	0-3,500 cps filter
PZA3-Z	Fuel pump inlet elbow	0-250g	--		X	Triaxial mounting pad 0-3,500 cps
PZA4-X	Fuel pump inlet elbow	0-250g	--		X	Triaxial mounting pad 0-3,500 cps

Figure 2-19. Launch Instrumentation Category Requirements (Sheet 3 of 5)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Category M	Category HD	Time Period/Action/Notes
	ENGINE-MONITORED INSTRUMENTATION PARAMETERS (cont)					
PZA8-Y	Fuel pump housing	0-250g	--		X	Triaxial mounting pad 0-3,500 cps
PZA9-Z	Fuel pump housing	0-250g	--		X	0-3,500 cps
CZA10-Y	LOX dome	0-707g	--		X	dc to 10 kc ±2 db
CZA4-Y	LOX dome	0-707g	--		X	dc to 10 kc ±2 db
CG1a	Combustion chamber	0-3,000 psia	--		X	dc to 10 kc ±2 db
GG1c	Gas generator chamber	0-1,500 psia	--		X	dc to 10 kc ±2 db
--	LOX pump inlet	0-200 psia	--		X	dc to 10 kc ±2 db
See notes.	LOX duct inlet temperature	-300° to -250° F	±1.0	X		Engine position 1 or 2 is mandatory, and one of engine positions 3, 4, or 5 is mandatory. Other positions are highly desirable.
--	LOX suction line pressure	0-200 psia	±0.5	See notes.		One of five engine positions is mandatory; others are highly desirable. This measurement may be classified as highly desirable if a LOX tank ullage pressure measurement is operational.
--	Engine control valve start signal	0-40 vdc	--		X	
--	Engine control valve stop signal	0-40 vdc	--		X	
--	Redundant shutdown valve signal	0-40 vdc	--		X	
--	Hypergol installed switch signal	0-40 vdc	--	X		
--	No. 1 thrust OK pressure switch pickup signal	0-40 vdc	--	See notes.		Two of three thrust OK pressure switches are classified as mandatory, and the other classified as highly desirable.
--	No. 2 thrust OK pressure switch pickup signal	0-40 vdc	--	See notes.		Two of three thrust OK pressure switches are classified as mandatory, and the other classified as highly desirable.

Figure 2-10. Launch Instrumentation Category Requirements (Sheet 4 of 5)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Category M	Category HD	Time Period/Action/Notes
ENGINE-MONITORED INSTRUMENTATION PARAMETERS (cont)						
--	No. 3 thrust OK pressure switch pick-up signal	0-40 vdc	--	See notes.		Two of three thrust OK pressure switches are classified as mandatory, and the other classified as highly desirable.
--	LOX dome and gas generator LOX injector purge	0-1,500 psia	±1.0	X		
--	Ground hydraulic supply temperature	0° to 200° F	±1.0	X		
--	DC voltage	0-40 vdc	±1.0	X		

Figure 2-19. Launch Instrumentation Category Requirements (Sheet 5 of 5)

Instrumentation Tap	Description	Redline Values Minimum	Redline Values Maximum	Time Period/Action/Notes
NH2a[a]	Control system supply pressure (engine position 1 only)	400 psig 415 psig[b]	1,800 psig 1,850 psig[b]	Measurements of engine positions 2 through 5 may be used as redline backups. A facility-supplied hydraulic umbilical connection pressure, when corrected for system delta P, is an acceptable alternate for this redline.
920				Required anytime hydraulic system is in operation prior to start of LOX loading.
		1,400 psig 1,450 psig[b]	1,800 psig 1,850 psig[b]	Required from start of LOX loading to checkout valve engine return position command.
		1,400 psig 1,450 psig[b]	1,600 psig 1,650 psig[b]	Required from checkout valve engine return position command to engine control valve start solenoid energized.

(a) Engines not incorporating MD96 change. On engines incorporating MD96 change, a stage or facility instrumentation tap must be utilized to monitor control system supply pressure.
(b) Pressure values are applicable at the engine interface.

Figure 2-20. Launch Operating Redline Instrumentation Requirements (Sheet 1 of 3)

Instrumentation Tap	Description	Redline Values		Time Period/Action/Notes
		Minimum	Maximum	
See notes.	Turbopump LOX inlet temperature	--	-275°F	Temperature is measured at or below LOX pre-valve. Required at engine control valve start signal. Applicable for engine position 1 or 2 and for engine position 3, 4, or 5.
LS1	Turbopump No. 1 bearing temperature	0° F	--	Required from start of LOX loading to engine control valve start signal. This parameter may be deleted if turbopump bearing thermostat T3 is used as an interlock.
Engine interface	Turbopump LOX seal purge pressure	60 psig	100 psig	Maximum allowable pressure during facility or stage system checkout is 125 psig. Required from start of admitting LOX to engine propellant feed system and anytime LOX is in engine propellant feed system. Common supply system measurement to 5 engines is acceptable. 920
CGT1	Engine environmental temperature	0° F	130° F	Measurements of engine position 2, then 1, 3, 4, and 5 may be used as redline alternates. 907 Common supply system temperature measurement, when corrected for system delta T, to 5 engines is acceptable backup for this redline.
See notes.	Turbopump LOX seal leakage	--	See notes.	A visual inspection of oxidizer overboard drain line is required with LOX in engine system to verify no liquid leakage exists at engine control valve start signal.
Engine interface	Turbopump LOX inlet pressure	78.3 psia		Required at engine control valve start signal. LOX pre-valves open must be interlocked to make sure all LOX pre-valves are open at engine start. If pressure is measured at or immediately below stage LOX pre-valve, 75 psia is minimum. One of five engine position measurements or LOX tank ullage pressure measurement of a minimum value of 23.7 psia is acceptable as redline alternate.

Figure 2-20. Launch Operating Redline Instrumentation Requirements (Sheet 2 of 3)

Instrumentation Tap	Description	Redline Values		Time Period/Action/Notes
		Minimum	Maximum	
KF6a-1	Fuel pump inlet pressure No. 1 (engine position 1 only)	43.3 psia		Fuel pre-valves open must be interlocked to make sure all fuel pre-valves are open at engine start. Fuel tank ullage minimum pressure redline is an acceptable alternate with 27 psia. Measurements of engine positions 2 through 5 or No. 2 fuel pump inlet pressure may be used as redline backup. Required at engine control valve start signal.
Engine interface	Hydraulic supply temperature	60° F	130° F	Required from start of LOX loading to engine control valve start signal. Common supply system measurement to 5 engines is acceptable.
Engine interface	DC electrical voltage	--	32 vdc	From initial power application to checkout valve engine return position command. Common voltage measurement to 5 engines is acceptable.
		24 vdc	30 vdc	From checkout valve engine return position command to engine control valve start signal.
920 Engine interface	LOX dome and gas generator LOX injector purge	120 psig		From engine igniter firing signal to engine thrust OK pressure switch signal at a maximum lockup pressure of 1,200 psig. Common supply system measurement to 5 engines is acceptable.

Figure 2-20. Launch Operating Redline Instrumentation Requirements (Sheet 3 of 3)

2.7 APPLICABLE SPECIFICATIONS.

2.7.1 Throughout this manual reference is made to the following specifications by title and basic document number; however, in all cases the issue specified below shall govern.

MIL-B-131E Amendment 1 14 July 1967	Barrier Material, Water Vaporproof, Flexible, Heat Sealable
MIL-C-14201A 23 April 1956	Corrosion Preventive, Soft Film, Cold Application
MIL-C-16173D Amendment 2 19 November 1968	Corrosion Preventive Compound, Solvent Cutback, Cold Application, Grade I
MIL-C-81302B 23 December 1968	Cleaning Compound, Solvent Trichlorotrifluoroethane 925

MIL-F-25558B Amendment 3 14 March 1963	Fuel Ramjet Engine, Grade RJ-1
932 MIL-L-25567C 9 June 1971	Leak Test Compound, Oxygen Systems
MIL-P-25508D 16 March 1962	Propellant, Oxygen
925 MIL-P-27401B 19 September 1962	Propellant Pressurizing Agent, Nitrogen
MIL-P-25576C Amendment 1 3 November 1967	Propellant, Kerosene
MSFC-SPEC-217 10 August 1962	Trichloroethylene, Technical
932 MSFC-STD-500A Amendment 2 25 September 1970	S-IC Stage Storage
MIL-T-27602A 25 January 1965	Trichloroethylene, Oxygen Propellant Compatible
DB-F-1421 29 February 1968	Fluorocarbon Refrigerants (Type 12)
925 O-T-634b Amendment 1 9 October 1968	Trichloroethylene, Technical
P-D-680 Amendment 2 9 June 1964	Dry Cleaning Solvent
PPP-T-0060C 925 Amendment 2 2 March 1970	Tape: Pressure-Sensitive Adhesive; Waterproof, For Packaging
TT-I-735a Amendment 2 5 May 1964	Isopropyl Alcohol
925 VV-L-800A 20 February 1970	Lubricating Oil, General Purpose, Preservative, (Water-Displacing, Low Temperature)
VV-P-236 17 December 1954	Petrolatum, Technical
Helium	Bureau of Mines, Helium Grade A

SECTION III

OPERATING PROCEDURES

WARNING

THE FOLLOWING GROUND SUPPORT EQUIPMENT MUST BE OPERATED BY AUTHORIZED PERSONNEL TRAINED IN THE USE OF THE EQUIPMENT.

G2030, Oxidizer Dome Flushing Kit
G2037, Fuel Drainage Kit
G2039, Scavenge Pump
G3104, Pneumatic Flow Tester
G3132, Test Plate, Plug, and Tool Set
G3135, Hypergol System Tool Kit
G3136, Thrust Chamber Throat Plug
G3142, Engine Checkout Console
G3144, Turbine Exhaust Exit Pressure Check Fixture
G3153, High-Voltage Igniter
G4049 or 75M51505, Engine Vertical Installer
G4069, Engine Handler
G4079, Nozzle Extension Alinement Tool
G4089 or 99-9026815, Thrust Chamber Throat Security Closure
9026622, Inert Igniter
99-9012908, Fuel Drain Vent Adapter Kit

SCOPE. This section contains recommended detail procedures to perform authorized activities specified in section I. In the event of conflict between criteria specified in sections I and II and in this section, sections I and II criteria shall apply. During the following procedures, Stage Contractor and/or NASA supplied detailed procedures must be used when installing interconnects between the engine and ground support equipment and/or checkout equipment that are not supplied by the Engine Contractor. When performing work specified in this manual, all local safety and health directives must be complied with. It is assumed these directives are in compliance with the Occupational and Safety Health Act. When local safety and health directives are more stringent than those specified in this manual, the local directives will prevail.

3.1 INSPECTIONS.

3.1.1 When no recommendations are made for the method of performing the inspection activities specified in sections I and II, no additional instructions are required.

3.1.2 VARIABLE ORIFICE INSPECTION. Visually verify that part number and size of each variable orifice installed on the engine agrees, within machining tolerance, with the variable orifice nominal size recorded in the Engine Log Book. The orifice is identified with the actual measured size, which may differ from the Engine Log Book Record (nominal size) to the extent of the tolerances listed as follows:

Part Number	Tolerance (Inch)
RD251-4071-	±0.001
RD251-4072-	±0.001
RD251-4080-	±0.001
RD251-4083-	±0.001
RD251-4085-	±0.001
RD251-4087-	±0.001
RD251-4098-	±0.001
RD251-4100-	±0.002
RD251-4103-	±0.002
RD251-4104-	±0.002
RD251-4108-	±0.001
RD251-4118-	±0.002
RD251-4129-	±0.0005
RD251-4130-	±0.0005
RD251-4131-	±0.0005
RD251-5001-	±0.001
RD273-1027-	+0.0005, -0.0000

3.1.3 OLDEST ASSEMBLY/INSTALLATION DATE INSPECTION. Verify that date embossed on metal strip attached to engine mount strut and marked OLDEST ASSEMBLY/ INSTALLATION DATE agrees with oldest install date recorded in Engine Log Book on Age Control Log for Component Synthetic Rubber Items form. If the dates do not agree, determine accuracy of Engine Log Book entry; then, if required, emboss a new 1/2-inch wide metal strip of aluminum, CRES, or zinc with the words (3/32-inch-high letters) OLDEST ASSEMBLY/INSTALLATION DATE followed by the oldest install date recorded in Engine Log Book and safetywire new metal strip in place of old metal strip with Inconel lockwire MS20995N.

3.1A CONTAMINATION AND DAMAGE PREVENTION.

3.1A.1 When working with or around the engine, the following procedures should be observed and performed, as applicable, to preclude possible contamination and/or damage to the engine.

a. Make sure that clothing worn by personnel is free of loose particles and fibers and pockets are emptied of foreign objects that could contribute to contamination.

b. Take only required parts, tools, and test equipment in engine area; perform an accounting of tools and parts at beginning and end of a procedure.

c. Make sure that all test equipment and tools used meet the cleanness requirements for use in liquid oxygen, fuel, and pneumatic systems.

d. Make sure that tools are properly tethered to carrying individual or are carried in a suitably tethered bag when work is being performed above engine.

e. Provide water shields and wind breaks when an engine system is to be opened in an outdoor location during rain or high winds.

f. Make sure that areas are checked above, around, and below system being opened for operations that may cause or allow contamination of system. Take proper measures to prevent contamination of other systems from system being opened.

WARNING

The following procedure uses trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

- Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

g. Prior to opening any engine system, use a regulated source of low-pressure (less than 30 psig) gaseous nitrogen (MIL-P-27401) or clean, dry air conforming to cleanness and humidity requirements of MIL-P-27401 to blow area free of accumulated loose contaminants (water, sand, etc); then using a clean, lint-free cloth moistened with trichloroethylene (MIL-T-27602), wipe area free of all visible contaminants.

h. Provide a suitable container to catch residual fluids when a system is opened.

i. Install protective devices as quickly as possible when a system is opened, to prevent the entry of contaminants.

CAUTION

Closures having sponge rubber seals must not be used, since contamination of component or system can result.

j. Use protective closures and covers specified in R-3896-4 for opened engine systems and removed-part openings when at all possible. Make sure that protective closures and covers are cleaned as outlined in R-3896-3 prior to installation. Secure protective closures and covers with the required number of fasteners. If fewer than the required number of fasteners are used, adequate protection may not be provided.

k. If protective closures or covers specified in R-3896-4 are not available, flanged areas may be packaged using method shown in figure 3-A1 and as follows:

CAUTION

When securing Aclar film or bags to the line with tape, a minimum of 25 percent of the tape width must contact the body of the line to prevent the entry of contaminants.

NOTE

The tape used in this procedure is pressure-sensitive tape RB0195-002 (Rocketdyne).

(1) Cover open ends of line with Aclar No. 33C film (0.002-inch minimum thickness) (Allied Chemical Corp). Wrap film over periphery of flange and secure film to body of line with tape.

(2) Install a bag (0.004-inch minimum thickness) made from clean plastic sheet and strip (Federal Specification L-P-378, Type II) over Aclar film to completely cover and extend beyond film. Expel air from bag, and secure bag to body of line with tape.

NOTE

Clean polyethylene bags (Federal Stock No. 8105-LC0-6811) or clean polyethylene tubing (Federal Stock No. 8135-782-7460), heat sealed at one end, may be used instead of plastic sheet and strip. All polyethylene material used must be 0.004-inch minimum thickness.

(3) Attach a certificate of cleanness to taped area, if required.

(4) Install a second bag (0.004-inch minimum thickness) made from clean plastic sheet and strip (Federal Specification L-P-378, Type II) over first bag. Expel air from bag, and secure bag to body of line with tape.

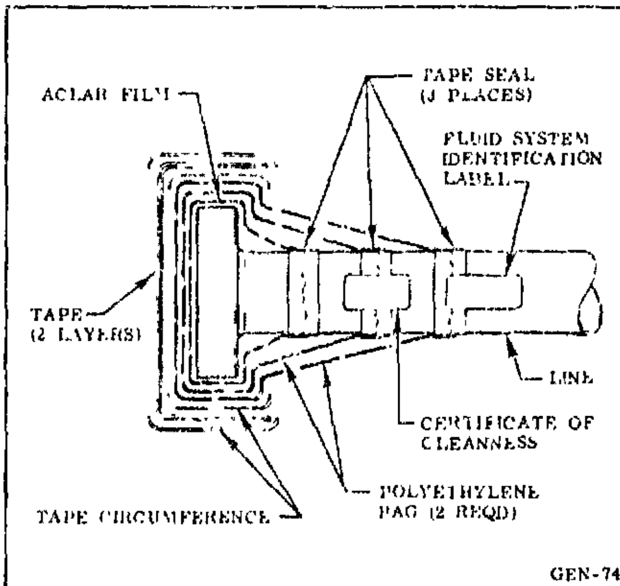


Figure 3-A1. Alternate Protective Closures for Engine Lines

NOTE

Clean polyethylene bags (Federal Stock No. 8105-LC0-6811) or clean polyethylene tubing (Federal Stock No. 8135-782-7460), heat sealed at one end, may be used instead of plastic sheet and strip. All polyethylene material used must be 0.004-inch minimum thickness.

(5) Gather and tape bag over periphery of flange to prevent flange from cutting through bag.

(6) Apply 2 layers of tape over outer bag. Tape must cover surface of flange and extend over periphery of flange. Secure ends of tape by applying a layer of tape around periphery of flange.

(7) Attach a fluid system identification label to line, if required.

l. Package pressure caps, plugs, seals, and miscellaneous small parts being retained for reinstallation in clean plastic sheet and strip (Federal Specification L-P-378, Type II). Secure package by heat sealing or with pressure-sensitive tape RB0195-002 (Rocketdyne).

NOTE

Clean polyethylene bags (Federal Stock No. 8105-LC0-6811) or clean polyethylene tubing (Federal Stock No. 8135-782-7460) heat sealed at one end, may be used. All polyethylene material used must be 0.004 inch thick.

m. The following standard plug and caps of the appropriate size may also be used to protect engine and removed-part openings:

(1) Plug AN806-JX in tube coupling nuts

(2) Plug AN814-XXJ and O-ring MS28775 in threaded parts

(3) Cap AN929-XXJ on threaded male fittings

WARNING

The following procedure uses cleaning compound (MIL-C-81302), which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

- The following procedure uses isopropyl alcohol, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

- Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

n. Before removal of a fluid-system closure, clean exterior surfaces of closure using a clean, hemmed nylon cloth or a clean brush moistened with unused cleaning compound (MIL-C-81302) or isopropyl alcohol (Federal Specification TT-I-735). Dry closure with a regulated source of low-pressure (less than 30 psig) gaseous nitrogen (MIL-P-27401) or clean, dry air conforming to the cleanness and humidity requirements of MIL-P-27401.

o. Package protective closures and covers to be reinstalled on the same system opening in clean plastic sheet and strip (Federal Specification L-P-378, Type II). Seal package with pressure-sensitive tape RB0195-002 (Rocketdyne) or by heat sealing.

NOTE

Clean polyethylene bags (Federal Stock No. 8105-LC0-6811) or clean polyethylene tubing (Federal Stock No. 8135-782-7460) heat sealed at one end, may be used. All polyethylene material used must be 0.004 inch thick.

3.1B MATERIALS.

3.1B.1 See figure 3-A2 for materials required to perform tasks specified in this manual.

3.2 UNINSTALLED-ENGINE TEST PROCEDURES.

3.2.A1 Engine Checkout Console G3142 is used for testing uninstalled engines. Panels on the engine checkout console are identified by reference designation number or by nomenclature. In the procedures, panels will be identified by placing the reference designation number or the nomenclature, as applicable, in parentheses.

Identification	Name	Use
Aclar No. 33C (Allied Chemical Corp)	Film	Protecting parts.
Airtex 217, Type II (Eon Corp)	Tying tape	Tying bags on fuel overboard drain system.
BB-F-1241, Type 12 (Federal Specification)	Refrigerant	Leak testing system joints.
Brayco 777 (Bray Oil Co)	Hydraulic fluid	Lubricating hot gas seals.
Bureau of Mines, Grade A	Helium	Leak testing heat exchanger helium coils and lines.
C-5A (Felt Products)	Thread compound	Lubricating hot gas fitting threads.
Ethafoam (Dow Chemical Corp)	Foam	Cushioning thrust chamber nozzle extension on pallet.
FS1281 (Dow Chemical Corp)	Grease	Lubricating fuel system packings.
Krytox 143AZ (Du Pont)	Fluorinated oil	Lubricating thrust chamber fuel and oxidizer seals.
L-P-378, Type II (Federal Specification)	Plastic sheet and strip	Packaging parts and collecting fuel system overboard drain system fluid.
MB0210-003 (NR, Space Division)	Trichloroethylene	Flushing thrust chamber fuel jacket and LOX dome and flushing gas generator LOX injector.
MIL-B-131	Vapor-proof barrier material	Packaging pyrotechnic igniters.
MIL-C-14201, Grade 2	Corrosion preventive	Preserving turbopump bearings.
MIL-C-16173, Grade I	Corrosion preventative compound	Protecting unpainted stationary surfaces.
MIL-C-81302	Cleaning compound	Cleaning desiccant bags, exterior of closures before they are removed, and leak-test compound from joints.
MIL-F-25558	RJ-1 fuel	Engine hydraulic system fluid from ground supply.
MIL-L-25567	Leak-test compound	Leak testing joints pressurized with gaseous nitrogen.

Figure 3-A2. Materials Specified in This Manual (Sheet 1 of 3)

Identification	Name	Use
MIL-P-25508	Liquid oxygen	Engine oxidizer system fluid.
MIL-P-25576	Propellant kerosene	Engine fuel system fluid.
MIL-P-27401	Gaseous nitrogen	Pressurizing fluid for leak and function testing engine systems and fluid for engine purge systems.
MIL-T-27602	Trichloroethylene	Handcleaning exterior surfaces of engine before opening an engine system, flushing thrust chamber fuel jacket and LOX dome, and flushing gas generator LOX injector.
MSFC-SPEC-217	Trichloroethylene	Flushing thrust chamber fuel jacket and LOX dome and flushing gas generator LOX injector.
MS20995N	Inconel lockwire	Safetywiring fittings with lockwire holes and safetywiring torque gear housing cap.
No number	Aluminum foil tape	Protecting space between thrust chamber tubes and exhaust manifold.
O-T-634, Type I (Federal Specification)	Trichloroethylene	Flushing thrust chamber fuel jacket and LOX dome and flushing gas generator LOX injector.
P-D-680, Type I (Federal Specification)	Drycleaning compound	Cleaning hypergol system test tool and manifold.
PPP-T-60 (Federal Specification)	Waterproof tape	Packaging pyrotechnic igniters and securing fuel overboard drain system fluid collection bags.
RB0140-012 (Rocketdyne)	Lubricant grease	Lubricating threads and packings in fuel, oxidizer, hydraulic, and overboard drain systems disconnected during checkout, servicing, and storage. Lubricating test equipment used during engine testing.
RB0195-002 (Rocketdyne)	Pressure-sensitive tape	Securing Ethafoam on thrust chamber nozzle extension pallet and securing Aclar No. 33C film.
RB0210-003 (Rocketdyne)	Trichloroethylene	Flushing thrust chamber fuel jacket and LOX dome and flushing gas generator LOX injector.

Figure 3-A2. Materials Specified in This Manual (Sheet 2 of 3)

Identification	Name	Use
RB0210-016 (Rocketdyne)	Corrosion preventative	Preserving turbopump bearings and protecting unpainted stationary surfaces.
RB0210-017 (Rocketdyne)	Ethylene glycol	Thrust chamber fuel jacket prefill fluid.
RB0295-00' (Rocketdyne)	Desiccant	Packaging pyrotechnic igniter and maintaining engine interior humidity.
RTV-102 (General Electric)[a]	White sealant	Sealing area between thrust chamber tubes and external bands.
SAE 5W	Oil	Lubricating turbopump torque gear shaft.
TT-I-735 (Federal Specification)	Isopropyl alcohol	Cleaning closures.
VV-L-800 (Federal Specification)	Lubricating oil	Protecting unpainted working surfaces.
VV-P-236 (Federal Specification)	Petrolatum	Lubricating thrust chamber tube surface that contacts thrust chamber throat plug and lubricating overlap area on turbine exhaust exit pressure test fixture.
WD-40 (Rocket Chemical Co)	Preservative	Lubricating turbopump torque gear shaft.
8105-LCO-6811 (Federal Stock No.)	Polyethylene bag	Packaging parts and collecting fuel system overboard drain system fluid.
8135-782-7460 (Federal Stock No.)	Polyethylene tubing	Packaging parts and collecting fuel system overboard drain system fluid.

(a) Compound has limited shelf life. Refer to age-controlled compounds in R-3896-3 for usability test.

Figure 3-A2. Materials Specified in This Manual (Sheet 3 of 3)

3.2.1 PREPARING ENGINE AND ENGINE CHECKOUT CONSOLE FOR TEST. The following paragraphs prepare Engine Checkout Console G3142 and the engine for continuous or individual tests.

CAUTION

Low-flow pneumatic flowmeters (rotometer type) used in the following procedures are easily damaged by flow surges. All valves, regulators, or other flow control devices in systems containing these flowmeters must be actuated very slowly to prevent damage to the flowmeters.

a. Verify that console circuit breaker, switches, and lights are in the off or neutral position, regulators and hand valves are closed, and pressure gages indicate zero.

b. Verify interconnection between consoles. (See figure 3-1.)

c. Verify that MISSILE AIR FLOW and LOX CLEAN AIR FLOW flowmeters are calibrated at the pressure at which flows are to be measured.

d. Verify that facility electrical, pneumatic, and hydraulic sources are applied to consoles.

e. Determine tests to be performed; then see figures 3-1 and 3-2, and install required electrical equipment.

NOTE

For continuous checkout, all electrical equipment should be installed.

- Electrical cable connector torque need be only fingertight.

f. Move MAIN POWER switch (1A8) to ON. The following lights must come on:

(1) MAIN POWER ON, +DC GROUNDED (dim), and -DC GROUNDED (dim) (1A8)

(2) NO. 1 NO THRUST, NO. 2 NO THRUST, and NO. 3 NO THRUST (1A7)

(3) GROUND and MANUAL (2A7)

(4) CLOSED (2A3)

(5) NO. 1 CLOSED and NO. 2 CLOSED (2A2)

(6) NO. 1 CLOSED and NO. 2 CLOSED (2A6)

g. Press CIRCUIT BREAKER 15 AMPS (2A9). All flowmeter lights must come on.

h. Slowly open GN_2, MSL AIR, L. C. AIR, HELIUM, FREON NO. 1, FREON NO. 2, and HYDRAULIC PRESSURE shutoff valves (MANIFOLD PRESSURE SHUTOFF VALVE PANEL). The following lights must come on:

(1) GN_2 PRESS ON

(2) MISSILE AIR ON

(3) LOX CLEAN AIR ON

(4) HELIUM PRESS ON

(5) NO. 1 FREON PRESS ON

(6) NO. 2 FREON PRESS ON

(7) HYD PRESS ON (1A7)

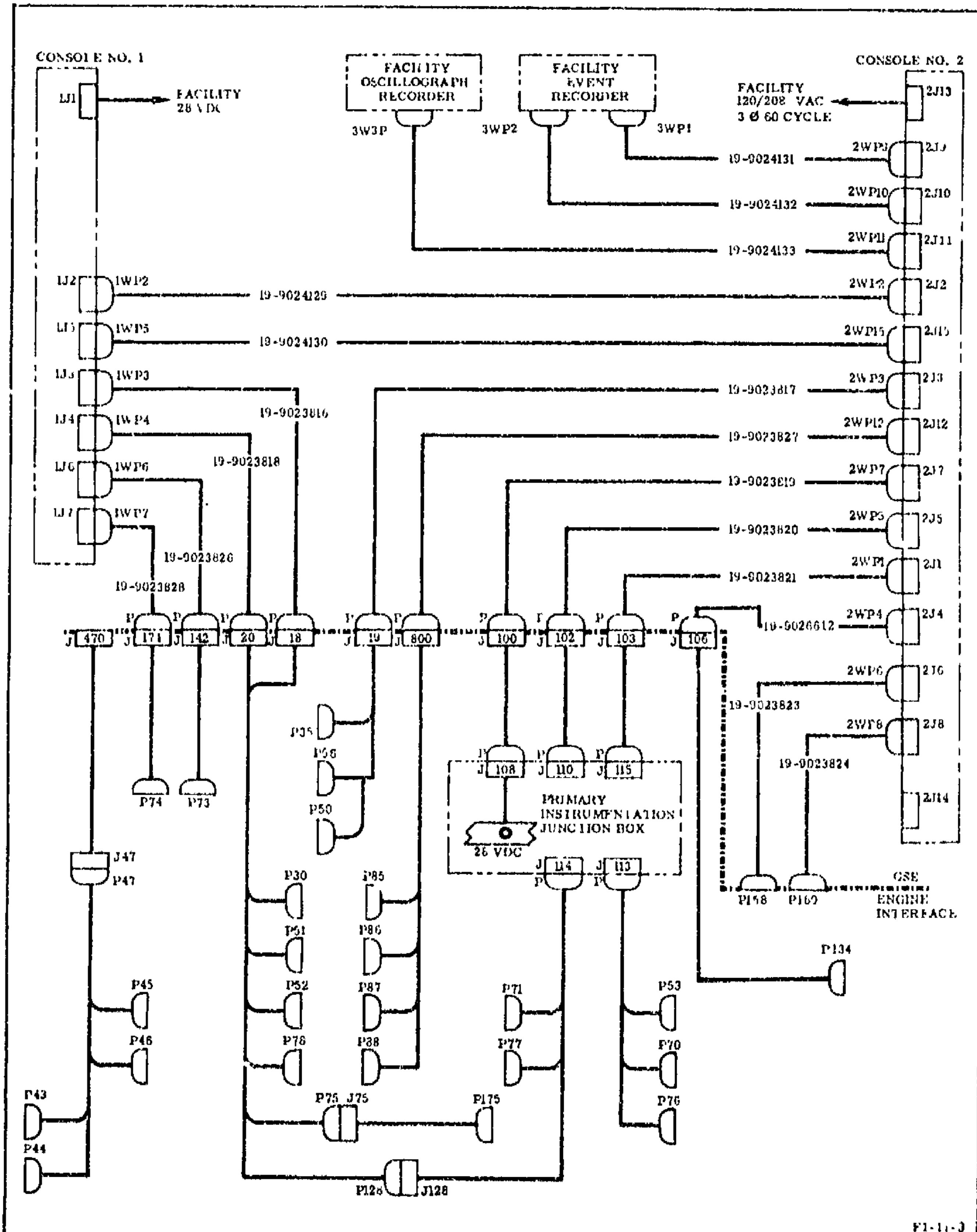


Figure 3-1. Engine to Engine Checkout Console Test Setup Cable Diagram

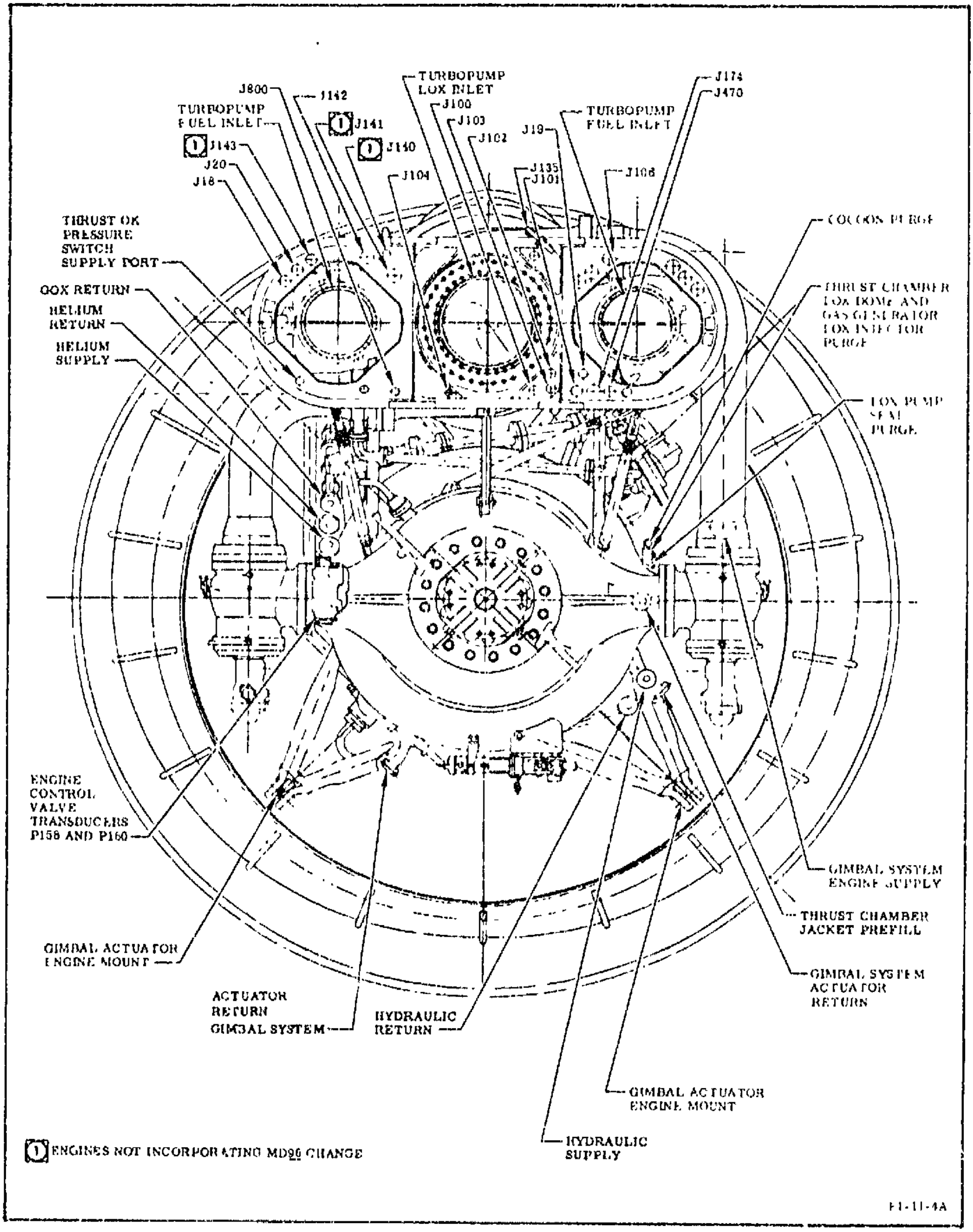


Figure 3-2. Engine Connect Points for Testing

3.2.2 ELECTRICAL TESTS FOR UNINSTALLED ENGINES. (See figure 3-3 through 3-5.)

3.2.2.1 Flight Instrumentation System Function Test. Test instrumentation used to perform the flight instrumentation system function test activity is provided by the Stage Contractor. The test activity when complemented by criteria referenced in section II, requires no additional instructions; therefore, no recommendations are provided for the method of accomplishing this activity.

3.2.2.2 Turbopump Heater Function Test.

a. Verify that engine checkout console is prepared for electrical operation (paragraph 3.2.1).

Procedure	Result
b. Move LIGHT and AC LINE switches (2A9) (inside temperature recorder door) to ON.	Temperature recorder neon light comes on.

NOTE

The temperature recorder requires a 5-minute warmup period.

Procedure	Result
c. Move MOTOR switch (2A9) (inside temperature recorder door) to ON.	Chart paper moves 30 inches per hour; channels 1, 2, and 3 print ambient temperature.

CAUTION

In the following procedures, any time the HEATER OVER TEMPERATURE light comes on and/or the HEATER TEMP NORMAL light goes off, this test must be discontinued and the cause of the indication determined.

Procedure	Result
d. Move HEATER POWER switch (2A9) to ON.	AC POWER PHASE A, AC POWER PHASE B, AC POWER PHASE C, and HEATER TEMP NORMAL lights (2A9) come on.
e. Record meter values of No. 1 and No. 2 heaters.	No. 1 HEATER CURRENT and No. 2 HEATER CURRENT meters (2A9) indicate 7.5 ±2.5 amperes; channel 1 prints heater temperature rise.
f. Allow heaters to cycle 3 times. Record minimum and maximum temperatures for each cycle.	Temperature range for thermostat pickup and dropout must be 65° to 180° F.

NOTE

If ambient temperature is above 85° F, the heaters may not cycle. Thermostats can be cooled with a spray refrigerant, Type 12 (Federal Specification BB-F-1421) applied in short bursts directly on the thermostat.

Procedure	Result
g. Move MOTOR, AC LINE, and LIGHT switches (2A9) to OFF.	Temperature recorder neon light goes off and chart paper stops.
h. Move HEATER POWER switch (2A9) to OFF.	AC POWER PHASE A, AC POWER PHASE B, AC POWER PHASE C, and HEATER TEMP NORMAL lights (2A9) go off.

3.2.2.3 Hypergol Installed Switch Function Test.

a. Verify that engine checkout console is prepared for electrical operation (paragraph 3.2.1).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Remove pin and closure from hypergol manifold cartridge container inlet port.

WARNING

The following procedure uses dry-cleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

c. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680). Lubricate (Method A) threads with lubricant grease RB0140-012 (Rocketdyne).

CAUTION

When installing the hypergol system test tool into the hypergol manifold cartridge container inlet port, extreme care must be used to prevent damage to the hypergol cartridge follower.

- The threads of the test tool cap must be clean and free of nicks to prevent galling the threads of the cap and container inlet port.

Procedure	Result
d. Lubricate (Method L) cap packing with FS1281 grease (Dow Corning Corp); then carefully insert hypergol system test tool 9021279 into hypergol manifold cartridge container inlet port, and screw cap (clockwise) onto inlet port until cap bottoms.	HYPERGOL CARTRIDGE INSTALLED light (2A7) remains off.
e. Depress and hold lever of test tool.	HYPERGOL CARTRIDGE INSTALLED light (2A7) comes on.
f. Release lever.	HYPERGOL CARTRIDGE INSTALLED light (2A7) goes off.

g. Remove hypergol system test tool.

WARNING

The following procedure uses dry-cleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

h. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680).

i. Remove packaging from hypergol manifold cartridge container inlet port closure. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp). Install closure and secure with attaching pin.

3.2.2.4 Checkout Valve Timing Test.

a. Verify that engine checkout console is prepared for electrical operation (paragraph 3.2.1).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aB. Remove pressure cap from checkout valve engine return hose drain quick-disconnect.

Procedure	Result
b. Connect a drain hose between quick-disconnect on checkout valve engine return hose and facility hydraulic drain.	Some hydraulic fluid may drain from checkout valve engine return hose when hose is connected and when valve is cycled.
c. Turn on facility event recorder and set speed at 50 inches per minute.	Channels 13 and 14 indicate off, and 15 and 16 indicate on. Disregard other channels.

CAUTION

During the following steps, ground hydraulic pressure must not be applied to engine during checkout valve cycling to preclude introducing hydraulic fluid into the fuel feed system.

Procedure	Result
d. Lift guard, move GRD CHECKOUT switch (2A7) to ENGINE, and hold until valve reaches full travel.	ENGINE light (2A7) comes on and GROUND light goes off; channels 13 and 14 indicate on and 15 and 16 indicate off.

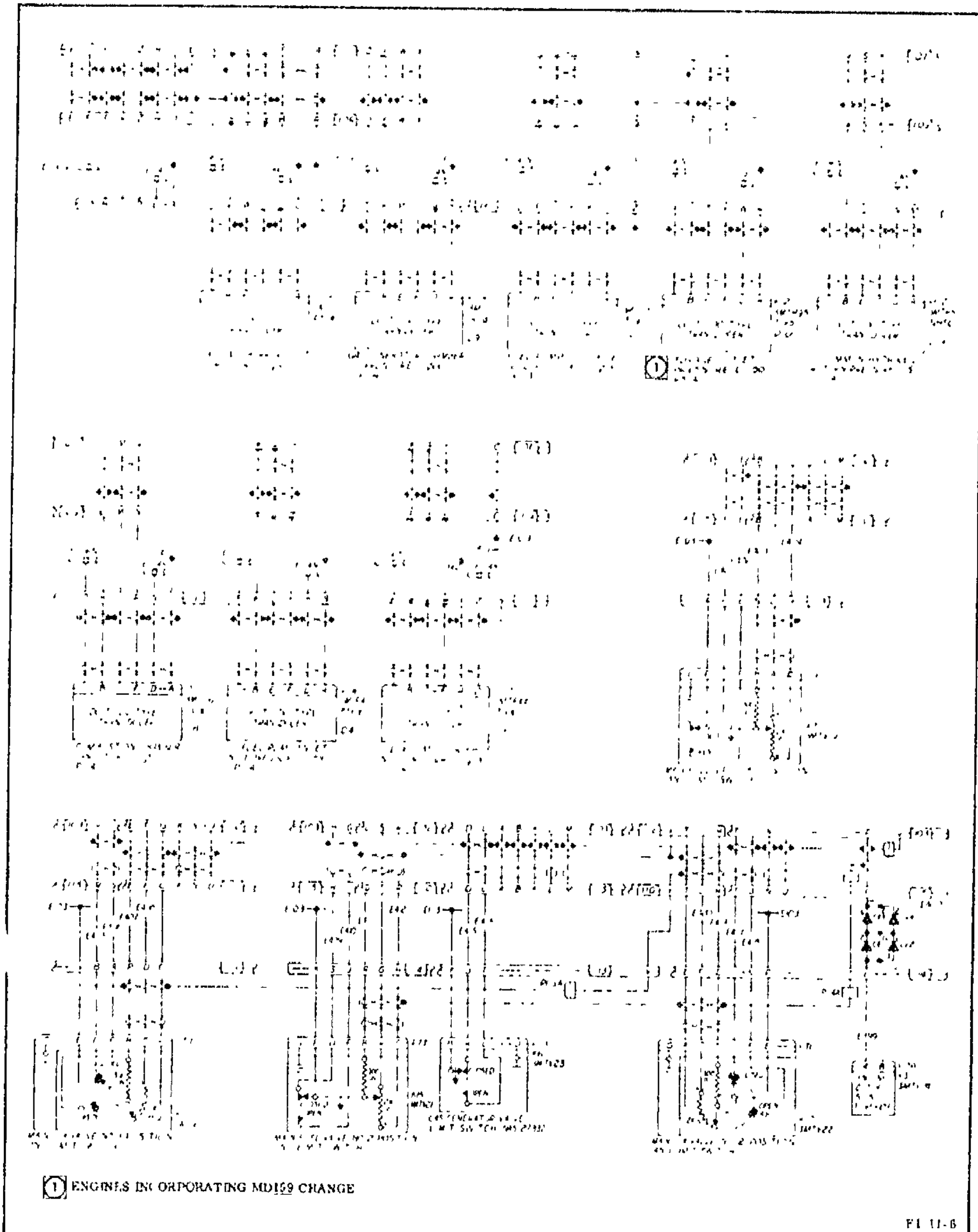


Figure 3-3. Primary Flight Instrumentation Schematic (Sheet 1 of 2)

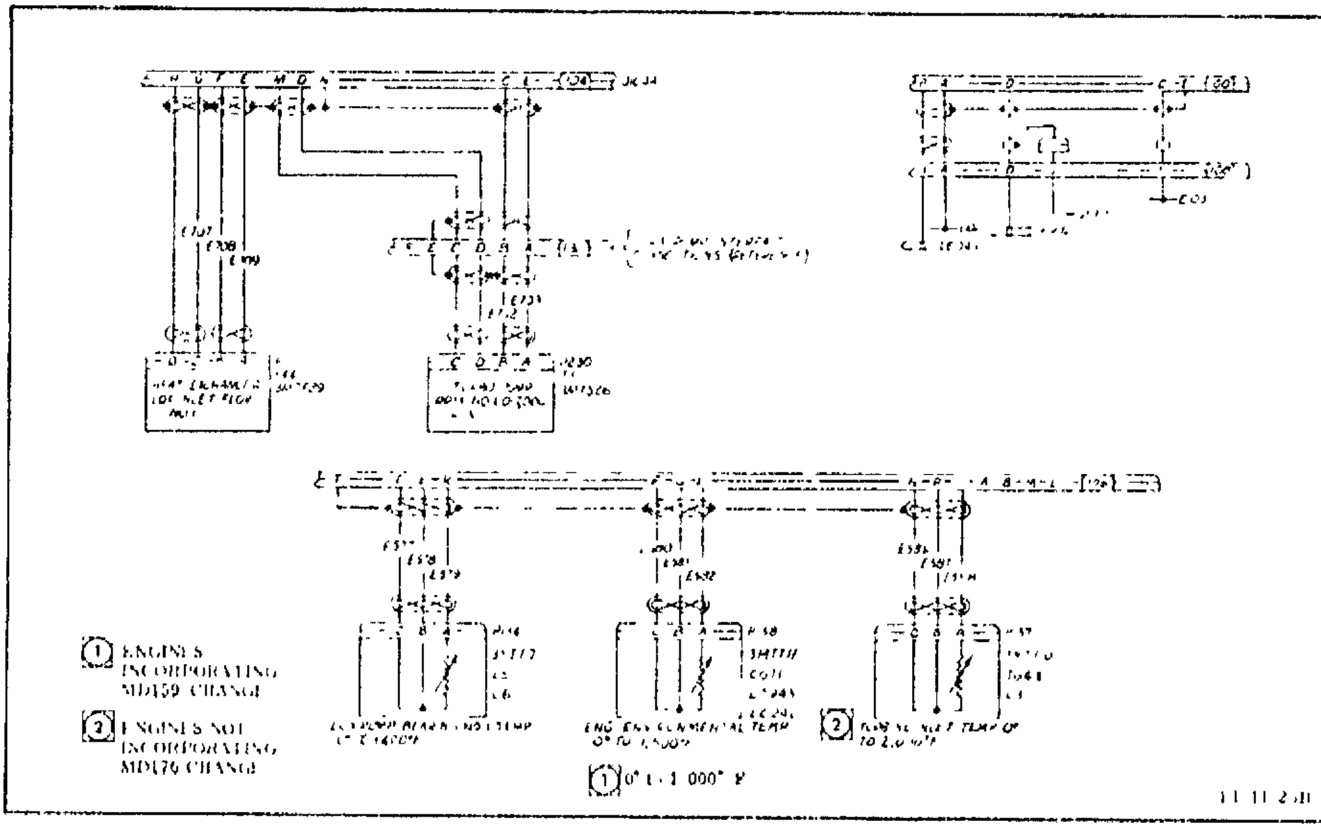


Figure 3-3. Primary Flight Instrumentation Schematic (Sheet 2 of 2)

Procedure	Result
e. Release GRD CHECKOUT switch (2A7) (GROUND).	GROUND light (2A7) comes on and ENGINE light goes off; channels 13 and 14 indicate off and 15 and 16 indicate on.
f. Measure and record valve travel time from ground position dropout (channel 16) to engine position pickup (channel 14) and from engine position dropout (channel 14) to ground position pickup (channel 16).	Travel time must be 0.5 to 3.5 seconds for each cycle.

Procedure	Result
g. Repeat steps d through f 2 additional times.	As specified in steps d through f.
h. Turn facility event recorder off.	Recorder stops.

i. Remove drain hose connected in step b.

j. Remove pressure cap from packaging, and install pressure cap on checkout valve engine return hose quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

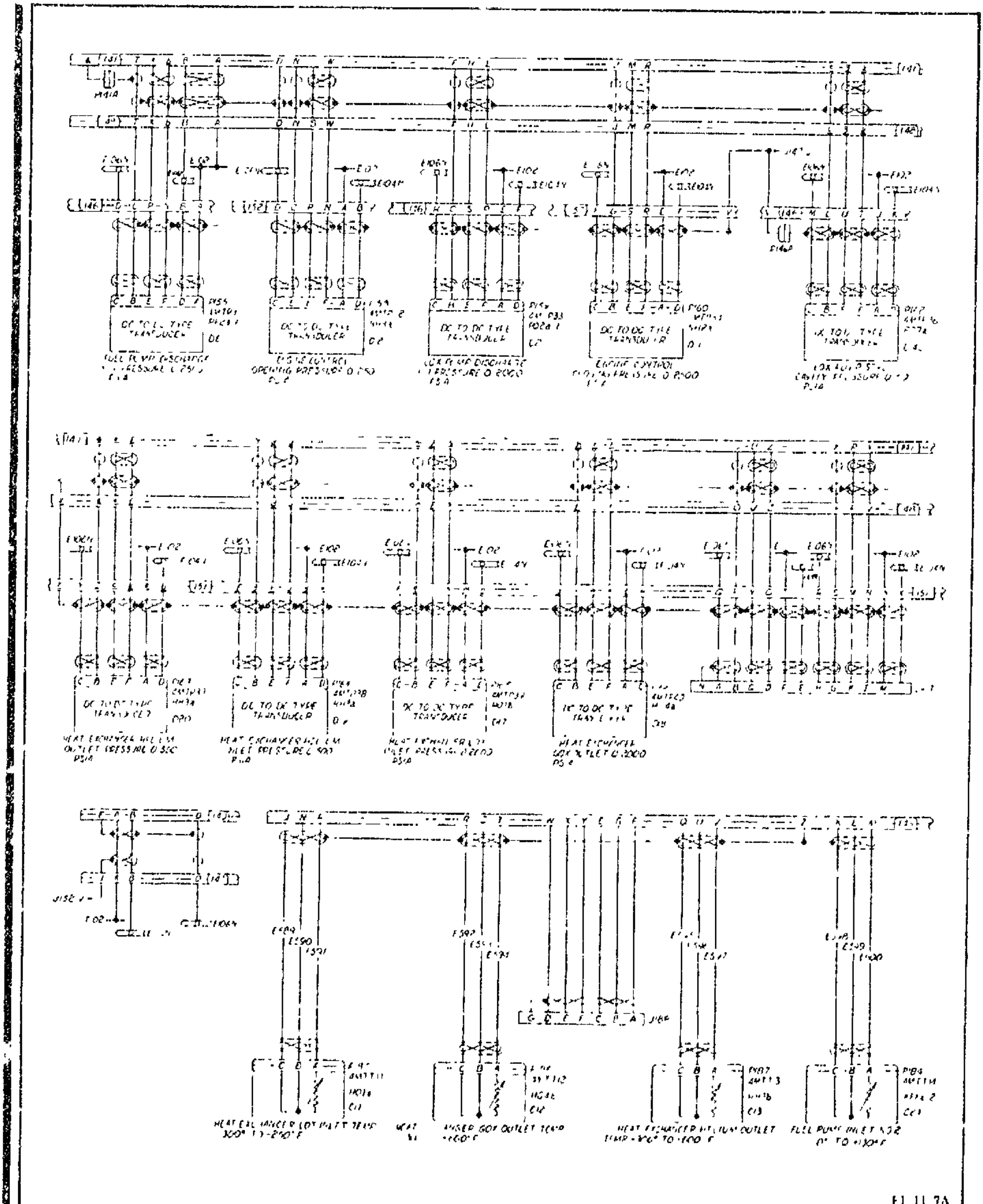


Figure 3-4. Auxiliary Flight Instrumentation Schematic (Engines Not Incorporating MD96 Change)

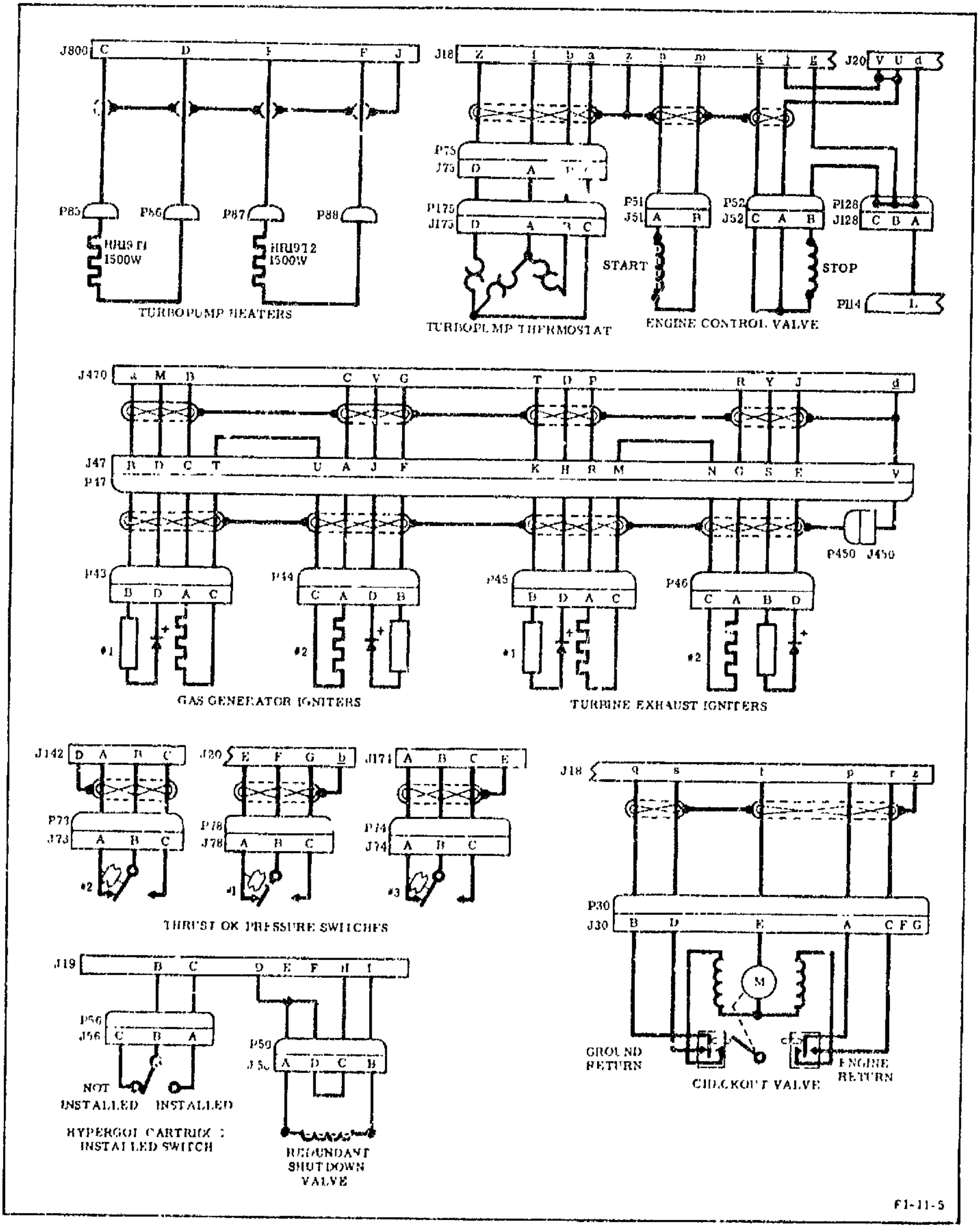


Figure 3-5. Electrical Control Schematic

3.2.3 LEAK AND FUNCTION TEST PROCEDURES FOR UNINSTALLED ENGINES. (See figures 3-1 through 3-8.)

3.2.3.1 Turbopump Torque Test.

a. Remove cap on torque-gear housing.

b. Attach a torque wrench with an adapter (1-1/16 inch deep socket) and an extension (2 feet long) to torque-pinion-gear shaft.

Procedure	Result
c. Depress lockpin on torque-gear housing, and depress torque-pinion-gear by applying pressure to adapter.	Torque-pinion-gear shaft engages turbopump shaft.
d. Using torque wrench, slowly rotate turbopump shaft clockwise and counterclockwise one full revolution minimum. Record maximum turbopump shaft breakaway and running torque value.	Moving elements must not rub, bind, scuff, or register an uneven torque. Torque must not exceed 20 ft-lb.

NOTE

One revolution of the turbopump shaft requires 5 revolutions of the turbopump torque gear.

- Lubrication of the turbopump torque-gear shaft with preservative WD-40 (Rocket Chemical Co) or oil (SAE 5 weight) may reduce binding, rubbing, and scuffing noise or uneven torque of the turbopump torque gear. Refer to R-3896-3 for procedure on preservative application.

e. Remove torque wrench, extension, and adapter.

f. Verify that lockpin on torque-gear housing is fully extended and that torque-pinion-gear shaft is in lockout position.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

g. Lubricate (Method J) packing with lubricant grease RB0140-012 (Rocketdyne); then install packing on torque-gear housing cap.

h. Lubricate (Method A) threads of torque-gear housing cap with lubricant grease RB0140-012 (Rocketdyne); then install cap fingertight on torque-gear housing. Safetywire cap with Inconel lockwire MS20995N.

3.2.3.2 Thrust OK Pressure Switches Leak and Function Test.

a. Verify that engine checkout console is prepared for electrical and pneumatic operation (paragraph 3.2.1).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Verify that NO. 1 NO THRUST, NO. 2 NO THRUST, and NO. 3 NO THRUST pressure switch-lights (1A7) are on.

bA. Remove plastic cap from pressure switch checkout connection at engine interface. Retain plastic cap for reinstallation.

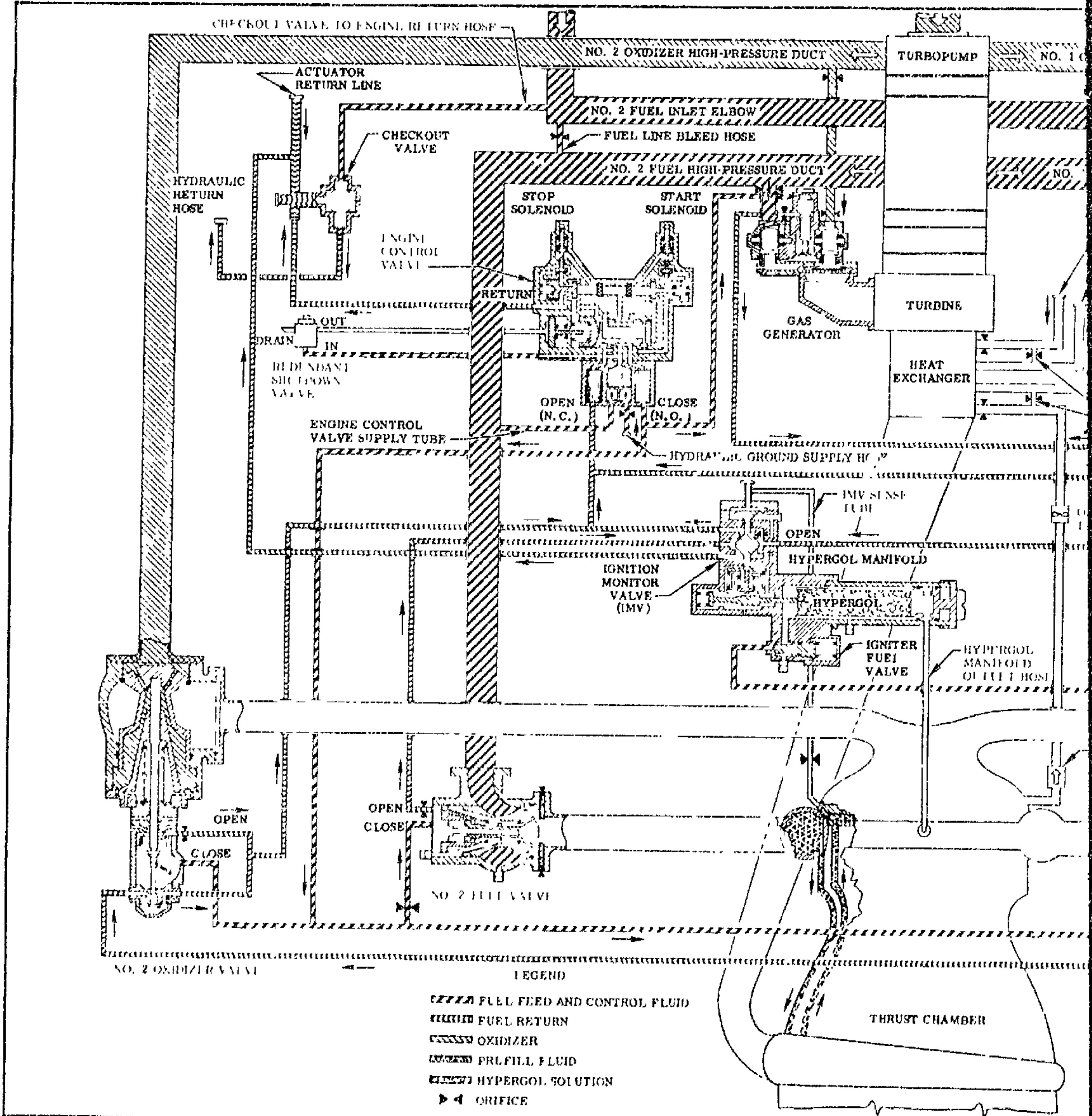
NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

c. Lubricate (Method A) threads of pressure switch checkout connection with lubricant grease RB0140-012 (Rocketdyne); then install pressure switches adapter 9025291, or equivalent, on pressure switch checkout connection at interface panel. Torque adapter hose coupling nut to 135-165 in-lb.

d. Connect fuel hose between adapter and FUEL B.S. LINE port (2A3).

e. Position F/M SEL valve (2A3) to BY-PASS.



CHECKOUT VALVE TO ENGINE RETURN HOSE
NO. 2 OXIDIZER HIGH-PRESSURE DUCT
TURBOPUMP
ACTUATOR RETURN LINE
NO. 2 FUEL INLET ELBOW
CHECKOUT VALVE
FUEL LINE BLEED HOSE
HYDRAULIC RETURN HOSE
NO. 2 FUEL HIGH-PRESSURE DUCT
STOP SOLENOID
START SOLENOID
ENGINE CONTROL VALVE
RETURN
TURBINE
OUT
DRAIN
IN
GAS GENERATOR
REDUNDANT SHUTDOWN VALVE
HEAT EXCHANGER
OPEN (N.C.)
CLOSE (N.O.)
ENGINE CONTROL VALVE SUPPLY TUBE
IMV SENSE TUBE
OPEN
HYPERGOL MANIFOLD
IGNITION MONITOR VALVE (IMV)
HYPERGOL
IGNITER FUEL VALVE
HYPERGOL MANIFOLD OUTLET HOSE
OPEN
CLOSE
OPEN
CLOSE
NO. 2 FUEL VALVE
NO. 2 OXIDIZER VALVE
LEGEND
FUEL FEED AND CONTROL FLUID
FUEL RETURN
OXIDIZER
PREFILL FLUID
HYPERGOL SOLUTION
ORIFICE
THRUST CHAMBER

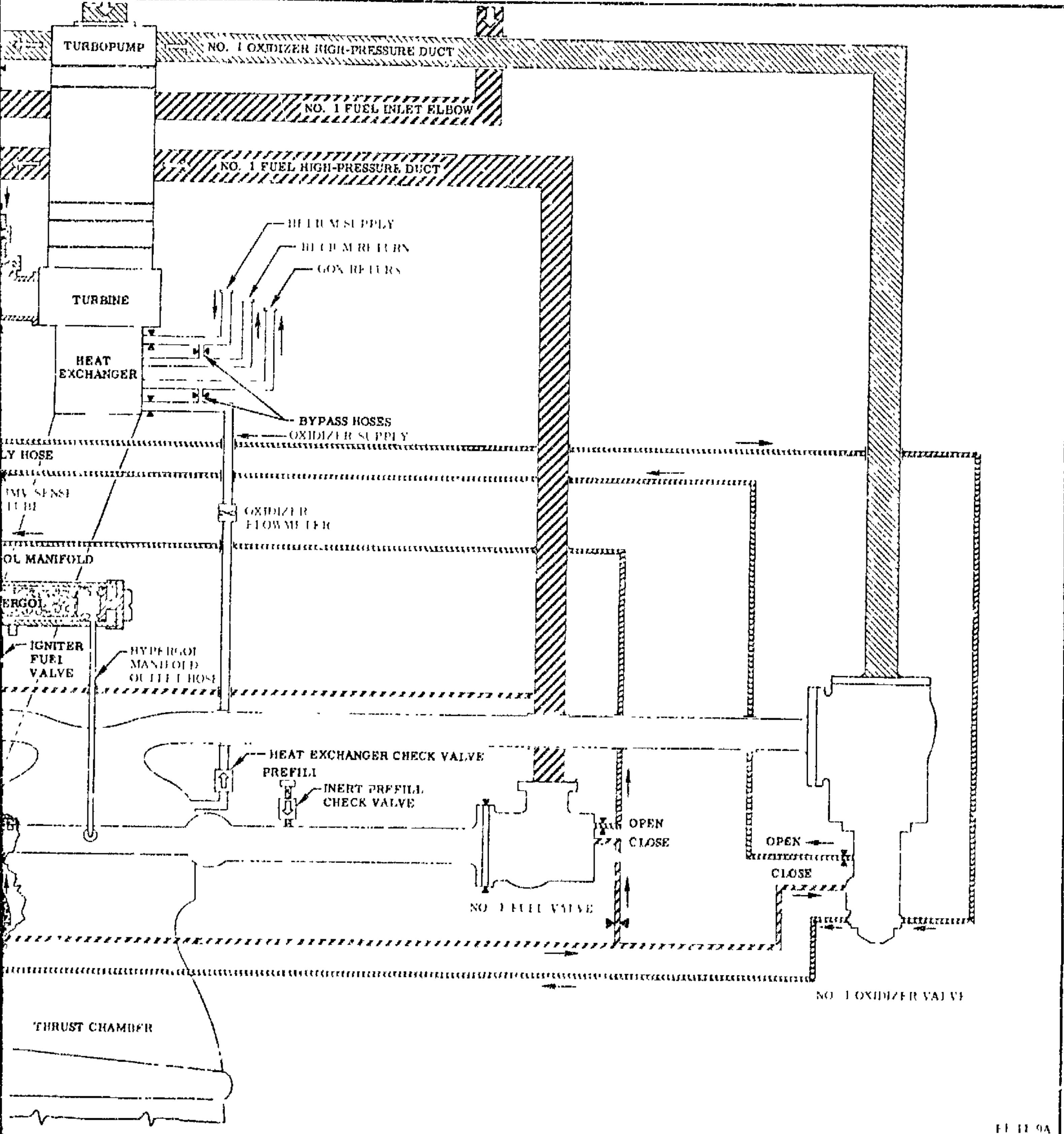


Figure 3-6. Fluid Control Schematic

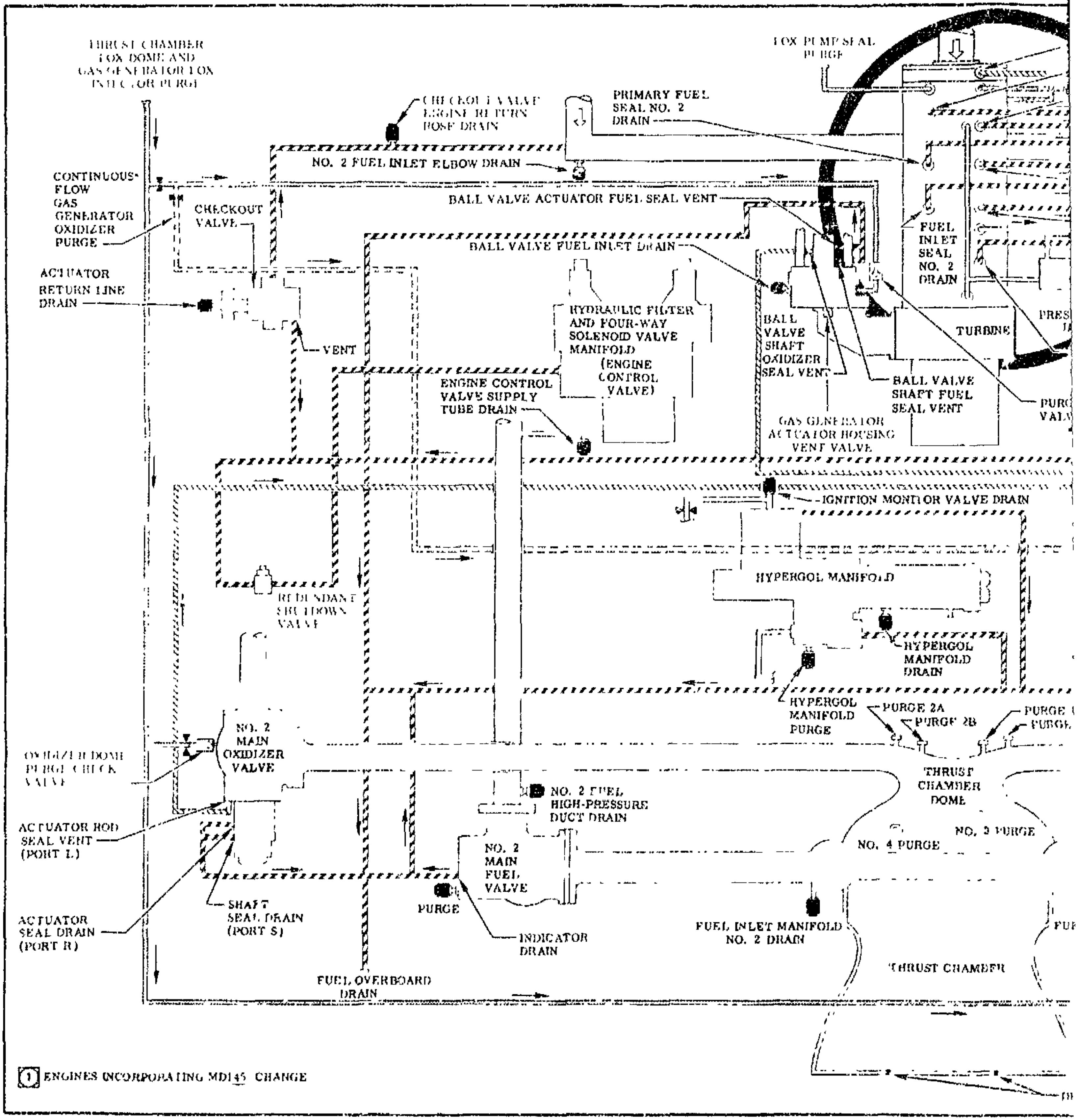
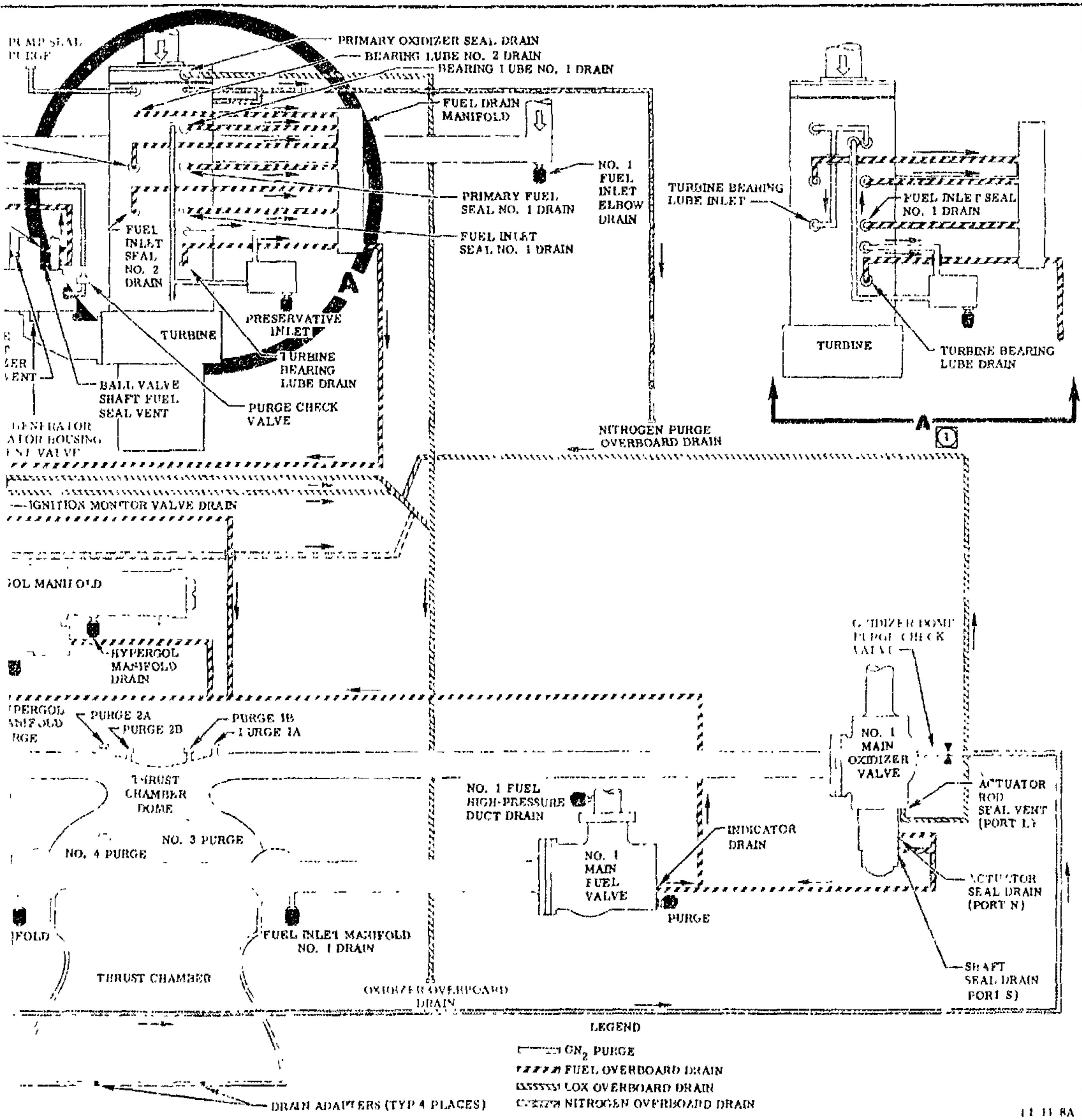


Figure 3-7. Fluid Purge and Drain Schematic



PUMP SEAL PURGE
PRIMARY OXIDIZER SEAL DRAIN
BEARING LUBE NO. 2 DRAIN
BEARING LUBE NO. 1 DRAIN
FUEL DRAIN MANIFOLD
NO. 1 FUEL INLET ELBOW DRAIN
PRIMARY FUEL SEAL NO. 1 DRAIN
FUEL INLET SEAL NO. 1 DRAIN
FUEL INLET SEAL NO. 2 DRAIN
PRESERVATIVE INLET
TURBINE
TURBINE BEARING LUBE DRAIN
BALL VALVE SHAFT FUEL SEAL VENT
PURGE CHECK VALVE
NITROGEN PURGE OVERBOARD DRAIN
IGNITION MONITOR VALVE DRAIN
HYPERGOL MANIFOLD DRAIN
PURGE 2A
PURGE 2B
PURGE 1B
PURGE 1A
THRUST CHAMBER DOME
NO. 3 PURGE
NO. 4 PURGE
FUEL INLET MANIFOLD NO. 1 DRAIN
THRUST CHAMBER
OXIDIZER OVERBOARD DRAIN
DRAIN ADAPTERS (TYP 4 PLACES)
TURBINE BEARING LUBE INLET
FUEL INLET SEAL NO. 1 DRAIN
TURBINE
TURBINE BEARING LUBE DRAIN
A
1
OXIDIZER DOME PURGE CHECK VALVE
NO. 1 MAIN OXIDIZER VALVE
ACTUATOR ROD SEAL VENT (PORT L)
NO. 1 FUEL HIGH-PRESSURE DUCT DRAIN
INDICATOR DRAIN
NO. 1 MAIN FUEL VALVE
PURGE
ACTUATOR SEAL DRAIN (PORT N)
SHAFT SEAL DRAIN PORT S)
LEGEND
GN2 PURGE
FUEL OVERBOARD DRAIN
LOX OVERBOARD DRAIN
NITROGEN OVERBOARD DRAIN

CAUTION

In the following procedure, pressurization rates must be limited to 50 psig/sec from 0 to 895 psig and 5 psig/sec from 895 to 1,270 psig.

Procedure	Result
f. Slowly open FUEL BS REG HIGH (2A3) until HIGH pressure gage (2A4) indicates 1,125-1,200 psi.	Facility check calips switch tube and switch manifold are pressurized.
g. Apply leak-test compound (MIL-L-25567), or equivalent, to joints and fittings of facility check calips switch tube and to switch manifold cover plate. Record results	No leakage is allowable.

h. Close FUEL BS REG HIGH (2A3).

CAUTION

In the following procedure, depressurization rates must be limited to 5 psig/sec from 1,270 to 895 psig.

i. Slowly open bleed valve (FUEL BS BLEED panel) until LOW pressure gage (2A4) indicates zero; then close valve.

j. (Deleted)

CAUTION

In the following procedure, pressurization rates must be limited to 50 psig/sec from 0 to 895 psig and 5 psig/sec from 895 to 1,270 psig.

k. Slowly open FUEL BS REG HIGH (2A3) until pressure switches actuate as indicated by lights.	NO. 1 THRUST OK, NO. 2 THRUST OK, and NO. 3 THRUST OK lights (1A7) come on; NO. 1 NO THRUST, NO. 2 NO THRUST, and NO. 3 NO THRUST lights go off.

l. Slowly open FUEL BS REG HIGH (2A3) until HIGH pressure gage (2A4) indicates 1,240 ±30 psi.

m. Close FUEL BS REG HIGH (2A3).

CAUTION

In the following procedure, depressurization rates must be limited to 5 psig/sec from 1,270 to 895 psig and 50 psig/sec from 895 to 0 psig.

Procedure	Result
n. Slowly open bleed valve (FUEL BS BLEED panel) until pressure switches deactuate, as indicated by lights. Close valve after gage indicates zero.	NO. 1 NO THRUST, NO. 2 NO THRUST, and NO. 3 NO THRUST lights (1A7) come on; NO. 1 THRUST OK, NO. 2 THRUST OK, and NO. 3 THRUST OK lights go off.
o. Repeat steps j through n 3 times. Record actuation and deactuation pressure for each switch during each test.	On the second and third tests, each pressure switch must actuate at 1,060 ±65 psig and deactuate within 75 ±25 psig of its actuation pressure.

oA. Remove pressure switch checkout connection plastic cap from packaging.

p. Disconnect fuel hose, remove adapter, and install plastic cap RD265-5016-0004 on pressure switch checkout connection fingertight.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

q. Remove all leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

Port Location	Plug and Bleeder[a]	Seal	Plug Torque (in-lb)
Thrust chamber combustion chamber pressure transducer (tap CG1e) (on transducer adapter)	AN814-2JL[b]	RE261-3004-1002[c]	100-120
Thrust chamber combustion chamber pressure transducer (tap CG1e) (on injector flange)	AN814-2JL[b]	RE261-3004-1002[c][d]	70 ±5
No. 1 and No. 2 oxidizer valves to oxidizer dome (on dome flanges)	AN814-2JL[e]	RE261-3004-0002[f][g]	70 ±5
Heat exchanger check valve to oxidizer dome (on dome flange)	AN814-2JL[e]	RE261-3004-0002[f][g]	70 ±5
No. 1 and No. 2 fuel manifold inlets (on inlet flange)	AN814-2JL[e]	RE261-3004-0002[f][h]	70 ±5
Prefill liquid level detector (on fuel manifold)[i]	AN814-2JL[e]	RE261-3004-0002[f][h]	70 ±5
Heat exchanger to exhaust manifold (on exhaust manifold)	AN814-2JL[b]	RE261-3004-1002[c][d]	70 ±5
No. 1 and No. 2 fuel inlet elbows to fuel pump inlets (on elbow flanges)	AN814-2J[e]	RD262-3001-0002[j]	10-16
Fuel pump outlet to No. 1 fuel high-pressure duct (on pump flange)	AN814-2JL[e]	MS29512-02[j]	11-15
Fuel pump outlet to No. 2 fuel high-pressure duct (on pump flange)	AN814-2JL[e]	MS29512-02[j]	11-15
No. 1 fuel high-pressure duct (on pump end flange and valve end flange) (2 reqd)	MS9015-02[e]	MS29512-02[j]	75 ±5
No. 2 fuel high-pressure duct (on pump end flange and valve end flange) (2 reqd)	MS9015-02[e]	MS29512-02[j]	75 ±5

(a) Safetywire with Inconel lockwire MS20995N after torquing, as applicable.
(b) Lubricate (Method A) with thread compound C-5A (Felt Products).
(c) Interchangeable with 12100AA2.
(d) Lubricate (Method R) with Brayco 777 hydraulic fluid (Bray Oil Co).
(e) Lubricate (Method A) with lubricant grease RB0140-012 (Rocketdyne).
(f) Interchangeable with 12100CR2.
(g) Lubricate (Method R) with fluorinated oil Krytox 143AZ (Du Pont) or lubricant grease RB0140-012 (Rocketdyne).
(h) Lubricate (Method R) with fluorinated oil Krytox 143AZ (Du Pont).
(i) Engines not incorporating MD123 change.
(j) Lubricate (Method J) with lubricant grease RB0140-012 (Rocketdyne).

Figure 3-8. Seal Monitoring Port Requirements (Sheet 1 of 3)

Port Location	Plug and Bleeder[a]	Seal	Plug Torque (in-lb)
No. 2 fuel high-pressure duct to gas generator fuel duct (at orifice)	AN814-2JL[e]	RD262-3001-0002[j]	10-16
Oxidizer suction duct to oxidizer pump	AN814-2JL[e]	RE261-3004-0002[f]	35 ±5
No. 1 and No. 2 oxidizer pump discharge to oxidizer high-pressure ducts (on pump flange)	RD265-3012-0001[e]	RE261-3004-0002[f]	10-16
No. 2 oxidizer pump outlet pressure transducer (tap PO2a-2) (on No. 2 high-pressure duct)	AN814-2JL[e]	RE261-3004-0002[f]	50 ±5
No. 2 oxidizer high-pressure duct to gas generator oxidizer duct (duct end) (at downstream orifice)	AN814-2JL[e]	RE261-3004-0002[f]	70 ±5
No. 1 and No. 2 oxidizer high-pressure ducts to oxidizer valves (on oxidizer valve flanges)	AN814-2J[e]	RE261-3004-0002[f]	35-40
Gas generator chamber pressure transducer (tap GG1d) (on gas generator injector)	MS9015-02[b]	RE261-3004-1002[c]	85-95
Heat exchanger check valve to oxidizer flowmeter (on flowmeter flange)	MS9015-02[e]	RE261-3004-0002[f]	10-15 ft-lb
Heat exchanger oxidizer flowmeter to heat exchanger oxidizer supply hose (on flowmeter flange)	MS9015-02[e]	RE261-3004-0002[f]	10-15 ft-lb
Heat exchanger oxidizer supply hose to heat exchanger (on heat exchanger)	AN814-2JL[e]	RE261-3004-1002[c]	70 ±5

(a) Safetywire with Inconel lockwire MS20995N after torquing, as applicable.
(b) Lubricate (Method A) with thread compound C-5A (Felt Products).
(c) Interchangeable with 12100AA2.
(e) Lubricate (Method A) with lubricant grease RB0140-012 (Rocketdyne).
(f) Interchangeable with 12100CR2.
(j) Lubricate (Method J) with lubricant grease RB0140-012 (Rocketdyne).

Figure 3-8. Seal Monitoring Port Requirements (Sheet 2 of 3)

Port Location	Plug and Bleeder[a]	Seal	Plug Torque (in-lb)
Heat exchanger GOX duct (heat exchanger end) to heat exchanger (on heat exchanger)	AN814-2JL[e]	RE261-3004-1002[c]	70 ±5
Helium supply duct (heat exchanger end) at heat exchanger	AN814-2JL[e]	RE261-3004-1002[c]	70 ±5
Helium return duct (heat exchanger end) at heat exchanger	AN814-2JL[e]	RE261-3004-1002[c]	70 ±5
Turbine to heat exchanger (on heat exchanger flange)	AN814-2JL[b]	RE261-3004-1002[c]	70 ±5
Turbine outlet pressure transducer (tap TG5c) (on heat exchanger)	AN814-2JL[b]	RE261-3004-1002[c]	70 ±5

(a) Safetywire with Inconel lockwire MS20995N after torquing, as applicable.
(b) Lubricate (Method A) with thread compound C-5A (Fell Products).
(c) Interchangeable with 12100AA2.
(e) Lubricate (Method A) with lubricant grease RB0140-012 (Rocketdyne).

Figure 3-8. Seal Monitoring Port Requirements (Sheet 3 of 3)

3.2.3.3 LOX Pump Seal Purge Leak and Function Test.

a. Verify that engine checkout console is prepared for electrical and pneumatic operation (paragraph 3.2.1).

b. Verify that covers are removed from nitrogen purge overboard drain line and oxidizer overboard drain line at thrust chamber exit. When cover is removed from oxidizer overboard drain, verify that no evidence of fluid exists. Notify Engine Contractor if fluid exists.

c. Remove closures from pump seal purge line, and install LOX seal and gas generator actuator purge adapter 9022012, or equivalent, on line. Torque adapter fasteners to 70-80 in-lb.

d. Connect a hose between pump seal purge line and LOX PUMP SEAL & GG ACTUATOR PURGE (1A5).

e. Open LOX PUMP SEAL PURGE shutoff valve (1A5).

NOTE

The following procedure introduces pressure into the LOX pump seal purge system. When pressure is first applied the oxidizer overboard drain line and nitrogen purge line exits must be observed for evidence of fluid.

f. Open LC AIR PRESS REG (1A5) until LOX CLEAN AIR PRESS gage indicates 85 ±10 psi, and verify absence of fluid from oxidizer overboard drain line and nitrogen purge drain line.

CAUTION

Leak-test compound used in the following procedure must not be used on overboard drain line exits to preclude introducing leak-test compound into the lines.

- Leak-test compound must not be used on flex line bellows since it cannot be removed from the bellows.

Procedure	Result
g. Apply leak-test compound (MIL-L-25567) to all joints and fittings of LOX pump seal purge system.	No leakage is allowable.

NOTE

In the following procedure, if leakage is expected in excess of 4,000 scim, two flowtesters must be used, connected in parallel, at each line.

Procedure	Result
h. Using Pneumatic Flow Testers G3104, or equivalent, simultaneously measure flowrate at exit end of nitrogen purge overboard drain line and oxidizer overboard drain line. Record flowrate.	Flowrate past the turbopump intermediate seal LOX side and fuel side must not exceed 5,000 scim at each line. If combined drain line flowrate does not exceed zero, perform LOX pump seal isolation test (paragraph 3.2.4.1).
i. Close LC AIR PRESS REG (1A5).	LOX CLEAN AIR PRESS gage (1A5) decreases to zero.

j. Close LOX PUMP SEAL PURGE shutoff valve.

k. Remove adapter 9022012, or equivalent, from pump seal purge line, and install closure on line. Torque closure fasteners fingertight plus 1/4 turn

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting from suffocation.

l. Remove all leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.2.3.4 Heat Exchanger Helium System Leak Test.

a. Verify that engine checkout console is prepared for electrical and pneumatic operation (paragraph 3.2.1).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Remove cover and install heat exchanger helium line inlet test plate 9024407, or equivalent, on helium supply duct (heat exchanger end). Torque fasteners to 120-155 in-lb.

c. Connect a pneumatic hose from plate 9024407 to FUEL BS LINE (2A3).

d. Remove cover and install pressure test fixture T-5039231 on helium return duct (heat exchanger end). Torque fasteners to 25-30 in-lb.

e. Position F/M SEL valve to BYPASS.

Procedure	Result
f. Open FREON TO FUEL BS shutoff valve (2A3) until LOW gage (2A4) pointer starts to move. Close valve.	Refrigerant, Type 12 enters helium system.
g. Open FUEL BS REG HIGH (2A3) until HIGH gage (2A4) indicates 400 ±10 psi.	Helium ducts and heat exchanger coil are pressurized.

CAUTION

If leak-test compound is used in the following procedure, it must not be used on flex line bellows, since it cannot be removed from bellows.

Procedure	Result
h. Using Halogen Leak Detector 5797934-G1 (General Electric), or equivalent, monitor and record leakage at all flanges, fittings, instrumentation lines, and bellows in heat exchanger helium system.	No leakage is allowable except at joints listed in step i.
i. Verify leakage using leak-test compound (MIL-L-25567), or equivalent, when leakage is suspected at the following joints:	Fuzz leakage (as defined in section II) is allowable.

(1) Helium supply duct (heat exchanger end) to heat exchanger

(2) Heat exchanger to helium return duct (heat exchanger end)

(3) Helium bypass hose to helium return duct (heat exchanger end)

(4) Heat exchanger helium outlet instrumentation hose to helium return duct instrumentation tap HH3a (on engines not incorporating MD96 change)

(5) Heat exchanger helium outlet instrumentation hose to transducer (on engines not incorporating MD96 change)

(6) Heat exchanger helium outlet temperature transducer to helium outlet duct instrumentation tap HH3b (on engines not incorporating MD96 change)

j. Close FUEL BS REG HIGH (2A3).

Procedure	Result
k. Open FUEL BS BLEED valve on panel below (2A4) until LOW gage (2A4) indicates zero. Close valve.	Helium ducts and heat exchanger coil are depressurized.

l. Remove pneumatic hose from plate 9024407 and HELIUM HT EXCH INLET (1A5).

m. Remove heat exchanger helium line inlet test plate 9024407 and pressure test fixture T-5039231, and install covers on helium supply duct (heat exchanger end) and helium return duct (heat exchanger end).

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

n. If leak-test compound was used, remove all leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.2.3.5 Heat Exchanger LOX System Leak Test.

a. Verify that engine checkout console is prepared for electrical and pneumatic operation (paragraph 3.2.1).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Install Thrust Chamber Throat Plug G3136 (paragraph 3.6.15).

c. Install an adapter with a drain hose on throat plug quick-disconnect. Vent hose outside of thrust chamber to atmosphere. Secure hose with hose outlet pointed away from personnel.

d. Remove cover from, and install pressure test fixture T-5039232 on GOX duct (heat exchanger end). Torque fasteners to 50-55 in-lb.

e. Connect an oxidizer-clean hose from fixture T-5039232 to LOX HT EXCH INLET (1A5).

CAUTION

In the following step, the gaseous nitrogen supply hose must be supported to prevent the weight on the seal valve stem from damaging the seal.

eA. Connect a source of gaseous nitrogen to throat plug seal. Using a suitable material, support the gaseous nitrogen supply hose to relieve all weight of hose from seal valve stem.

Procedure	Result
f. Pressurize throat plug seal to 50 (+5, -10) psig. Maintain pressure during remainder of test.	Thrust chamber throat plug seal is pressurized.
g. Open GOX BACK PRESS valve (1A6).	
h. Open FREON TO GN_2 shutoff valve (1A5) until GOX PRESS gage pointer starts to move; then close valve.	Refrigerant, Type 12 enters oxidizer system.
i. Open GN_2 PRESS REG (1A5) until GOX PRESS gage indicates 100 ±5 psi.	Oxidizer ducts and heat exchanger coil are pressurized.
j. Using Pneumatic Flow Tester G3104 at adapter on throat plug quick-disconnect, measure and record reverse-flow leakage past heat exchanger check valve gate.	Maximum allowable leakage is 50 scim.
jA. Open GN_2 PRESS REG (1A5) until GOX PRESS gage indicates 1,400 ±20 psig.	Oxidizer ducts and heat exchanger coil pressure is increased.

k and l. (Deleted)

CAUTION

If leak-test compound is used in the following procedure, it must not be used on flex line bellows, since it cannot be removed from bellows.

Procedure	Result
m. Using Halogen Leak Detector 579793 G1 (General Electric), or equivalent, monitor and record leakage at all flanges, fittings, instrumentation lines, and bellows in heat exchanger LOX system. Monitor and record leakage of oxidizer coil at exhaust system manifold exit.	No leakage is allowable except at joints listed in step mA.
mA. Verify leakage using leak-test compound (MIL-L-25567), or equivalent, when leakage is suspected at the following joints:	Fuzz leakage (as defined in section II) is allowable.

(1) Heat exchanger to GOX duct (heat exchanger end)

(2) Oxidizer bypass hose to GOX duct (heat exchanger end)

n. Close GN_2 PRESS REG (1A5).	Supply pressure to heat exchanger oxidizer system stops.
o. Open GN2 BLEED valve on panel below (1A6) until GOX PRESS gage (1A5) indicates zero. Close valves.	Oxidizer ducts and heat exchanger coil are depressurized.

oA. Close GOX BACK PRESS valve (1A6).

p. Disconnect oxidizer-clean hose from fixture T-5039232 and LOX HT EXCH INLET (1A5). Cap open port on fixture.

q. Decrease thrust chamber throat plug seal pressure to zero.

r. Remove Thrust Chamber Throat Plug G3136 (paragraph 3.6.16).

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

s. If leak-test compound was used, remove leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.2.3.6 <u>Ignition Monitor Valve Diaphragm Leak Test.</u> When flowtesters are specified, Pneumatic Flow Tester G3104, or equivalent, must be used.

a. Verify that engine checkout console is prepared for electrical and pneumatic operation (paragraph 3.2.1).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Remove pressure cap and install engine checkout valve high-pressure adapter 9022038-21, or equivalent, on CONTROL port quick-disconnect.

c. Connect pneumatic hose from adapter to IMV CONT PORT (2A7).

d. Remove thrust chamber exit closure and security closure or thrust chamber throat closure, if installed.

e. Disconnect ignition monitor valve drain tube from ignition monitor valve ATMOS REF port.

NOTE

Steps eA through eC are optional.

eA. Remove attaching hardware that secures ignition monitor valve sense tube clamp to bracket on thrust chamber fuel inlet manifold. Retain attaching hardware for reinstallation if acceptable for reuse in accordance with requirements of section II.

eB. Remove attaching hardware that secures ignition monitor valve sense tube to thrust chamber fuel inlet manifold, carefully separate flanges, and remove seal plate. Retain attaching hardware for reinstallation if acceptable for reuse in accordance with requirements of section II.

eC. Install pressure test fixture T-5043436, or equivalent, on thrust chamber fuel inlet manifold between ignition monitor valve sense tube flange and fuel inlet manifold flange. Torque nuts to 47-57 in-lb. Connect a red streamer to test fixture.

Procedure	Result
f. Make sure GRD CHECKOUT switch is at GROUND.	Checkout valve GROUND light (2A7) is on.

g. Verify that HYPERGOL CARTRIDGE INSTALLED light (2A7) is off.

CAUTION

The following procedure pressurizes the ignition monitor valve CONTROL port. If HYPERGOL CARTRIDGE INSTALLED light is on and pressure in excess of 100 psig is applied to ignition monitor valve CONTROL port, damage to the valve cartridge follower can result.

Procedure	Result
h. Open IMV CONT PRESS REG (2A7) until IMV CONTROL PRESS HIGH gage indicates 1,400 ±20 psi.	CONTROL port is pressurized.
i. Using flowtester, measure and record leakage at ignition monitor valve ATMOS REF port.	No leakage is allowable.
j. Close IMV CONT PRESS REG (2A7). Open IMV CONTROL BLEED valve until IMV CONTROL PRESS LOW gage indicates zero. Close valve.	CONTROL port is depressurized.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

k. Remove plugs, and lubricate (Method A) fitting and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne), and install ignition monitor valve drain tube. Torque coupling nuts to 270-345 in-lb.

Procedure	Result
l. Open IMV CONT PRESS REG (2A7) until IMV CONTROL PRESS HIGH gage indicates 1,400 ±20 psi.	CONTROL port is pressurized.
m. Apply leak-test compound (MIL-L-25567) to all pressurized joints of ignition monitor valve cap.	No leakage is allowable.
n. Close IMV CONT PRESS REG (2A7). Open IMV CONTROL BLEED valve until IMV CONTROL PRESS LOW gage indicates zero. Close valve.	CONTROL port is depressurized.

o. Remove pneumatic hose from adapter and IMV CONT PORT.

p. Remove engine checkout valve high-pressure adapter 9022038-21 from ignition monitor valve CONTROL port quick-disconnect. Remove pressure cap from packaging, and install pressure cap on quick-disconnect finger-tight.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

q. Remove all leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

NOTE

Steps r through u are required only if the ignition monitor valve sense tube was blanked off.

r. Verify that ignition monitor valve sense tube clamp is disconnected; then remove fasteners that secure ignition monitor valve sense tube to thrust chamber fuel inlet manifold, and remove blank plate from between flanges.

s. Verify alinement of ignition monitor valve sense tube as outlined in R-3896-3.

t. Remove seal plate from packaging, and install seal plate between ignition monitor valve sense tube and thrust chamber fuel inlet manifold. Secure tube to manifold with 4 bolts, 8 washers, and 4 nuts. Torque nuts to 47-57 in-lb.

u. Install clamp securing ignition monitor valve sense tube to bracket on thrust chamber fuel inlet manifold. Torque clamp fasteners to 24-30 in-lb.

3.2.3.7 Hypergol Manifold Leak and Function Test. When flowtesters are specified in this procedure, Pneumatic Flow Tester G3104, or equivalent, must be used.

a. Verify that engine checkout console is prepared for pneumatic and electrical operation (paragraph 3.2.1).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Remove igniter fuel valve drain tube and ignition monitor valve drain tube.

c. Remove pressure cap from hypergol manifold purge quick-disconnect.

d. Remove pressure cap from hypergol manifold drain quick-disconnect and connect a pneumatic hose from quick-disconnect to IMV CONT PORT (2A7).

e. Remove pin and closure from hypergol manifold cartridge container inlet port.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

f. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680). Lubricate (Method A) threads with lubricant grease RB0140-012 (Rocketdyne).

CAUTION

When installing hypergol simulator into the hypergol manifold cartridge container inlet port, extreme care must be used to prevent damage to the hypergol cartridge follower.

- The threads of the hypergol simulator cap must be clean and free of nicks, to prevent galling the threads of the cap and inlet port.

g. Make sure that threads of cap on hypergol simulator T-5029716, or equivalent, are clean and free of nicks; then lubricate (Method L) simulator shaft O-ring with FS1281 grease (Dow Corning Corp), and carefully insert simulator into hypergol manifold cartridge container inlet port. Screw simulator clockwise until it bottoms.

h. Verify that pressure cap is installed on union in simulator cap.

i. Remove closure from No. 1 fuel pump inlet; then cover fuel inlet with Aclar No. 33C film (0.002-inch minimum thickness) (Allied Chemical Corp) punctured in such a manner as to prevent a pressure buildup in the fuel pump without allowing contaminants to enter pump. Secure film with pressure-sensitive tape RB0195-002 (Rocketdyne), or equivalent.

Procedure	Result
j. Slowly open IMV CONT PRESS REG (2A7) until IMV CONTROL PRESS LOW gage indicates 200 ±10 psi.	Hypergol manifold is pressurized.
k. Using flowtester, measure and record poppet reverse flow leakage of the hypergol manifold purge quick-disconnect.	Maximum allowable leakage is 3 scim.
l. Using flowtester, measure leakage past igniter fuel valve piston shaft O-ring at igniter fuel valve vent port.	Maximum allowable leakage is 0.25 scim.
m. Using flowtester, measure leakage past cam follower O-ring at ATMOS REF port.	Maximum allowable leakage is 0.25 scim.
n. Close IMV CONT PRESS REG (2A7). Open IMV CONTROL BLEED valve until IMV CONTROL PRESS LOW gage indicates zero. Close valve.	Hypergol manifold is depressurized.

o. Remove plugs, lubricate (Method A) fittings and (Method G) tubes with lubricant grease RB0140-012 (Rocketdyne), and install ignition monitor valve drain and igniter fuel valve drain tubes. Torque coupling nuts to 270-345 in-lb.

p. Remove pressure cap from packaging, and install pressure cap on hypergol manifold purge quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

Procedure	Result
q. Slowly open IMV CONT PRESS REG (2A7) until IMV CONTROL PRESS LOW gage indicates 200 ±10 psi.	Hypergold manifold is pressurized.

NOTE

If igniter fuel valve relieves prior to attaining 190 psig, IMV CONT PRESS REG (2A7) must be closed until valve reseats, since step r must be performed at a pressure level below the valve opening pressure.

Procedure	Result
r. Apply leak-test compound (MIL-L-25567) to all pressurized joints and ports of hypergol manifold.	No leakage is allowable.
s. Slowly open IMV CONT PRESS REG (2A7) until igniter fuel valve relieves or IMV CONTROL PRESS HIGH gage indicates 280 psi. Record relieving pressure.	Hypergol manifold pressure is increased, and igniter fuel valve relieves. Maximum igniter fuel valve relieving pressure is 270 psig.
t. Close IMV CONT PRESS REG (2A7). Open IMV CONTROL BLEED valve until IMV CONTROL PRESS LOW gage indicates zero. Close valve.	Hypergol manifold is depressurized and igniter fuel valve closes.
u. Perform steps s and t two additional times.	As specified in steps s and t.

v. Remove pneumatic hose from hypergol manifold drain quick-disconnect and IMV CONT PORT (2A7). Remove pressure cap from packaging, and install pressure cap on hypergol manifold drain quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

w. Remove Aclar film from No. 1 fuel pump inlet and reinstall closure on the inlet.

x. Remove hypergol simulator T-5029716, or equivalent, from hypergol manifold cartridge container inlet port.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

y. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680).

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

z. Remove packaging from hypergol manifold cartridge container inlet port closure. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp). Install closure and secure with attaching pin.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

aa. Remove all leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.2.3.8 Hydraulic Control System Leak and Function Test.

a. Verify that engine checkout console is prepared for electrical, pneumatic, and hydraulic operation (paragraph 3.2.1).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

b. Remove closure from checkout valve ground return hose, and install pressure test fixture T-5039240, or equivalent, on hose. Lubricate (Method J) fixture O-ring with lubricant grease RB0140-012 (Rocketdyne). Torque fasteners to 35-40 in-lb.

c. Verify that engine checkout valve is in ground position; then install a hydraulic hose between test fixture and HYD RETURN port (2A1).

d. Remove closure from engine control valve ground supply hose, lubricate (Method J) fixture O-ring with lubricant grease RB0140-012 (Rocketdyne), and install pressure test fixture T-5039234, or equivalent, on hose. Torque fasteners to 34-50 in-lb.

dA. Install a hydraulic hose between test fixture and HYD HI-FLOW OUTLET (1A2).

e. Remove pressure cap from ignition monitor valve CONTROL port quick-disconnect, and install engine checkout valve adapter 9022007-11 on quick-disconnect.

f. Connect a pneumatic hose from adapter to IMV CONT PORT (2A7). Install pressure cap on remaining port of adapter.

g. Remove pressure cap from, and attach a drain hose to, the following quick-disconnects:

(1) Engine control valve supply tube drain

(2) Checkout valve engine return hose drain

gA. Remove pressure cap from, and attach a drain hose to, the following quick-disconnects:

(1) No. 1 fuel high-pressure duct drain

(2) No. 2 fuel high-pressure duct drain

CAUTION

In the following procedure, during removal of the gas generator ball valve fuel inlet quick-disconnect cap, the quick-disconnect body must not be allowed to turn since a torque decrease between quick-disconnect body and adapter or adapter and gas generator ball valve fuel housing can result in seal leakage.

(3) Gas generator ball valve fuel inlet drain

(4) Turbopump No. 1 fuel inlet elbow drain

(5) Turbopump No. 2 fuel inlet elbow drain

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

gB. After completion of drainage from hoses installed in step gA, remove drain hoses, except for No. 1 fuel high-pressure duct drain on engines with gimbal actuators installed. Remove pressure caps from packaging, and install pressure caps, except for gas generator ball valve fuel inlet drain, on each quick-disconnect. Torque 3/8-inch pressure caps to 30-40 ft-lb and 3/4-inch pressure caps to 70-75 ft-lb.

gC. Lubricate (Method A) threads of gas generator ball valve fuel inlet drain quick-disconnect with lubricant grease RB0140-012 (Rocketdyne) or FS1281 grease (Dow Corning Corp), and install pressure cap. Torque pressure cap to 210-230 in-lb.

gD. Safetywire all quick-disconnect pressure caps with Inconel lockwire MS20995N.

Procedure	Result
h. Move LIGHT and AC LINE switches (2A9) (inside temperature recorder door) to ON.	Temperature recorder neon light comes on.

NOTE

The temperature recorder requires a 5-minute warmup period.

i. Move MOTOR switch (2A9) (inside temperature recorder door) to ON. Monitor hydraulic fluid temperature.

iA. Open HYD HI-FLOW SHUTOFF valve (1A2).

j. Open HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,800 ±50 psi. Maintain this pressure for 5 minutes minimum while performing steps k through lA.	Hydraulic control system is pressurized.
k. Monitor hydraulic fluid leakage from all flanges, fittings, and instrumentation lines connected to the following:	No leakage is allowable. (If surface wetting is noted at any time during test, refer to section II to determine if this condition is acceptable.)

(1) No. 1 and No. 2 oxidizer valves

(2) No. 1 and No. 2 fuel valves

(3) Ignition monitor valve

(4) Checkout valve

(5) Gas generator ball valve

(6) Engine control valve

(7) Redundant shutdown valve

l. Monitor and record hydraulic fluid leakage at:

Procedure	Result
(1) Engine hydraulic supply check valve leakage from engine control valve supply tube drain quick-disconnect drain line	2 cc/m maximum
(2) Checkout valve ball seal leakage from checkout valve engine return hose drain quick-disconnect drain line	2 cc/m maximum

NOTE

In the following step, previously recorded component leakage should be used as a guide for determining component isolation sequence. When leakage is accounted for, no further isolation is required. If necessary, refer to paragraph 3.2.4.2 for isolation procedures.

m. Monitor fuel overboard drain line, at thrust chamber exit, for fuel leakage. Any leakage requires isolation from fuel overboard drain line and recording of leakage rate of the following components:

(1) Redundant shutdown valve	2 cc/m fuel leakage maximum from drain port
(2) Ignition monitor valve	5 cc/m fuel leakage maximum from drain port
(3) Engine control valve	5 cc/m fuel leakage maximum from override drain port
(4) All other components common to this drain system	No leakage is allowable.

Procedure	Result
n. Close HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi.	System pressure decreases and stabilizes.
nA. Monitor and record actuator return line drain quick-disconnect poppet leakage (center engine only).	5 drops per minute maximum

o. Verify that hydraulic fluid has circulated for a minimum of 15 minutes to remove entrapped air from hydraulic control system before proceeding with test.

p. Open IMV CONT PRESS REG (2A7) until IMV CONTROL PRESS LOW gage indicates 50 ±5 psi.	Ignition monitor valve CONTROL port is pressurized.
q. Move FOUR-WAY VALVE switch (1A1) to START.	Engine control valve start solenoid is energized. NO. 1 CLOSED and NO. 2 CLOSED (2A2), gas generator CLOSE (2A3), and NO. 1 CLOSED and NO. 2 CLOSED (2A6) lights go off. NO. 1 OPEN and NO. 2 OPEN (2A2), gas generator OPEN (2A3), and NO. 1 OPEN and NO. 2 OPEN (2A6) lights come on.

qA. Open HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,800 ±50 psi.

r. Monitor and record hydraulic fluid leakage from all flanges, fittings, and instrumentation lines connected to the following:	No leakage is allowable. (If surface wetting is noted at any time during test, refer to section II to determine if this condition is acceptable.)

(1) No. 1 and No. 2 oxidizer valves

(2) No. 1 and No. 2 fuel valves

(3) Ignition monitor valve

(4) Checkout valve

(5) Gas generator ball valve

(6) Engine control valve

(7) Redundant shutdown valve

NOTE

In the following step, previously recorded component leakage should be used as a guide for determining component isolation sequence. When leakage is accounted for, no further isolation is required. If necessary, refer to paragraph 3.2.4.2 for isolation procedures.

s. Monitor fuel overboard drain line, at thrust chamber exit, for fuel leakage. Any leakage requires isolation from fuel overboard drain line and recording of leakage rate of the following components:

Procedure	Result
(1) Redundant shutdown valve	2 cc/m fuel leakage maximum from drain port
(2) Ignition monitor valve	5 cc/m fuel leakage maximum from drain port
(3) Engine control valve	5 cc/m fuel leakage maximum from override drain port
(4) All other components common to this drain system	No leakage is allowable.

sA. Close HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi.

Procedure	Result
t. Move FOUR-WAY VALVE switch (1A1) to STOP.	Engine control valve start solenoid is energized. NO. 1 OPEN and NO. 2 OPEN (2A2), gas generator OPEN (2A3), and NO. 1 OPEN and NO. 2 OPEN (2A6) lights go off. NO. 1 CLOSED and NO. 2 CLOSED (2A2), gas generator CLOSE (2A3), and NO. 1 CLOSED and NO. 2 CLOSED (2A6) lights come on.
u. Move FOUR-WAY VALVE switch (1A1) to START.	Engine control valve start solenoid is energized. NO. 1 CLOSED and NO. 2 CLOSED (2A2), gas generator CLOSE (2A3), and NO. 1 CLOSED and NO. 2 CLOSED (2A6) lights go off. NO. 1 OPEN and NO. 2 OPEN (2A2), gas generator OPEN (2A3), and NO. 1 OPEN and NO. 2 OPEN (2A6) lights come on.

v and w. (Deleted)

WARNING

The following procedure energizes the redundant shutdown valve solenoid, which causes the valve housing to heat up. After electrical power has been applied continuously, the valve solenoid case temperature can cause injury to personnel touching the case.

- If the redundant shutdown valve is kept energized for more than 15 minutes, the solenoid temperature increase will cause the valve to actuate slower.

Procedure	Result
x. Press and hold REDUNDANT SHUT-DOWN VALVE switch (1A1).	Redundant shutdown valve is energized. NO. 1 OPEN and NO. 2 OPEN (2A2), gas generator OPEN (2A3), and NO. 1 OPEN and NO. 2 OPEN (2A6) lights go off. NO. 1 CLOSED and NO. 2 CLOSED (2A2), gas generator CLOSE (2A3), and NO. 1 CLOSED and NO. 2 CLOSED (2A6) lights come on.

xA. Open HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,800 ±50 psi.

y. After hydraulic system has been pressurized for a minimum of 2 minutes, monitor and record fluid leakage at fuel overboard drain line.	2 cc/m maximum

NOTE

Unaccounted for fluid leakage in excess of 2 cc/m requires leakage isolation (paragraph 3.2.4.2) of redundant shutdown valve drain port seal.

Procedure	Result
yA. Close HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi.	System pressure decreases and stabilizes.

CAUTION

The following procedure deenergizes the redundant shutdown valve which will cause approximately 25 cc of hydraulic fluid to be expelled from the fuel overboard drain line. Personnel must be clear of drain line exit.

z. Release REDUNDANT SHUT-DOWN VALVE switch (1A1).	Redundant shutdown valve solenoid is de-energized.

zA. Close HYD HI-FLOW SHUTOFF valve (1A2).

CAUTION

The HYD HI-FLOW SHUTOFF valve must be completely closed before closing the HYD HI-FLOW REG, to prevent damage to pressure reducing valve 19-9023747.

aa. Close HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates zero.	Hydraulic control system is depressurized.
ab. Close IMV CONT PRESS REG (2A7) until IMV CONTROL PRESS LOW gage indicates zero.	Ignition monitor valve CONTROL port is depressurized.

3.2.3.9 Ignition Monitor Valve Shuttle Pressure Test.

a. Verify that engine checkout console is prepared for electrical, pneumatic, and hydraulic operation (paragraph 3.2.1).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Remove attaching hardware that secures ignition monitor valve sense tube clamp to bracket on thrust chamber fuel inlet manifold. Retain attaching hardware for reinstallation if acceptable for reuse in accordance with requirements of section II.

c. Remove attaching hardware that secures ignition monitor valve sense tube to thrust chamber fuel inlet manifold; carefully separate flanges, and remove seal plate. Retain attaching hardware for reinstallation if acceptable for reuse in accordance with requirements of section II.

d. Install pressure test fixture T-5043436, or equivalent, on thrust chamber fuel inlet manifold between ignition monitor valve sense tube flange and fuel inlet manifold flange. Torque nuts to 47-57 in-lb. Connect a red streamer to test fixture.

dA. Verify that drain hoses are installed on engine control valve supply tube drain and checkout valve engine return hose drain (paragraph 3.2.3.8).

dB. Remove pressure cap from, and attach a drain hose to the following quick-disconnects:

(1) No. 1 fuel high-pressure duct drain

(2) No. 2 fuel high-pressure duct drain

CAUTION

In the following procedure, during removal of the gas generator ball valve fuel inlet quick-disconnect cap, the quick-disconnect body must not be allowed to turn since a torque decrease between quick-disconnect body and adapter or adapter and gas generator ball valve fuel housing can result in seal leakage.

(3) Gas generator ball valve fuel inlet drain

(4) Turbopump No. 1 fuel inlet elbow drain

(5) Turbopump No. 2 fuel inlet elbow drain

dC. After completion of drainage from hoses installed in step dA, remove drain hoses, except for No. 1 fuel high-pressure duct drain on engines with gimbal actuators installed. Remove pressure caps from packaging, and install pressure caps, except for gas generator ball valve fuel inlet drain, on each quick-disconnect. Torque 3/8-inch pressure caps to 30-40 ft-lb and 3/4-inch pressure caps to 70-75 ft-lb.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

dD. Lubricate (Method A) threads of gas generator ball valve fuel inlet drain quick-disconnect with lubricant grease RB0110-012 (Rocketdyne) or FS1281 grease (Dow Corning Corp), and install pressure cap. Torque pressure cap to 210-230 in-lb.

dE. Safety wire all quick-disconnect pressure caps with Inconel lockwire MS20995N.

e. Verify that hydraulic system is connected to engine (paragraph 3.2.3.8).

f. Verify that a pneumatic hose is installed between ignition monitor valve CONTROL port and IMV CONT PORT (2A7) (paragraph 3.2.3.8).

fA. Open HYD HI-FLOW SHUTOFF valve (1A2).

Procedure	Result
g. Open HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi.	Engine hydraulic control system is pressurized.
h. Move FOUR-WAY VALVE switch (1A1) to START.	NO. 1 CLOSED and NO. 2 CLOSED (2A2), and gas generator CLOSE (2A3) lights go off. NO. 1 OPEN and NO. 2 OPEN (2A2), and gas generator OPEN (2A3) lights come on.
i. Slowly open IMV CONT PRESS REG (2A7). Monitor and record IMV CONTROL PRESS LOW gage pressure when No. 1 and No. 2 fuel valves open.	NO. 1 CLOSED and NO. 2 CLOSED lights (2A6) go off. NO. 1 OPEN and NO. 2 OPEN lights (2A6) come on. Shuttle pressure must be 20 ±4 psig.
j. Move FOUR-WAY VALVE switch (1A1) to STOP.	NO. 1 OPEN and NO. 2 OPEN (2A2), gas generator OPEN (2A3), and NO. 1 OPEN and NO. 2 OPEN (2A6) lights go off. NO. 1 CLOSED and NO. 2 CLOSED (2A2), gas generator CLOSE (2A3), and NO. 1 CLOSED and NO. 2 CLOSED (2A6) lights come on.

Procedure	Result
k. Close IMV CONT PRESS REG (2A7). Open IMV CONTROL BLEED valve until IMV CONTROL PRESS LOW gage indicates zero. Close valve.	CONTROL port is depressurized.
l. Repeat steps h through k 2 additional times.	Ignition monitor valve shuttle pressures recorded in the 3 tests must be within 2 psig of each other.

lA. Close HYD HI-FLOW SHUTOFF valve (1A2).

CAUTION

The HYD HI-FLOW SHUTOFF valve must be completely closed before closing the HYD HI-FLOW REG, to prevent damage to pressure reducing valve 19-9623747.

Procedure	Result
m. Close HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates zero.	Engine hydraulic control system is depressurized.

3.2.3.10 Ignition Monitor Valve Interflow Test.

a. Verify that engine checkout console is prepared for electrical, pneumatic, and hydraulic operation (paragraph 3.2.1).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Remove pin and closure from hypergol manifold cartridge container inlet port.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

c. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680). Lubricate (Method A) threads with lubricant grease RB0140-012 (Rocketdyne).

CAUTION

When installing the hypergol system test tool into the hypergol manifold cartridge container inlet port, extreme care must be used to prevent damage to the hypergol cartridge follower.

- The threads of the test tool cap must be clean and free of nicks to prevent galling the threads of the cap and inlet port.

Procedure	Result
d. Make sure that threads of test tool cap are clean and free of nicks; then lubricate (Method L) cap packing with FS1281 grease (Dow Corning Corp) and carefully insert hypergol system test tool 9021279 into hypergol manifold cartridge container inlet port. Screw cap (clockwise) onto inlet port until it bottoms.	HYPERGOL CARTRIDGE INSTALLED light (2A7) remains off.

dA. Verify that drain hoses are installed on engine control valve supply tube drain and checkout valve engine return hose drain (paragraph 3.2.3.8).

dB. Remove pressure cap from, and attach a drain hose to, the following quick-disconnects:

(1) No. 1 fuel high-pressure duct drain

(2) No. 2 fuel high-pressure duct drain

CAUTION

In the following procedure, during removal of the gas generator ball valve fuel inlet quick-disconnect cap, the quick-disconnect body must not be allowed to turn since a torque decrease between quick-disconnect body and adapter or adapter and gas generator ball valve fuel housing can result in seal leakage.

(3) Gas generator ball valve fuel inlet drain

(4) Turbopump No. 1 fuel inlet elbow drain

(5) Turbopump No. 2 fuel inlet elbow drain

dC. After completion of drainage from hoses installed in step dA, remove drain hoses, except for No. 1 fuel high-pressure duct drain on engines with gimbal actuators installed. Remove pressure caps from packaging, and install pressure caps, except for gas generator ball valve fuel inlet drain, on each quick-disconnect. Torque 3/8-inch pressure caps to 30-40 ft-lb and 3/4-inch pressure caps to 70-75 ft-lb.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

dD. Lubricate (Method A) threads of gas generator ball valve fuel inlet drain quick-disconnect with lubricant grease RB0140-012 (Rocketdyne) or FS1281 grease (Dow Corning Corp), and install pressure cap. Torque pressure cap to 210-230 in-lb.

dE. Safetywire all quick-disconnect pressure caps with Inconel lockwire MS20995N.

e. Verify that hydraulic system is connected to engine (paragraph 3.2.3.8).

f. Verify that pressure test fixture is installed between ignition monitor valve sense tube flange and thrust chamber fuel inlet flange (paragraph 3.2.3.9).

g. Verify that a pneumatic hose is installed between ignition monitor valve CONTROL port and IMV CONT PORT (2A7) (paragraph 3.2.3.8).

Procedure	Result
h. Depress and hold lever of test tool.	HYPERGOL CARTRIDGE INSTALLED light (2A7) comes on.

hA. Open HYD HI-FLOW SHUTOFF valve (1A2).

Procedure	Result
i. Open HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi.	Engine hydraulic control system is pressurized.
j. Move FOUR-WAY VALVE switch (1A1) to START.	NO. 1 CLOSED and NO. 2 CLOSED (2A2) and gas generator CLOSE (2A3) lights go off. NO. 1 OPEN and NO. 2 OPEN (2A2), and gas generator OPEN (2A3) lights come on.

CAUTION

The following procedure pressurizes the ignition monitor valve CONTROL port. With the HYPERGOL CARTRIDGE INSTALLED light on, pressure in excess of 100 psig must not be applied to the ignition monitor valve CONTROL port or damage to the ignition monitor valve bolt can result.

Procedure	Result
k. Slowly open IMV CONT PRESS REG (2A7) until IMV CONTROL PRESS LOW gage indicates 28 ±2 psi.	CONTROL port is pressurized.
l. Wait 5 minutes, then verify that No. 1 and No. 2 valves remain closed. Record results.	NO. 1 CLOSED and NO. 2 CLOSED lights (2A6) remain on.
m. Move FOUR-WAY VALVE switch (1A1) to STOP.	NO. 1 OPEN and NO. 2 OPEN (2A2), and gas generator OPEN (2A3) lights go off. NO. 1 CLOSED and NO. 2 CLOSED (2A2), and gas generator CLOSE (2A3) lights come on.
n. Close IMV CONT PRESS REG (2A7). Open IMV CONTROL BLEED valve until IMV CONTROL PRESS LOW gage indicates zero. Close valve.	CONTROL port is depressurized.

nA. Close HYD HI-FLOW SHUTOFF valve (1A2).

CAUTION

The HYD HI-FLOW SHUTOFF valve must be completely closed before closing the HYD HI-FLOW REG, to prevent damage to pressure reducing valve 19-9023747.

Procedure	Result
o. Close HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates zero.	Engine hydraulic control system is depressurized.

Procedure	Result
p. Release lever on hypergol test tool.	HYPERGOL CARTRIDGE INSTALLED light (2A7) goes off.

3.2.3.11 Valve Timing Test.

a. Verify that engine checkout console is prepared for electrical, pneumatic, and hydraulic operation (paragraph 3.2.1).

a-1A. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Verify that drain hoses are installed on engine control valve supply tube drain and checkout valve engine return hose drain (paragraph 3.2.3.8).

aB. Remove pressure cap from, and attach a drain hose to, the following quick-disconnects:

(1) No. 1 fuel high-pressure duct drain

(2) No. 2 fuel high-pressure duct drain

CAUTION

In the following procedure, during removal of the gas generator ball valve fuel inlet quick-disconnect cap, the quick-disconnect body must not be allowed to turn since a torque decrease between quick-disconnect body and adapter or adapter and gas generator ball valve fuel housing can result in seal leakage.

(3) Gas generator ball valve fuel inlet drain

(4) Turbopump No. 1 fuel inlet elbow drain

(5) Turbopump No. 2 fuel inlet elbow drain

aC. After completion of drainage from hoses installed in step aA, remove drain hoses, except for No. 1 fuel high-pressure duct drain on engines with gimbal actuators installed. Remove pressure caps from packaging, and install pressure caps, except for gas generator ball valve fuel inlet drain, on each quick-disconnect. Torque 3/8-inch pressure caps to 30-40 ft-lb and 3/4-inch pressure caps to 70-75 ft-lb.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

aD. Lubricate (Method A) threads of gas generator ball valve fuel inlet drain quick-disconnect with lubricant grease RB0140-012 (Rocketdyne) or FS1281 grease (Dow Corning Corp), and install pressure cap. Torque pressure cap to 210-230 in-lb.

aE. Safetywire all quick-disconnect pressure caps with Inconel lockwire MS20995N.

b. Verify that hydraulic system is connected to engine (paragraph 3.2.3.8).

c. Verify that pressure test fixture is installed between ignition monitor valve sense tube flange and thrust chamber fuel inlet flange (paragraph 3.2.3.9).

d. Verify that pneumatic hose is installed between ignition monitor valve CONTROL port and IMV CONT PORT (2A7) (paragraph 3.2.3.8).

e. Verify that on temperature recorder (2A9) (inside recorder door) MOTOR, LIGHT, and AC LINE switches are on.

NOTE

Temperature recorder requires a 5-minute warmup period.

eA. Open HYD HI-FLOW SHUTOFF valve (1A2).

Procedure	Result
f. Open HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,550 ±20 psi.	Hydraulic control system is pressurized.

g. Circulate hydraulic fluid for a minimum of 15 minutes to remove entrapped air from hydraulic control system before proceeding with test.

h. Turn on facility instrumentation. Record oxidizer valves, fuel valves, and gas generator ball valve timing during steps i through o.

i. Move FLOWMETER SEL switch (2A1) to LOW.

Procedure	Result
j. Move IMV CONTROL switch (2A7) to AUTOMATIC.	MANUAL light (2A7) remains on.
k. Make sure IMV CONTROL BLEED valve (2A7) is closed. Open IMV CONT PRESS REG until IMV CONTROL PRESS LOW gage indicates 50 ±5 psi.	IMV CONTROL PRESS LOW gage indicates 50 ±5 psi.
l. Move FOUR-WAY VALVE switch (1A1) to START.	NO. 1 CLOSED and NO. 2 CLOSED (2A2), and gas generator CLOSE (2A3) lights go off. NO. 1 OPEN and NO. 2 OPEN (2A2), and gas generator OPEN (2A3) lights come on. MANUAL light (2A7) goes off and AUTOMATIC light comes on. NO. 1 CLOSED and NO. 2 CLOSED (2A6) lights go off. NO. 1 OPEN and NO. 2 OPEN (2A6) lights come on.
m. Move FOUR-WAY VALVE switch (1A1) to STOP.	NO. 1 OPEN and NO. 2 OPEN (2A2), gas generator OPEN (2A3), and NO. 1 OPEN and NO. 2 OPEN (2A6) lights go off. NO. 1 CLOSED and NO. 2 CLOSED (2A2), gas generator CLOSE (2A3), and NO. 1 CLOSED and NO. 2 CLOSED (2A6) lights come on. AUTOMATIC light goes off, and MANUAL light comes on.

Procedure	Result
n. Close IMV CONT PRESS REG (2A7). Open IMV CONTROL BLEED valve until IMV CONT PRESS gage indicates zero. Close valve.	Ignition monitor valve CONTROL port is depressurized.
o. Repeat steps k through n 2 additional times.	As specified in steps k through n.
p. Make sure IMV CONTROL BLEED valve (2A7) is closed. Open IMV CONT PRESS REG until IMV CONTROL PRESS LOW gage indicates 50 ±5 psi.	IMV CONTROL PRESS LOW gage indicates 50 ±5 psi.
q. Move FOUR-WAY VALVE switch (1A1) to START and hold. Obtain an ammeter reading and record current drain of start solenoid; then release switch.	Current drain must not exceed 0.60 amperes. NO. 1 CLOSED and NO. 2 CLOSED (2A2), and gas generator CLOSE (2A3) lights go off. NO. 1 OPEN and NO. 2 OPEN (2A2), and gas generator OPEN (2A3), lights come on. MANUAL light (2A7) goes off, and AUTOMATIC light comes on. NO. 1 CLOSED and NO. 2 CLOSED (2A6) lights go off. NO. 1 OPEN and NO. 2 OPEN (2A6) lights come on.
r. Monitor hydraulic fluid flowrate on HYD RETURN FLOW (2A1). Record flowrate.	Flowrate with valves open must be 11.6 ±1.1 gpm.

Procedure	Result
s. Press and hold down REDUNDANT SHUTDOWN VALVE switch (1A1). Obtain an ammeter reading and record current drain of solenoid; then release switch.	Current drain must not exceed 2.0 amperes. NO. 1 OPEN and NO. 2 OPEN (2A3), and NO. 1 OPEN and NO. 2 OPEN (2A6) lights go off. NO. 1 CLOSED and NO. 2 CLOSED (2A2), gas generator CLOSE (2A3), and NO. 1 CLOSED and NO. 2 CLOSED (2A6) lights come on. AUTOMATIC light (2A7) goes off, and MANUAL light comes on.
t. Move FOUR-WAY VALVE switch (1A1) to STOP and hold. Obtain an ammeter reading, and record current drain of solenoid; then release switch.	Current drain must not exceed 0.60 amperes.
u. Monitor hydraulic fluid flowrate on HYD RETURN FLOW (2A1). Record flowrate.	Flowrate with valves closed must be 11.6 ±1.1 gpm.
v. Monitor facility instrumentation record of the 4 timing tests.	Valve timing must meet requirements of section I.
w. Move IMV CONTROL switch (2A7) to MANUAL.	MANUAL light remains on.

x. Turn off facility instrumentation.

xA. Close HYD HI-FLOW SHUTOFF valve (1A2).

CAUTION

The HYD HI-FLOW SHUTOFF valve must be completely closed before closing the HYD HI-FLOW REG, to prevent damage to pressure reducing valve 19-9023747.

Procedure	Result
y. Close HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates zero.	Hydraulic control system is depressurized.
z. On temperature record (2A9) (inside recorder door), move MOTOR, LIGHT, and AC LINE switches to OFF.	Recorder stops

aa. Move FLOWMETER SEL switch (2A1) to BYPASS.

ab. Verify that ignition monitor valve sense tube clamp is disconnected; then remove fasteners that secure ignition monitor valve sense tube to thrust chamber fuel inlet manifold, and remove blank plate from between flanges.

ac. Verify alinement of ignition monitor valve sense tube as outlined in R-3896-3.

ad. Remove seal plate from packaging, and install seal plate between ignition monitor valve sense tube and thrust chamber fuel inlet manifold. Secure tube to manifold with 4 bolts, 8 washers, and 4 nuts. Torque nuts to 47-57 in-lb.

ae. Install clamp securing ignition monitor valve sense tube to bracket on thrust chamber fuel inlet manifold. Torque clamp fasteners to 24-30 in-lb.

af. Disconnect pneumatic hose from between ignition monitor valve CONTROL port quick-disconnect and IMV CONT PORT (2A7).

ag. Remove engine checkout valve adapter 9022007-11 from ignition monitor valve CONTROL port quick-disconnect. Remove pressure cap from packaging, and install pressure cap on quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

ah. Remove drain hoses and install pressure caps on each of the following quick-disconnects. Torque quick-disconnect pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

(1) Engine control valve supply tube drain

(2) Checkout valve engine return hose drain

(3) No. 1 fuel high-pressure duct drain on engines with gimbal actuators installed

3.2.3.12 Fuel Feed System Leak Test. When a flowtester is specified in this procedure, Pneumatic Flow Tester G3104, or equivalent, must be used.

a. Verify that engine checkout console is prepared for electrical, pneumatic, and hydraulic operation (paragraph 3.2.1).

b. Verify that hydraulic system is connected to engine (paragraph 3.2.3.8).

bA. Perform, as applicable, contamination and damage procedures outlined in paragraph 3.1A when performing this test.

c. On engines not incorporating MD161 change, remove closure from No. 1 fuel pump inlet elbow, and install outboard fuel inlet test plate 9020162 not incorporating captive bolts. Torque plate fasteners to 120-155 in-lb.

d. On engines incorporating MD161 change, remove closure dust cover and install outboard fuel inlet test plate 9020162 incorporating captive bolts. Torque plate fasteners to 120-155 in-lb.

e. Connect a fuel hose between plate INLET port and FUEL PUMP INLET port (1A3).

f. On engines not incorporating MD161 change, remove closure from No. 2 fuel pump inlet elbow, and install inboard fuel inlet test plate 9020161 not incorporating captive bolts. Torque plate fasteners to 120-155 in-lb.

g. On engines incorporating MD161 change, remove closure dust cover and install inboard fuel inlet test plate 9020161 incorporating captive bolts. Torque plate fasteners to 120-155 in-lb.

gA. Vent exhaust system by removing plug from either gas generator IGNITER boss.

h. Verify that thrust chamber exit and thrust chamber throat closures are removed and that fuel overboard drain line at exit end of thrust chamber is vented to ambient.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

i. Remove cross-to-lateral drain tube from between cross and fuel overboard drain line Y-fitting, and install pressure cap AN929-16C on fuel overboard drain line Y-fitting. Lubricate (Method A) threads on line with lubricant grease RB0140-012 (Rocketdyne). Torque pressure cap to 1,200-1,400 in-lb.

j. Remove fuel drain manifold cover plate and seal plate from fuel drain manifold, and install fuel seal drain manifold adapter 9020907. Torque fasteners to 43-47 in-lb.

k. Remove plugs from INLET and PRIMARY ports on adapter.

kA. Remove pin and closure from hypergol manifold cartridge container inlet port.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

kB. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680). Lubricate (Method A) threads with lubricant grease RB0140-012 (Rocketdyne).

CAUTION

When installing hypergol simulator into the hypergol manifold cartridge container inlet port, extreme care must be used to prevent damage to the hypergol cartridge follower.

- The threads of the hypergol simulator cap must be clean and free of nicks, to prevent galling the threads of the cap and inlet port.

kC. Make sure that threads of cap on hypergol simulator T-5029716, or equivalent, are clean and free of nicks; then lubricate (Method L) simulator shaft O-ring with FS1281 grease (Dow Corning Corp), and carefully insert simulator into hypergol manifold cartridge container inlet port. Screw simulator clockwise until it bottoms.

kD. Verify that pressure cap is installed on union in simulator cap.

l. Remove pressure caps from the following quick-disconnects:

(1) No. 1 and No. 2 fuel high-pressure duct drains

(2) No. 1 and No. 2 fuel inlet elbow drains

(3) Engine control valve supply tube drain

(4) Checkout valve engine return hose drain

CAUTION

In the following procedure, during removal of gas generator ball valve fuel inlet quick-disconnect cap, the quick-disconnect body must not be allowed to turn since torque decrease between quick-disconnect body and adapter or adapter and gas generator ball valve fuel housing can result in seal leakage.

(5) Gas generator ball valve fuel inlet drain

lA. Open HYD HI FLOW SHUTOFF valve (1A2).

Procedure	Result
m. Open HYD HI-FLOW REG until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi. Monitor hydraulic fluid leakage.	Engine hydraulic control is pressurized. No leakage is allowable.
n. Slowly open MSL AIR PRESS REG (1A3) until FUEL PUMP INLET PRESS gage (1A4) indicates 80 ±5 psi. Move MSL AIR F/M SEL valve to HIGH (1A3).	Fuel feed system is pressurized, and flowrate is indicated on MISSILE AIR FLOW HIGH flowmeter (1A3).
o. Using flow-tester, measure and record poppet reverse flow leakage at each quick-disconnect listed in step l.	Leakage at each quick-disconnect poppet must not exceed 3 scim.

p. Remove pressure caps from packaging, and install pressure caps on quick-disconnects listed in step l, except for gas generator ball valve fuel inlet drain. Torque 3/8-inch pressure caps to 30-40 ft-lb and 3/4-inch pressure caps to 70-75 ft-lb.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

pA. Lubricate (Method A) threads of gas generator ball valve fuel inlet drain quick-disconnect with lubricant grease RB0140-012 (Rocketdyne) or FS1281 grease (Dow Corning Corp), and install pressure cap. Torque pressure cap to 210-230 in-lb.

pB. Safetywire all quick-disconnect pressure caps with Inconel lockwire MS20995N.

q through s. (Deleted)

CAUTION

Leak-test compound used in the following procedure must not be used on overboard drain line exits to preclude introducing leak-test compound into the lines.

- Leak-test compound must not be used on flex line bellows since it cannot be removed from the bellows.

Procedure	Result
t. Using leak-test compound (MIL-L-25567), or equivalent, monitor leakage at flanges, gimbal yoke bellows, fittings, and instrumentation lines on or connected to the following:	No leakage is allowable.

(1) No. 1 and No. 2 fuel inlet elbows

(2) No. 1 and No. 2 fuel high-pressure ducts

(3) No. 1 and No. 2 fuel valves

(4) Gas generator fuel feed duct

(5) Gas generator ball valve fuel side

(6) Igniter fuel supply tube from No. 1 fuel high-pressure duct to hypergol manifold igniter fuel inlet port

(7) Fuel volute to valve lube feed tube (pump volute to bearing coolant control valve)

(8) Turbopump balance cavity high-pressure tube and turbopump balance cavity return line

(9) Engine control valve supply tube from No. 2 fuel high-pressure duct to engine control valve

(10) Checkout valve engine return hose

tA. Remove cap on torque-gear housing.

tB. Attach a torque wrench with an adapter (1-1/16 inch deep socket) and an extension (2 feet long) to torque-pinion-gear shaft.

Procedure	Result
tC. Depress lock-pin on torque-gear housing, and depress torque-pinion-gear by applying pressure to adapter.	Torque-pinion-gear shaft engages turbopump shaft.

NOTE

In the following procedures, one revolution of the turbopump shaft requires 5 revolutions of the turbopump torque gear.

Procedure	Result
u. Using flow-tester, measure leakage past turbopump fuel inlet.	Leakage past turbopump fuel inlet seal must not exceed 50 scim.

Procedure	Result
seal at INLET port on adapter. Record leakage (turbopump shaft rotating and stationary). Slowly rotate turbopump shaft to determine maximum leakage rate whether rotating or stationary.	
v. Using flowtester, measure leakage at PRIMARY port on adapter. Record leakage (turbopump shaft rotating and stationary). Slowly rotate turbopump shaft to determine maximum leakage rate whether rotating or stationary.	Leakage past turbopump primary fuel seal must not exceed 50 scim.

w. Wait until flow of MISSILE AIR FLOW LOW flowmeter or MISSILE AIR FLOW HIGH flowmeter, as applicable, has stabilized for at least 2 minutes. Measure and record total fuel feed system leakage.

Procedure	Result
x. Using flowtester, measure leakage at fuel drain disconnected in step i. Record results.	Leakage past gas generator ball valve fuel shaft seal must not exceed 0.25 scim.
y. Using flowtester, measure leakage from fuel overboard drain at thrust chamber exit. Record results.	Leakage past bearing coolant control valve check valves must not exceed 2 scim.
z. Using flowtester, measure nominal leakage past turbopump fuel inlet seal at inlet port on adapter (turbopump shaft stationary). Record results.	Leakage past turbopump fuel inlet seal must not exceed 50 scim.
aa. Using flowtester, measure nominal leakage past turbopump primary fuel seal at PRIMARY port on adapter (turbopump shaft stationary). Record results.	Leakage past turbopump primary fuel seal must not exceed 50 scim.
ab. Remove plug from hypergol manifold instrumentation tap IF3, and using a flowtester, measure leakage past igniter fuel valve poppet.	Maximum allowable leakage at igniter fuel valve poppet is 0.5 scim.
ac. Close MSL AIR PRESS REG (1A3), and move MSL AIR F/M SEL valve to BYPASS.	Flow through MISSILE AIR FLOW HIGH flowmeter (1A3) decreases to zero.
ad. Slowly open FUEL PUMP BLEED valve (MANIFOLD BLEED PANEL).	FUEL PUMP INLET PRESS gage (1A4) decreases to zero.

adA. Close HYD HI-FLOW SHUTOFF valve (1A2).

CAUTION

The HYD HI-FLOW SHUTOFF valve must be completely closed before closing the HYD HI-FLOW REG, to prevent damage to pressure reducing valve 19-9023747.

Procedure	Result
ae. Close HYD HI-FLOW REG (1A2)	HYD HI-FLOW PRESS gage (1A2) decreases to zero.

af. Add the following leakage rate results to obtain total fuel feed system measured vent leakage rates:

(1) Bearing coolant valve check valves leakage (step y)

(2) Nominal turbopump fuel inlet seal leakage (step z)

(3) Nominal turbopump primary fuel seal leakage (step aa)

ag. Subtract the total fuel feed system measured vent leakage rate obtained in step af from total fuel feed system measured leakage rate obtained in step w. The result is the calculated leakage rate past checkout valve ENG RETURN port ball seal, gas generator fuel feed system, and skirt and nose seals of both fuel valves.

ah. If calculated leakage obtained in step ag is greater than 15 scim, perform checkout valve isolation leak test as outlined in paragraph 3.2.4.3 and, using this total fuel feed system leakage rate, subtract total fuel system measured vent leakage, step ag, to obtain leakage rate past gas generator fuel feed system and fuel valves skirt and nose seal.

ai. If gas generator ball valve fuel ball seal and fuel valves skirt and nose seal leakage still exceeds 15 scim, perform gas generator fuel feed system isolation leak test (paragraph 3.2.4.4).

aj. If fuel valves skirt and nose seal leakage still exceeds 15 scim, perform fuel valves skirt and nose seal isolation leak test (paragraph 3.2.4.5).

ak. Remove fuel hose from outboard fuel inlet test plate and FUEL PUMP INLET port (1A3).

al. On engines not incorporating MD161 change, remove test plates from No. 1 and No. 2 fuel pump inlets, remove closures from packaging, and install closures on inlets. Tighten closure fasteners fingertight plus 1/4 turn.

am. On engines incorporating MD161 change, remove test plates from No. 1 and No. 2 fuel pump inlets, remove dust covers from packaging, and install dust covers on inlet closures.

an. Remove fuel seal drain manifold adapter from fuel drain manifold, remove fuel drain manifold cover plate and seal plate from packaging, and reinstall fuel drain manifold cover plate and seal plate removed in step j. Torque bolts to 44-47 in-lb. Safetywire bolts with Inconel lockwire MS20995N.

ao and ap. (Deleted)

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

aq. Remove plug and packing from packaging. Lubricate (Method J) packing and (Method A) plug with lubricant grease RB0140-012 (Rocketdyne). Install plug and packing in instrumentation tap IF3. Torque plug to 40-65 in-lb. Safetywire plug with Inconel lockwire MS20995N.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

ar. Remove all leak-test compound from joints and fittings with a clean, dry cloth or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

as. Remove torque wrench, extension, and adapter.

at. Verify that lockpin on torque-gear housing is fully extended and that torque-pinion-gear shaft is in lockout position.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

au. Lubricate (Method J) packing with lubricant grease RB0140-012 (Rocketdyne); then install packing on torque-gear housing cap.

av. Lubricate (Method A) threads of torque-gear housing cap with lubricant grease RB0140-012 (Rocketdyne); then install cap fingertight on torque-gear housing. Safetywire cap with Inconel lockwire MS20995N.

aw. Remove hypergol simulator T-5029716, or equivalent, from hypergol manifold cartridge container inlet port.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

ax. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680).

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

ay. Remove hypergol manifold cartridge container inlet port closure from packaging. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp). Install closure and secure with attaching pin.

3.2.3.13 LOX Feed System Leak Test. When a flowtester is specified in the procedure, Pneumatic Flow Tester G3104, or equivalent, must be used.

a. Verify that engine checkout console is prepared for electrical, pneumatic, and hydraulic operation (paragraph 3.2.1).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aB. Verify that exhaust system is vented through gas generator IGNITER boss (paragraph 3.2.3.12).

b. Remove protective closures from nitrogen purge overboard drain line and oxidizer overboard drain line at exit end of thrust chamber.

c. On engines not incorporating MD161 change, remove protective closure from turbopump oxidizer inlet, and install oxidizer pump inlet test plate 9020163 not incorporating captive bolts. Torque plate fasteners to 330-430 in-lb.

d. On engines incorporating MD161 change, remove dust cover and install oxidizer pump inlet test plate 9020163 incorporating captive bolts. Torque plate fasteners to 330-430 in-lb.

e. Connect an oxidizer hose between oxidizer pump inlet test plate 9020163 and LOX PUMP INLET port (1A3).

f. Install plug AN806J8 in nitrogen purge overboard drain line at thrust chamber exit.

g. Disconnect actuator rod seal vent tubes from OXID VENT port on No. 1 and No. 2 oxidizer valves. Cap tubes.

h. Move L.C. AIR F/M SEL valve (1A3) to BYPASS.

Procedure	Result
i. Slowly open L.C. AIR PRESS REG (1A3) until LOX PUMP INLET PRESS gage (1A4) indicates 80 ±5 psi. Move L.C. AIR F/M SEL valve (1A3) to HIGH. Record pressure.	LOX propellant feed system is pressurized, and LOX CLEAN AIR FLOW flowmeter (1A3) indicates flow.

iA. Remove cap on torque-gear housing.

iB. Attach a torque wrench with an adapter (1-1/16 inch deep socket) and an extension (2 feet long) to torque-pinion-gear shaft.

iC. Depress lock-pin on torque-gear housing, and depress torque-pinion-gear by applying pressure to adapter.	Torque-pinion-gear shaft engages turbopump shaft.

NOTE

In the following procedure, one revolution of the turbopump shaft requires 5 revolutions of the turbopump torque gear.

Procedure	Result
j. Using flowtester, measure and record leakage from oxidizer overboard drain line at thrust chamber exit. Slowly rotate turbopump shaft to determine maximum leakage rate whether rotating or stationary.	Leakage past turbopump primary LOX seal must not exceed 700 scim.
k. Using flowtester, measure and record leakage at actuator rod OXID VENT port of each oxidizer valve.	Leakage past each bottom rod lipseal must not exceed 30 scim.

l and m. (Deleted)

CAUTION

Leak-test compound used in the following procedure must not be used on overboard drain line exits to preclude introducing leak-test compound into the lines.

- Leak-test compound must not be used on flex line bellows since it cannot be removed from the bellows.

n. Using leak-test compound (MIL-L-25567) monitor leakage at flanges, gimbal yoke bellows, fittings, and instrumentation lines on or connected to the following:	No leakage is allowable, except on engines not incorporating MD128 change where fuzz leakage (as defined in section II) is allowable between gas generator ball valve oxidizer housing and actuator cavity housing joint.

(1) Oxidizer pump

(2) No. 1 and No. 2 oxidizer high-pressure ducts

(3) No. 1 and No. 2 oxidizer valves

(4) Gas generator oxidizer feed line

(5) Gas generator ball valve oxidizer side

(6) Oxidizer pump inlet to oxidizer pump volute

(7) Gas generator ball valve oxidizer side to actuator housing

(8) No. 1 and No. 2 oxidizer valves cover to housing

NOTE

In the following procedure, if leakage is less than 30 scim, Pneumatic Flow Monitor G3131 may be used.

o. Make sure that flowrate of LOX CLEAN AIR FLOW flowmeter (1A3) has stabilized for at least 2 minutes. Record total LOX propellant feed system leakage.

Procedure	Result
p. Using flowtester, measure and record leakage at oxidizer overboard drain line (turbopump shaft stationary).	Leakage past turb pump primary LOX seal must not exceed 700 scim.
q. Close L.C. AIR PRESS REG (1A3), and move L.C. AIR SEL valve to BYPASS.	LOX CLEAN AIR FLOW HIGH flowmeter (1A3) decreases to zero.
r. Slowly open LOX PUMP BLEED valve (MANIFOLD BLEED PANEL). Close valve after pressure decay.	LOX PUMP INLET PRESS gage (1A4) decreases to zero.

s. Add the following measured leakage rates to obtain total LOX propellant feed system measured vent leakage rate:

(1) Oxidizer valves bottom rod lip seal leakage rate (step k)

(2) Nominal turbopump primary LOX seal leakage rate (step p)

t. Subtract the sum of step s from recorded results of step o and record as the calculated leakage rate past gas generator LOX feed system and skirt and nose seal of both oxidizer valves.

u. If calculated leakage (step t) is greater than 10 scim, perform steps v and w, repeat steps i through k and o through t; then proceed to step x.

v. Verify that hydraulic system is connected to engine (paragraph 3.2.3.8).

Procedure	Result
w. Open HYD HI-FLOW SHUTOFF valve (1A2). Slowly open HYD HI-FLOW REG until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi. Monitor hydraulic fluid leakage.	Engine hydraulic control system is pressurized. No leakage is allowable.

wA. Close HYD HI-FLOW SHUTOFF valve (1A2).

CAUTION

The HYD HI-FLOW SHUTOFF valve must be completely closed before closing the HYD HI-FLOW REG, to prevent damage to pressure reducing valve 19-9023747.

Procedure	Result
x. Close HYD HI-FLOW REG (1A2).	HYD HI-FLOW PRESS gage (1A2) decreases to zero.

y. If calculated leakage (step t) is greater than 10 scim with hydraulic system pressurized, perform gas generator LOX feed system isolation leak test (paragraph 3.2.4.6).

z. If leakage after performance of step y is greater than 56 scim, perform oxidizer valves skirt and nose seal isolation leak test as outlined in paragraph 3.2.4.7.

aa. On engines not incorporating MD161 change, disconnect oxidizer hose, and remove plate 9020163 from oxidizer inlet by loosening all attaching bolts 3 full turns before removing individual bolts. Remove packaging from oxidizer inlet closure, and install closure on oxidizer inlet. Tighten closure fasteners finger-tight plus 1/4 turn.

ab. On engines incorporating MD161 change, disconnect oxidizer hose and remove plate 9020163 from oxidizer inlet closure. Install dust cover on closure.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

ac. Remove plugs, lubricate (Method A) fittings and (Method G) tubes with lubricant grease RB0140-012 (Rocketdyne), and reinstall actuator rod seal vent tubes and actuator seal drain tubes. Torque tube coupling nuts to 135-185 in-lb.

ad. Install oxidizer overboard drain line protective closure on drain line at exit end of thrust chamber. Torque closure fasteners fingertight plus 1/4 turn.

ae. Remove pressure test fixtures T-5039240 and T-5039234 from checkout valve ground return hose and engine control valve ground hydraulic supply hydraulic hose. Install plates on hoses. Torque plate fasteners to 35-40 in-lb.

af. Remove plug from nitrogen purge overboard drain line.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

ag. Remove all leak-test compound from joints and fittings with a clean, dry cloth or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

ah. Remove torque wrench, extension, and adapter.

ai. Verify that lockpin on torque-gear housing is fully extended and that torque-pinion-gear shaft is in lockout position.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

aj. Lubricate (Method J) packing with lubricant grease RB0140-012 (Rocketdyne); then install packing on torque-gear housing cap.

ak. Lubricate (Method A) threads of torque-gear housing cap with lubricant grease RB0140-012 (Rocketdyne); then install cap fingertight on torque-gear housing. Safetywire cap with Inconel lockwire MS20995N.

3.2.3.14 Exhaust System Leak Test.

a. Verify that engine checkout console is prepared for pneumatic operation (paragraph 3.2.1).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

b. Remove plug from instrumentation tap GO2a; then lubricate (Method J) adapter packing and (Method A) adapter union with lubricant grease RB0140-012 (Rocketdyne), and install engine exhaust system supply adapter 9022043, or equivalent, in gas generator instrumentation tap GO2a. Torque union to 55-80 in-lb. Retain removed hardware for reinstallation.

c. Connect an oxidizer-clean hose between adapter 9022043, or equivalent, and GG LOX INJECTOR & LOX DOME PURGE (1A5).

d. Remove either plug from gas generator IGNITER boss; then lubricate (Method J) adapter packing and (Method A) threads of union with lubricant grease RB0140-012 (Rocketdyne), and install engine exhaust system monitor adapter 9025299, or equivalent, in gas generator IGNITER boss. Torque union nut to 225-275 in-lb.

e. Remove closure from thrust chamber dome and gas generator purge tube, and install LOX dome and gas generator LOX purge adapter 9022010 or equivalent. Lubricate (Method J) adapter packing with lubricant grease RB0140-012 (Rocketdyne). Torque adapter fasteners to 70-80 in-lb. Verify that all ports on adapter are plugged or capped.

f. Connect a tee to adapter 9025299, or equivalent, attach a hand bleed valve to one end of tee, and close valve. Connect a fuel hose from other end of tee to INSTR TAP DNSTR OF TURB connection (1A5).

g. Remove clamp holding turbopump turbine and heat exchanger antifirex shield to provide access to flange seal monitoring port vent hose outlets.

Procedure	Result
h. Check that pedestal exhaust system manifold seal at thrust chamber exit is inflated to specified pressure.	Seal must remain inflated during remainder of test.
i. Open GG LOX PURGE shutoff valve (1A5). Slowly open LC AIR PRESS REG until PRESS DNSTR OF TURB gage indicates 10 ±1 psi.	Engine exhaust system is pressurized, and LOX CLEAN AIR PRESS gage (1A5) indicates 10 ±1 psi.
j. Remove closure from oxidizer overboard drain line and, using Pneumatic Flow Tester G3104, measure and record reverse-flow leakage past gas generator LOX purge check valve gate.	Maximum allowable leakage is 25 scim.
k. Remove plugs, and using Pneumatic Flow Tester G3104, measure and record leakage at the following static seal monitoring ports:	Maximum allowable leakages are as follows:
(1) Turbine to heat exchanger (on heat exchanger flange)	10 scim
(2) Heat exchanger to exhaust manifold (on exhaust manifold)	10 scim

l. Using Pneumatic Flow Tester G3104, or equivalent, at vent hose outlets, measure and record leakage from the following static seal monitoring ports:

(1) Gas generator combustor to turbine manifold inlet (on gas generator flange)	10 scim
(2) Gas generator injector to combustor	10 scim

CAUTION

Leak-test compound used in the following procedure must not be used on flex line bellows since it cannot be removed from the bellows.

m. Using leak-test compound (MIL-L-25567), leak-test the following flanges with leakage monitoring port plugs removed.

Procedure	Result
(1) Turbine manifold outlet to heat exchanger	Fuzz leakage (as defined in section II) is allowable.
(2) Heat exchanger to turbine exhaust manifold	Fuzz leakage (as defined in section II) is allowable.
(3) Gas generator combustor to turbine manifold inlet	No leakage is allowable.
(4) Gas generator injector to combustor	No leakage is allowable.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

n. Remove from packaging, lubricate (Method A), and install monitoring port plugs removed in step k. (See figure 3-8.)

o. Apply leak-test compound (MIL-L-25567) to all flanges, fittings, and instrumentation lines on or connected to the following and record results:	No leakage is allowable, except on engines not incorporating MD176 change at flight turbine manifold temperature transducer where fuzz leakage (as defined in section II) is allowable.

(1) Gas generator ball valve (downstream of oxidizer ball and fuel ball)

(2) Gas generator ball valve to gas generator injector

(3) Gas generator combustor

(4) Turbine exhaust manifold and heat exchanger

(5) Thrust chamber exhaust manifold weld joints

CAUTION

The exhaust system must be depressurized as outlined in steps p through r, to prevent contamination of the engine and checkout console systems.

Procedure	Result
p. Close GG LOX PURGE shutoff valve (1A5).	Supply pressure to exhaust system stops.
q. Open hand bleed valve on igniter boss adapter until PRESS DNSTR OF TURB gage indicates zero.	Exhaust system is depressurized.
r. Close LC AIR PRESS REG (1A5) until LOX CLEAN AIR PRESS gage indicates zero.	Console purge system is depressurized.

s. Remove fuel hose from adapter 9025290 and INSTR TAP DNSTR OF TURB. Remove hand bleed valve from adapter.

t. Remove oxidizer-clean hose from adapter 9022043 and GG LOX INJECTOR & LOX DOME PURGE. Remove adapters.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

u. Remove plug and K-seal from packaging. Lubricate (Method A) plug threads with lubricant grease RB0140-012 (Rocketdyne), and install plug and K-seal 12100CR4 in instrumentation tap GO2a. Torque plug to 80-90 in-lb. Safetywire plug with Inconel lockwire MS20995N.

v. (Deleted)

w. Deflate exhaust system manifold seal at thrust chamber exit.	Seal is depressurized.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

x. Remove all leak-test compound from joints and fittings with a clean, dry cloth or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

y. Install turbopump turbine and heat exchanger antifirex shield. Position clamp coupling joints within 3 degrees of a line extending from the center of the fuel inlet elbows through the turbopump aft support. Torque clamp coupling joint nuts to 85-95 in-lb.

3.2.3.15 LOX Dome and Gas Generator LOX Injector Purge Leak and Function Test.

a. Verify that engine checkout console is prepared for pneumatic operation (paragraph 3.2.1)

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

b. Remove closure from LOX dome and gas generator LOX injector purge interface, and install LOX dome and gas generator LOX purge adapter 9022010. Lubricate (Method J) adapter packing with lubricant grease RB0140-012 (Rocketdyne). Torque adapter fasteners to 70-80 in-lb. Verify that all ports on adapter are plugged or capped.

c. Connect an oxidizer-clean hose between adapter 9022010 and GG LOX INJECTOR & LOX DOME PURGE (1A5).

d. Verify that exhaust system is vented through gas generator IGNITER boss (paragraph 3.2.3.12).

e. Verify that thrust chamber exit, thrust chamber throat, and oxidizer overboard drain line closures are removed and that thrust chamber exit is clear during test.

f. Open GG LOX PURGE shutoff valve (1A5).

Procedure	Result
g. Open LC AIR PRESS REG (1A5) until LOX CLEAN AIR PRESS gage indicates 100 ±5 psi.	Airflow through system is verified at gas generator igniter port thrust chamber injector and overboard drain line or by feeling individual purge system lines.

CAUTION

Leak-test compound used in the following procedure must not be used on overboard drain line exits to preclude introducing leak-test compound introduced into the lines.

- Leak-test compound must not be used on flex line bellows since it cannot be removed from the bellows.

h. Apply leak-test compound (MIL-L-25567) to all joints and fittings of LOX dome and gas generator LOX injector purge system.	No leakage is allowable.
i. Close GG LOX PURGE shutoff valve (1A5) and LC AIR PRESS REG.	LOX CLEAN AIR PRESS gage (1A5) decreases to zero.

j and k. (Deleted)

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

l. Remove all leak-test compound from joints and fittings with a clean dry cloth or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.2.3.16 Turbopump Bearing Coolant System Leak and Function Test.

a. Verify that engine checkout console is prepared for electrical and pneumatic operation (paragraph 3.2.1).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Remove closures from nitrogen purge overboard drain line and oxidizer overboard drain line at thrust chamber exit.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

c. Remove closure from pump seal purge line, and install LOX seal and gas generator actuator purge adapter 9022012, or equivalent, on line. Lubricate (Method J) adapter gasket with lubricant grease RB0140-012 (Rocketdyne). Torque adapter fasteners to 70-80 in-lb.

d. Install pressure test fixture T-5039241, or equivalent, on fuel overboard drain line at thrust chamber exit. Lubricate (Method J) fixture O-ring with lubricant grease RB0140-012 (Rocketdyne). Torque fixture fasteners to 10-15 in-lb.

e. Connect a fuel hose between pressure test fixture and PRESERVATIVE INLET port (1A2).

f. Verify that cross-to-lateral drain tube is removed from between cross and fuel overboard drain line (paragraph 3.2.3.12).

g. Verify that pressure cap AN929-16J is installed on fuel overboard drain line (paragraph 3.2.3.12).

h. Connect an oxidizer-clean hose between adapter on pump seal purge line and LOX PUMP SEAL & GG ACTUATOR PURGE port (1A5).

i. Open LOX PUMP SEAL PURGE shutoff valve (1A5).

j. Open LC AIR PRESS REG (1A5) until LOX CLEAN AIR PRESS gage indicates 75 ±5 psi.

k. Open PRESERVATIVE INLET S/O valve (1A2).

CAUTION

When pressurizing fuel overboard drain line, pressure in drain system must not exceed 15 psig or damage to drain line can result.

<u>Procedure</u>	<u>Result</u>
l. Open GN_2 PRESS REG (1A2) until PRESERVATIVE INLET PRESS gage indicates 10 ±1 psi.	Fuel overboard drain line and fuel drain manifold and lines are pressurized up to bearing coolant valve outlet port.

CAUTION

Leak-test compound used in the following procedure must not be used on overboard drain line exits to preclude introducing leak-test compound into the lines.

- Leak-test compound must not be used on flex line bellows since it cannot be removed from the bellows.

m. Apply leak-test compound (MIL-L-25567) to all joints and fittings on bearing coolant outlet (lube valve to turbine bearing lube fuel hose) and drain lines	No leakage is allowable.
n. Close GN_2 PRESS REG (1A2).	PRESERVATIVE INLET PRESS gage (1A2) decreases to zero.
o. Close LC AIR PRESS REG (1A5).	LOX CLEAN AIR PRESS gage (1A5) decreases to zero.

p. Close LOX PUMP SEAL PURGE shutoff valve (1A5).

q. Disconnect fuel hose from PRESERVATIVE INLET port, and pressure test fixture at fuel overboard drain line.

r. Remove pressure test fixture T-5039241 from fuel overboard drain line.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

s. Remove pressure cap from overboard drain line, and reinstall cross-to-lateral drain tube. Lubricate (Method A) the threads and lubricate (Method G) tube with lubricant grease RB0140-012 (Rocketdyne). Torque tube coupling nuts to 1,200-1,400 in-lb.

sA. Remove packaging; then clean and inspect threads of plug ST3950122RKL001 for adequate silver plating. Replace plug if silver plating is not adequate. Install washer 651912-3 on plug. Do not lubricate plug. Install plug in gas generator IGNITER boss and torque to 600-650 in-lb. Safetywire 2 igniter plugs together with Inconel lockwire MS20995N. As an alternate, plug MS9015-08 with washer 651912-3 or gasket AN901-8C may be used. If washer 651912-3 is used, install plug MS9015-08 in IGNITER boss and torque to 150-200 in-lb. If gasket AN901-8C is used, screw plug MS9015-08 fingertight into IGNITER boss. Check that gasket seats in recessed groove on IGNITER boss; then torque plug to 150-200 in-lb. Safetywire plug with Inconel lockwire MS20995N.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

t. Remove all leak-test compound from joints and fittings with a clean, dry cloth or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.2.3.17 <u>Thrust Chamber Pneumatic Leak Test.</u> When flowtesters are specified in this procedure, Pneumatic Flow Tester G3104, or equivalent, must be used.

a. Install Thrust Chamber Throat Plug G3136 (paragraph 3.6.15).

b. Verify that engine checkout console is prepared for pneumatic operation (paragraph 3.2.1).

bA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

c. Remove plug and install an oxidizer-clean adapter, incorporating a check valve and a union AN815-8C, or equivalent, in thrust chamber dome PURGE 1B port. Connect an oxidizer-clean hose between adapter check valve and GG LOX INJECTOR & LOX DOME PURGE (1A5).

d. Connect a fuel hose between thrust chamber throat plug quick-disconnect and FUEL B.S. LINE (2A3).

e. Remove closure from prefill check valve.

f. Install inlet port half of pressure test fixture T-5037801 on prefill check valve.

g. Verify installation of pressure test fixture T-5039232 on GOX duct (heat exchanger end) (paragraph 3.2.3.5). Connect an oxidizer-clean hose between adapter and LOX B.S. LINE (2A1).

h. Verify installation of hypergol system test tool 9021279 (paragraph 3.2.3.10).

i. Remove pressure caps from the following quick-disconnects:

CAUTION

In the following procedure, during removal of No. 1 and No. 2 fuel inlet manifold quick-disconnect pressure caps, the quick-disconnect body must not be allowed to turn since damage to quick-disconnect body can result.

(1) No. 1 and No. 2 fuel inlet manifold drains

(2) No. 1 and No. 2 fuel valve purge

(3) Hypergol manifold drain

(4) Hypergol manifold purge

(5) Ignition monitor valve control

CAUTION

In the following step, the gaseous nitrogen supply hose must be supported to prevent the weight on the seal valve stem from damaging the seal.

iA. Connect a source of gaseous nitrogen to throat plug seal. Using a suitable material, support the gaseous nitrogen supply hose to relieve all weight of hose from seal valve stem.

Procedure	Result
j. Pressurize throat plug seal to 50 (+5, -10) psig. Maintain pressure during remainder of test.	Thrust chamber throat plug seal is pressurized.

k. Move F/M SEL handle (2A3) and FLOWMETER SEL handle (2A1) to HIGH.

WARNING

The following procedure pressurizes the thrust chamber and can be extremely hazardous. All personnel must be kept clear of the thrust chamber exit during this test.

l. Open GG LOX PURGE shutoff valve (1A5). Open LC AIR PRESS REG until LOX CLEAN AIR PRESS gage indicates 30 (+0, -3) psi.	Thrust chamber is pressurized. FUEL BS PRESS PANEL LOW gage (2A4) and LOX BS PRESS PANEL LOW gage (2A8) indicate 30 (+0, -3) psi.

m and n. (Deleted)

o. Verify that LOX dome and gas generator LOX purge adapter 9022010 is installed and that all ports on adapter are plugged or capped (paragraph 3.2.3.15).

Procedure	Result
p. Remove closure from oxidizer overboard drain line and, using flowtester, measure and record reverse-flow leakage of No. 1 and No. 2 oxidizer dome purge check valve gates.	Maximum allowable leakage is 10 scim. If leakage exceeds 10 scim, perform oxidizer dome purge check valve isolation leak test as outlined in paragraph 3.2.4.8.

CAUTION

Leak-test compound used in the following procedure must not be used on flex line bellows since it cannot be removed from the bellows.

Procedure	Result
q. Apply leak-test compound (MIL-L-25567) to all flanges, fittings, and connections on or connected to the following and record results:	No leakage is allowable.

(1) Oxidizer valves and fuel valves (downstream of poppets)

(2) Ignition monitor valve sense tube

(3) Hypergol manifold outlet hose between hypergol manifold and thrust chamber

(4) Joints between thrust chamber dome and injector and between injector and thrust chamber body

(5) Thrust chamber instrumentation

(6) No. 1 and No. 2 oxidizer dome purge check valves

(7) Thrust chamber dome and gas generator oxidizer purge tubes

(8) Exposed thrust chamber tube surfaces

(9) Thrust chamber dome purge port plugs PURGE 1A, PURGE 2A, PURGE 2B, NO. 3 PURGE, and NO. 4 PURGE

Procedure	Result
r. Using flowtester, measure and record poppet reverse-flow leakage at each quick-disconnect listed in step i.	Leakage at each quick-disconnect poppet must not exceed 3 scim.
s. Using flowtester, measure and record reverse-flow leakage past the inert prefill check valve gate.	Maximum allowable leakage is 50 scim.

CAUTION

The thrust chamber must be depressurized as outlined in steps t through x, to prevent contamination of the engine and checkout console oxidizer systems.

Procedure	Result
t. Close GG LOX PURGE shutoff valve (1A5).	Supply pressure to thrust chamber stops.
u. Open FUEL B. S. BLEED valve on panel below (2A4) until FUEL BS PRESS PANEL LOW gage (2A4) indicates zero.	Thrust chamber is depressurized.
v. Open LOX BS BLEED valve on panel below (2A8) until LOX BS PRESS PANEL LOW gage (2A8) indicates zero.	Heat exchanger oxidizer system is depressurized.
w. Close LC AIR PRESS REG (1A5) until LOX CLEAN AIR PRESS gage indicates zero.	Checkout console purge system is depressurized.

x. Close FUEL B.S. BLEED valve on panel below (2A4), and LOX B.S. BLEED valve on panel below (2A8).

y. Remove oxidizer-clean hose and pressure test fixture T-5039232 from LOX B.S. LINE (2A1) and GOX duct (heat exchanger end). Install protective cover on GOX duct. Tighten fasteners fingertight plus 1/4 turn.

z. Remove fuel hose from thrust chamber throat plug quick-disconnect and FUEL B.S. LINE (2A3).

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

aa. Remove oxidizer-clean hose and adapter from GG LOX INJECTOR & LOX DOME PURGE (1A5) and PURGE 1B port. Remove plug and seal from packaging, lubricate (Method A) plug and (Method R) seal with lubricant grease RB0140-012 (Rocketdyne), and install plug and seal. Torque plug to 20-30 ft-lb, and record plug installation torque value. Safetywire plug with Inconel lockwire MS20995N.

ab. Reduce thrust chamber throat plug seal pressure to zero.

ac. Remove LOX dome and gas generator LOX purge adapter 9022010, and install closure on LOX dome and gas generator LOX injector purge interface. Tighten fasteners fingertight plus 1/4 turn.

CAUTION

In the following procedure, installation of No. 1 and No. 2 fuel inlet manifold quick-disconnect pressure caps, the quick-disconnect body must not be allowed to turn since damage to the quick-disconnect body can result.

ad. Remove pressure caps from packaging, and install pressure caps on quick-disconnects listed in step i. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

ae. Remove Thrust Chamber Throat Plug G3136 (paragraph 3.6.16).

af. Install thrust chamber throat security closure as outlined in paragraph 3.6.13.

ag. Remove pin that secures hypergol test tool cap, and carefully unscrew cap and remove tool from manifold.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

ah. Clean threads of hypergol manifold cartridge container and inlet port with drycleaning solvent (Federal Specification P-D-680).

ai. Remove packaging from hypergol manifold cartridge container inlet port closure. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp). Install closure and secure with attaching pin.

aj. Remove pressure test fixture T-5037801 and install closure on inert prefill check valve. Tighten fasteners fingertight plus 1/4 turn.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

ak. Remove all leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.2.4 ISOLATION TEST PROCEDURES FOR UNINSTALLED ENGINES.

3.2.4.1 LOX Pump Seal Isolation Test. This test is required only in the event flowrate past the turbopump intermediate seal is zero. This test determines if the purge supply or the system overboard drain lines are obstructed. Zero flowrate of the seal is acceptable.

a. With LOX pump seal purge system pressurized at 85 ±10 psig (refer to paragraph 3.2.3.3), rotate turbopump shaft approximately 2 revolutions and repeat leakage measurement at overboard drain lines. If leakage is within limits, continue test. (Refer to paragraph 3.2.3.3.)

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. If flowrate is not experienced from both sides of turbopump intermediate seal, backflow the turbopump intermediate seal from LOX side as follows:

(1) Close LC AIR PRESS REG (1A5) until LOX CLEAN AIR PRESS gage indicates zero.

(2) Disconnect hose from LOX pump seal purge interface.

(3) On engines not incorporating MD161 change, remove protective closure from turbopump oxidizer inlet, and install oxidizer pump inlet test plate 9020163 not incorporating captive bolts. Torque plate fasteners to 330-430 in-lb.

(4) On engines incorporating MD161 change, remove dust cover and install oxidizer pump inlet test plate 9020163 incorporating captive bolts. Torque plate fasteners to 330-430 in-lb.

(5) Connect an oxidizer hose between oxidizer pump inlet test plate 9020163 and LOX PUMP INLET port (1A3).

(6) Disconnect oxidizer seal vent tube from oxidizer drain tube. Loosen tube clamps, as required to gain access to oxidizer drain tube.

CAUTION

In the following procedure, the pressurization supply line must not be attached to oxidizer overboard drain tube at thrust chamber exit.

(7) Connect an oxidizer hose between LOX BS LINE port (2A1) and oxidizer drain tube.

(8) Move L.C. AIR F/M SEL valve (1A3) to BYPASS.

(9) Slowly open L.C. AIR PRESS REG (1A3) until LOX PUMP INLET PRESS gage (1A4) indicates 30 (+0, -5) psi.

(10) Move FLOWMETER SEL valve (2A1) to BYPASS.

(11) Slowly open L.C. AIR HIGH PRESS REG (2A1) until LOW pressure gage (2A8) indicates 20 (+0, -5) psi, and backflow the turbopump intermediate seal from LOX side allowing flow to go overboard through nitrogen purge overboard drain line and LOX pump seal purge interface.

(12) Verify flow from LOX pump seal purge interface and nitrogen overboard drain line.

(13) Close L.C. AIR HIGH PRESS REG (2A1) until LOW pressure gage (2A8) indicates zero.

(14) Close L.C. AIR PRESS REG (1A3), and open LOX PUMP BLEED valve (MANIFOLD BLEED PANEL) until LOX PUMP INLET PRESS gage (1A4) decreases to zero. Close valve after pressure decay.

(15) Disconnect oxidizer hose between LOX BS LINE port (2A1) and LOX drain tube.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

(16) Lubricate (Method A) threads of oxidizer drain tube and (Method G) oxidizer seal vent tube with lubricant grease RB0140-012 (Rocketdyne), and install oxidizer seal vent tube. Torque tube coupling nut to 1,500-1,800 in-lb. Secure clamps, as required.

(17) On engines not incorporating MD161 change, disconnect oxidizer hose, and remove plate 9020163 from oxidizer inlet by loosening all attaching bolts 3 full turns before removing individual bolts. Remove packaging from oxidizer inlet closure, and install oxidizer inlet closure on oxidizer inlet. Tighten closure fasteners finger tight plus 1/4 turn.

(18) On engines incorporating MD161 change, disconnect oxidizer hose and remove plate 9020163 incorporating captive bolts, from oxidizer inlet closure. Install dust cover on closure.

(19) Reconnect hose to LOX pump seal purge interface disconnected in substep 2.

(20) Verify leakage from both sides of turbopump intermediate seal as outlined in paragraph 3.2.3.3.

3.2.4.2 Fuel Overboard Drain Line Isolation Test. This test is required only in event of excessive leakage from fuel overboard drain line.

a. Close HYD HI-FLOW SHUTOFF valve (1A2).

CAUTION

The HYD HI-FLOW SHUTOFF valve must be completely closed before closing the HYD HI-FLOW REG, to prevent damage to pressure reducing valve 19-9023747.

Procedure	Result
aA. Close HYD HI-FLOW REG (1A2).	HYD HI-FLOW PRESS gage (1A2) indicates zero.

Procedure	Result
b. Close IMV CONT PRESS REG (2A7) until IMV CONTROL PRESS LOW gage indicates zero.	Ignition monitor valve CONTROL port is depressurized.

c. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

d. Remove redundant shutdown valve override line from between redundant shutdown valve and engine control valve as follows:

(1) Remove attaching hardware that secures line to redundant shutdown valve, and remove seal plate. Refer to R-3896-3 for handling information. Retain attaching hardware for reinstallation if acceptable for reuse in accordance with section II.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

(2) Install pressure test fixture T-5041521 on redundant shutdown valve OUT port. Lubricate (Method J) fixture O-ring with lubricant grease RB0140-012 (Rocketdyne). Torque fasteners to 85-95 in-lb.

(3) Disconnect line from engine control valve OVERRIDE port.

(4) Protect line from contaminants, and leave line installed on engine.

e. Remove control valve override drain tube from between tee and redundant shutdown valve DRAIN port.

f. Disconnect tube from ignition monitor valve ATMOS REF port.

Procedure	Result
g. Open IMV CONT PRESS REG (2A7) until IMV CONTROL PRESS LOW gage indicates 50 ±5 psi.	Ignition monitor valve CONTROL port is pressurized.

gA. Open HYD HI-FLOW SHUTOFF valve (1A2).

Procedure	Result
h. Open HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi. Maintain this pressure for 5 minutes minimum while performing step i.	Hydraulic control system is pressurized.

i. Monitor and record hydraulic fluid leakage at:

Procedure	Result
(1) Ignition monitor valve ATMOS REF port.	5 cc/m maximum
(2) Engine control valve OVERRIDE port.	5 cc/m maximum
(3) Redundant shutdown valve DRAIN port.	2 cc/m maximum

j. Verify that hydraulic fluid has circulated for a minimum of 15 minutes to remove entrapped air from hydraulic control system before proceeding with test.

Procedure	Result
k. Move FOUR-WAY VALVE switch (1A1) to START position.	Engine control valve start solenoid is energized. NO. 1 CLOSED and NO. 2 CLOSED (2A2), gas generator CLOSE (2A3), and NO. 1 CLOSED and NO. 2 CLOSED (2A6) lights go off. NO. 1 OPEN and NO. 2 OPEN (2A2), and gas generator OPEN (2A3), and NO. 1 OPEN and NO. 2 OPEN (2A6) lights come on.

Procedure	Result
l. Repeat step i.	As specified in step i.
m. Open HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,800 ±50 psi. Maintain this pressure for 5 minutes minimum.	Hydraulic control system pressure is increased.
n. Repeat step i.	As specified in step i.
o. Close HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi.	System pressure decreases and stabilizes.

WARNING

The following procedure energizes the redundant shutdown valve solenoid, which causes the valve housing to heat up. After electrical power has been applied continuously, the valve solenoid case temperature can cause injury to personnel touching the case.

- If the redundant shutdown valve is kept energized for more than 15 minutes, the solenoid temperature increase will cause the valve to actuate slower.

Procedure	Result
p. Press and hold REDUNDANT SHUT-DOWN VALVE switch (1A1)	Redundant shutdown valve is energized.
q. After hydraulic system has been pressurized for a minimum of 2 minutes, monitor and record fluid leakage at redundant shutdown valve DRAIN port.	Leakage past drain port seal must not exceed 2 cc/m.
r. Release REDUNDANT SHUTDOWN VALVE switch (1A1).	Redundant shutdown valve solenoid is de-energized.
s. HOLD FOUR-WAY VALVE switch (1A1) in STOP and monitor OVERRIDE port for leakage; then release switch.	Leakage past OVERRIDE port must not exceed 5 cc/m. NO. 1 OPEN and NO. 2 OPEN (2A2), gas generator OPEN (2A3), and NO. 1 OPEN and NO. 2 OPEN (2A6) lights go off. NO. 1 CLOSED and NO. 2 CLOSED (2A2), gas generator CLOSE (2A3), and NO. 1 CLOSED and NO. 2 CLOSED (2A6) lights come on.

sA. Close HYD HI-FLOW SHUTOFF valve (1A2).

CAUTION

The HYD HI-FLOW SHUTOFF valve must be completely closed before closing the HYD HI-FLOW REG, to prevent damage to pressure reducing valve 19-9023747.

Procedure	Result
t. Close HYD HI-FLOW REG (1A2).	HYD HI-FLOW PRESS gage decreases to zero.
u. Close IMV CONT PRESS REG (2A7) until IMV CONTROL PRESS LOW gage indicates zero.	Ignition monitor valve CONTROL port is depressurized.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

v. Remove plugs, lubricate (Method A) fittings and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne), and install control valve override drain tube between tee and redundant shutdown valve DRAIN port. Torque tube coupling nuts to 135-185 in-lb.

w. Remove pressure test fixture T-5041521; then remove packaging, and install redundant shutdown valve override line as follows:

(1) Install seal plate between line flange and redundant shutdown valve OUT port. Secure line to valve with 4 bolts and washers. Torque bolts to 85-95 in-lb. Safetywire bolts with Inconel lockwire MS20995N.

(2) Connect line to engine control valve OVERRIDE port. Torque coupling nut. During last 1/2 turn prior to seating flare, record maximum torque. Torque must be 50-200 in-lb. Continue to torque coupling nut to 270-340 in-lb above recorded torque.

wA. Open HYD HI-FLOW SHUTOFF valve (1A2).

Procedure	Result
x. Open HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi.	Hydraulic control system is pressurized.

WARNING

The following procedure energizes the redundant shutdown valve solenoid, which causes the valve housing to heat up. After electrical power has been applied continuously, the valve solenoid case temperature can cause injury to personnel touching the case.

CAUTION

If the redundant shutdown valve is kept energized for more than 15 minutes, the solenoid temperature buildup will cause the valve to actuate slower.

Procedure	Result
y. Press and hold REDUNDANT SHUTDOWN VALVE switch (1A1).	Engine control valve OVERRIDE port is pressurized.
z. Monitor redundant shutdown valve override line connection for leakage.	No leakage is allowable.
aa. Open HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,800 ±50 psi.	Hydraulic control system pressure is increased.
ab. Repeat step y.	As specified in step y.
ac. Close HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi.	System pressure decreases and stabilizes.

CAUTION

The following procedure deenergizes the redundant shutdown valve which will cause approximately 25 cc of hydraulic fluid to be expelled from the fuel overboard drain line. Personnel must be kept clear of drain line exit.

Procedure	Result
ad. Release REDUNDANT SHUTDOWN VALVE switch (1A1).	Redundant shutdown valve solenoid is deenergized.

adA. Close HYD HI-FLOW SHUTOFF valve (1A2).

CAUTION

The HYD HI-FLOW SHUTOFF valve must be completely closed before closing the HYD HI-FLOW REG, to prevent damage to pressure reducing valve 19-9023747.

Procedure	Result
adB. Close HYD HI-FLOW REG (1A2).	HYD HI-FLOW PRESS gage (1A2) decreases to zero.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

ae. Remove plugs, lubricate (Method A) fitting and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne), and install ignition monitor valve drain tube. Torque coupling nut to 270-345 in-lb.

af. Complete hydraulic control system leak and function test as outlined in paragraph 3.2.3.8.

3.2.4.3 Checkout Valve Isolation Leak Test.

a. Disconnect hydraulic hose from HYD RETURN port (2A1) and connect to ACT & HYD RETURN LINE port (2A7).

Procedure	Result
b. Open HYD HI-FLOW SHUTOFF valve (1A2). Slowly open HYD HI-FLOW REG until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi. Monitor hydraulic fluid leakage.	Engine hydraulic control system is pressurized. No leakage is allowable.
c. Move MSL AIR F/M SEL valve (1A3) to BYPASS, and open MSL AIR PRESS REG until FUEL PUMP INLET PRESS gage (1A1) indicates 80 ±5 psi; then move MSL AIR F/M SEL valve (1A3) to HIGH.	Fuel feed system is pressurized, and flowrate is indicated on MISSILE AIR FLOW HIGH flowmeter (1A3).

d. Wait until flow of MISSILE AIR FLOW HIGH has stabilized for at least 2 minutes, then measure total fuel feed system leakage. Record results. Use results to compute leakage past gas generator fuel feed system and fuel valves skirt and nose seal.

Procedure	Result
e. Close MSL AIR PRESS REG (1A3), and move MSL AIR F/M SEL valve to BYPASS.	Flow through MISSILE AIR FLOW flowmeter (1A3) decreases to zero.
f. Slowly open FUEL PUMP BLEED valve (MANIFOLD BLEED PANEL).	FUEL PUMP INLET PRESS gage (1A4) decreases to zero.

fA. Close HYD HI-FLOW SHUTOFF valve (1A2).

CAUTION

The HYD HI-FLOW SHUTOFF valve must be completely closed before closing the HYD HI-FLOW REG, to prevent damage to pressure reducing valve 19-9023747.

Procedure	Result
g. Close HYD HI-FLOW REG (1A2).	HYD HI-FLOW PRESS gage (1A2) decreases to zero.

h. Complete fuel feed system leak-test procedure as outlined in paragraph 3.2.3.12.

3.2.4.4 Gas Generator Fuel Feed System Isolation Leak Test.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Remove gas generator ball valve shaft fuel seal vent tube connected to banjo fitting on actuator housing.

CAUTION

The orifice plate removed in the following procedure is calibrated and must be protected from contamination and damage.

b. Remove attaching hardware that secures gas generator fuel duct to No. 2 fuel high-pressure duct, and remove orifice plate. Retain orifice plate for reinstallation. Retain attaching hardware for reinstallation if acceptable for reuse in accordance with requirements of section II.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

c. Install gas generator fuel feed duct test plate 9025270, or equivalent, between fuel duct and No. 2 fuel high-pressure duct. Lubricate (Method J) plate O-rings with lubricant grease RB0140-012 (Rocketdyne). Torque plate fasteners to 270-290 in-lb.

d. Remove plug from fuel duct port GF1, and install gas generator fuel feed duct adapter 9025271 in port. Lubricate (Method J) adapter packing and (Method A) threads of union with lubricant grease RB0140-012 (Rocketdyne). Torque union nut to 75-100 in-lb.

e. Connect a fuel hose between adapter and FUEL BS LINE port (2A3).

Procedure	Result
f. Open HYD HI-FLOW SHUTOFF valve (1A2), and slowly open HYD HI-FLOW REG until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi.	Engine hydraulic control system is pressurized.
g. Open FREON TO FUEL BS shutoff valve (2A3) until LOW pressure gage (2A4) pointer starts to move. Close valve.	Refrigerant, Type 12 enters gas generator fuel feed system.
h. Move F/M SEL valve (2A3) to BYPASS. Slowly open FUEL BS REG LOW (2A3) until LOW pressure gage (2A4) indicates 80 ±5 psi. Move F/M SEL valve to HIGH.	Gas generator fuel feed system is pressurized and LOW pressure gage (2A4) indicates 80 ±5 psi.

Procedure	Result
i. Using Halogen Leak Detector 5797934-G1 (General Electric), or equivalent, monitor leakage at all joints and fittings of fuel duct and fuel side of gas generator ball valve.	No leakage is allowable.
j. Using Pneumatic Flow Tester G3104, or equivalent, measure and record gas generator ball valve fuel shaft seal leakage at gas generator ball valve fuel vent port.	Maximum allowable leakage is 0.25 scim.
k. Verify that flow on FUEL B.S. LKG HIGH flowmeter (2A3) has stabilized for a minimum of 2 minutes; then record gas generator fuel ball seal leakage.	Maximum allowable leakage is 20 scim.
l. Move F/M SEL valve (2A3) to BYPASS.	Flow through FUEL B.S. LKG HIGH flowmeter decreases to zero.
m. Close FUEL BS REG LOW (2A3).	
n. Slowly open bleed (FUEL B.S. BLEED panel). Close valve after pressure decay.	LOW pressure gage (2A4) decreases to zero.
nA. Close HYD HI-FLOW SHUTOFF valve (1A2).	

CAUTION

The HYD HI-FLOW SHUTOFF valve must be completely closed before closing the HYD HI-FLOW REG, to prevent damage to pressure reducing valve 19-9023747.

Procedure	Result
o. Close HYD HI-FLOW REG (1A2).	HYD HI-FLOW PRESS gage (1A2) decreases to zero.

p. Disconnect gas generator fuel duct, remove plate 9025270, and reinstall fuel orifice and fuel duct on No. 2 fuel high-pressure duct. Verify that orifice installed is the same one as removed in step b. Torque bolts to 270-290 in-lb.

q. Remove fuel hose from adapter 9025271 and FUEL B.S. LINE port.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

r. Remove adapter from fuel duct port GF1. Remove plug and packing from packaging; then install plug removed in step d in port GF1. Lubricate (Method J) packing and (Method A) threads of plug with lubricant grease RB0140-012 (Rocketdyne). Torque plug to 40-65 in-lb. Safetywire plug with Inconel lockwire MS20995N.

rA. Remove plugs, lubricate (Method A) fittings and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne). and install gas generator ball valve shaft fuel seal vent tube removed in step a. Torque tube coupling nuts to 135-185 in-lb.

s. Secure system as outlined in paragraph 3.2.3.12.

3.2.4.5 Fuel Valves Skirt and Nose Seal Isolation Leak Test.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Remove No. 1 fuel high-pressure duct as outlined in R-3896-3.

b. Install fuel valve inlet test plate 9020155 on No. 1 fuel valve inlet. Torque test plate fasteners to 1,040-1,210 in-lb.

c. Connect a fuel hose between test plate and FUEL B.S. LINE port (2A3).

Procedure	Result
d. Open HYD HI-FLOW SHUTOFF valve (1A2) and HYD HI-FLOW REG until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi.	Engine hydraulic control system is pressurized.
e. Move F/M SEL valve (2A3) to BYPASS.	
f. Slowly open FUEL BS REG LOW (2A3) until pressure gage (2A4) indicates 80 ±5 psi.	No. 1 fuel valve is pressurized.

Procedure	Result
g. Move F/M SEL valve (2A3) to HIGH. Measure and record stabilized flow on FUEL B.S. LKG HIGH flowmeter.	Leakage past No. 1 fuel valve skirt and nose seal must not exceed 15 scim.
h. Subtract leakage in step g from leakage in fuel feed system leak test, paragraph 3.2.3.12, step aj. Record results.	Leakage past No. 2 fuel valve skirt and nose seal must not exceed 15 scim.
i. Close FUEL BS REG LOW (2A3), and move F/M SEL valve to BYPASS.	Flow through FUEL B.S. LKG HIGH flowmeter (2A3) decreases to zero.
j. Open bleed valve on FUEL B.S. BLEED panel; close valve after pressure decay.	LOW pressure gage (2A4) decreases to zero.

jA. Close HYD HI-FLOW SHUTOFF valve (1A2).

CAUTION

The HYD HI-FLOW SHUTOFF valve must be completely closed before closing the HYD HI-FLOW REG, to prevent damage to pressure reducing valve 19-9023747.

Procedure	Result
k. Close HYD HI-FLOW REG (1A2).	HYD HI-FLOW PRESS gage (1A2) decreases to zero.

l. Remove fuel valve inlet test plate 9020155 from No. 1 fuel valve inlet, and install No. 1 fuel high-pressure duct as outlined in R-3896-3.

m. Secure system as outlined in paragraph 3.2.3.12.

3.2.4.6 Gas Generator LOX Feed System Isolation Leak Test. When a flowtester is specified in this procedure, Pneumatic Flow Tester G3104, or equivalent, must be used.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Disconnect ball valve shaft oxidizer seal vent tube from banjo fitting on gas generator ball valve oxidizer vent port.

NOTE

The orifice plate removed in the following procedure is calibrated and must be protected from contamination and damage.

b. Remove attaching hardware that secures gas generator oxidizer duct (duct end) to No. 2 oxidizer high-pressure duct, and remove 2 seals and orifice plate. Retain attaching hardware for reinstallation, if acceptable for reuse in accordance with requirement of section II. Maintain orifice plate in an oxidizer-clean condition.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

c. Install gas generator oxidizer feed duct test plate 9025266, or equivalent, between gas generator oxidizer duct (duct end) and No. 2 oxidizer high-pressure duct. Lubricate (Method J) plate O-rings with lubricant grease RB0140-012 (Rocketdyne). Torque plate fasteners to 120-130 in-lb.

d. Remove plug from port GO1a on gas generator oxidizer duct (valve end). Lubricate (Method J) adapter packing and (Method A) threads of union with lubricant grease RB0140-012 (Rocketdyne) and install gas generator oxidizer feed duct adapter 9025267, or equivalent, in the port. Torque union nut to 75-100 in-lb.

e. Connect an oxidizer hose between adapter and LOX B. S. LINE port (2A1).

Procedure	Result
f. Open HYD HI-FLOW SHUTOFF VALVE (1A2). Slowly open HYD HI-FLOW REG until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi.	Engine hydraulic control system is pressurized.
g. Open FREON TO LOX B.S. shutoff valve (2A1) until LOW pressure gage (2A8) pointer starts to move; then close valve.	Refrigerant, Type 12 enters gas generator LOX feed system.
h. Move FLOWMETER SEL valve (2A1) to BYPASS. Slowly open L. C. AIR LOW PRESS REG (2A1) until LOW pressure gage (2A8) indicates 80 ±5 psi. Move FLOWMETER SEL valve to LOW.	Gas generator LOX feed system is pressurized, and LOW pressure gage (2A8) indicates 80 ±5 psi.

Procedure	Result
i. Using Halogen Leak Detector 5797934-G1 (General Electric), or equivalent, monitor leakage at all joints and fittings of LOX feed system and oxidizer side of gas generator ball valve.	No leakage is allowable.
j. Using flowtester, measure combined leakage past the gas generator ball valve oxidizer shaft seal (ball side) and the oxidizer to actuator housing seal at VENT port. Record leakage.	Maximum allowable leakage is 10 scim.

k. Verify that flow on LOX B.S. LEAKAGE LOW PRESS flowmeter (2A1) has stabilized for a minimum of 2 minutes; then record total gas generator oxidizer feed system leakage.

Procedure	Result
l. Subtract leakage recorded in step j from leakage recorded in step k. Record calculated leakage.	Maximum allowable calculated leakage past oxidizer ball seal is 10 scim.
m. Move FLOWMETER SEL valve (2A1) to BYPASS.	Flow through LOX B.S. LEAKAGE LOW PRESS flowmeter (2A1) decreases to zero.

n. Close L.C. AIR LOW PRESS REG (2A1).

Procedure	Result
o. Slowly open bleed valve (LOX B.S. BLEED panel). Close valve after pressure decay.	LOW pressure gages (2A8) decrease to zero.

oA. Close HYD HI-FLOW SHUTOFF valve (1A2).

CAUTION

The HYD HI-FLOW SHUTOFF valve must be completely closed before closing the HYD HI-FLOW REG, to prevent damage to pressure reducing valve 19-9023747.

Procedure	Result
p. Close HYD HI-FLOW REG (1A2).	HYD HI-FLOW PRESS gage (1A2) decreases to zero.

q. Disconnect gas generator oxidizer duct (duct end) from No. 2 oxidizer duct, and remove adapter 9025266.

r. Remove packaging and verify that orifice plate is the same as orifice plate removed in step b; then install orifice plate and 2 seals between duct flanges; torque fasteners to 120-130 in-lb.

s. Disconnect oxidizer hose from between adapter and LOX B.S. LINE port (2A1).

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

t. Remove adapter 9025267 from port GO1a on gas generator oxidizer duct (valve end), and install plug removed in step d. Lubricate (Method J) packing and (Method A) threads of plug with lubricant grease RB0140-012 (Rocketdyne). Torque plug to 40-80 in-lb. Safetywire plug with Inconel lockwire MS20995N.

u. Remove plug, lubricate (Method A) banjo fitting threads and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne), and connect ball valve shaft oxidizer seal vent tube to banjo fitting on gas generator ball valve oxidizer vent port. Torque tube coupling nut to 135-185 in-lb.

v. Secure system as outlined in paragraph 3.2.3.13.

3.2.4.7 Oxidizer Valves Skirt and Nose Seal Isolation Leak Test. This test is performed only if required by the LOX feed system leak test (paragraph 3.2.3.13).

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Remove No. 1 oxidizer high-pressure duct from engine as outlined in R-3896-3.

b. Install oxidizer valve inlet test plate 9020156 on oxidizer valve inlet. Torque test plate fasteners to 1,040-1,210 in-lb.

c. Remove oxidizer hose from adapter 9020163 on oxidizer pump inlet. Connect hose to adapter 9020156. Pressure cap open port on adapter 9020163.

cA. Open HYD HI-FLOW SHUTOFF valve (1A2).

Procedure	Result
d. Open HYD HI-FLOW REG (1A2) until HYD HI-FLOW PRESS gage indicates 1,550 ±50 psi.	Engine hydraulic control system is pressurized.

e. Move L.C. AIR F/M SEL valve (1A3) to BYPASS.

NOTE

In the following procedure, if leakage is less than 30 scim on LOX CLEAN AIR FLOW flowmeter (1A3), Pneumatic Flow Monitor G3131 may be used.

Procedure	Result
f. Slowly open L.C. AIR PRESS REG (1A3) until LOX PUMP INLET PRESS gage (1A4) indicates 80 ±5 psi. Move L.C. AIR F/M SEL valve (1A3) to HIGH. Measure and record stabilized flow on LOX CLEAN AIR FLOW flowmeter (1A3).	Leakage past No. 1 oxidizer valve skirt and nose seal and actuator rod oxidizer seal is indicated.
g. Subtract leakage in LOX feed system leak test (paragraph 3.2.3.13, step k) for No. 1 valve from leakage in step f.	Leakage past No. 1 oxidizer valve skirt and nose seal must not exceed 56 scim.
h. Subtract leakage in step f plus leakage in LOX feed system leak test (paragraph 3.2.3.13, step k) for No. 2 valve from calculated skirt and nose seal leakage (paragraph 3.2.3.13, step z).	Leakage past No. 2 oxidizer valve skirt and nose seal must not exceed 56 scim.
i. Close L.C. AIR PRESS REG (1A3), and move L.C. AIR F/M SEL valve to BYPASS.	LOX CLEAN AIR FLOW HIGH flowmeter (1A3) decreases to zero.
j. Open LOX PUMP BLEED valve (on MANIFOLD BLEED PANEL). Close valve after pressure decay.	LOX PUMP INLET PRESS gage (1A4) decreases to zero.

jA. Close HYD HI-FLOW SHUTOFF valve (1A2).

CAUTION

The HYD HI-FLOW SHUTOFF valve must be completely closed before closing the HYD HI-FLOW REG, to prevent damage to pressure reducing valve 19-9023747.

Procedure	Result
k. Close HYD HI-FLOW REG (1A2).	HYD HI-FLOW PRESS gage (1A2) decreases to zero.

l. Remove oxidizer hose and adapter.

m. Reinstall No. 1 oxidizer high-pressure duct as outlined in R-3896-3.

n. Secure system as outlined in paragraph 3.2.3.13.

3.2.4.8 <u>Oxidizer Dome Purge Check Valve Isolation Leak Test.</u>

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Remove clamp that secures No. 2 oxidizer dome purge line to support bracket. Retain attaching hardware for reinstallation, if acceptable for reuse in accordance with requirements outlined in section II.

b. Remove attaching hardware that secures No. 2 oxidizer dome purge line to No. 2 oxidizer dome purge check valve, and carefully remove orifice plate. Retain attaching hardware for reinstallation, if acceptable for reuse in accordance with requirements of section II.

Procedure	Result
c. Using Pneumatic Flow Tester G3104, measure reverse-flow leakage of No. 2 oxidizer dome purge check valve at check valve to line interface.	Maximum allowable leakage is 10 scim.

d. If leakage in step c is more than 10 scim, replace No. 2 oxidizer dome purge check valve as outlined in R-3896-3.

e. Subtract leakage obtained in step c for No. 2 oxidizer dome purge check valve gate from leakage obtained in thrust chamber pneumatic leak test (paragraph 3.2.3.17, step p) to obtain leakage for No. 1 oxidizer dome purge check valve gate. If leakage of No. 1 oxidizer dome purge check valve gate is more than 10 scim, replace No. 1 oxidizer dome purge check valve gate as outlined in R-3896-3.

f through h. (Deleted)

i. Remove packaging and install No. 2 oxidizer valve dome purge line as follows:

(1) Verify alinement of line as outlined in R-3896-3.

(2) Install same orifice plate as removed between line and oxidizer dome purge check valve. Secure line to valve with 4 bolts and washers. Torque bolts to 33-39 in-lb. Safety-wire bolts with Inconel lockwire MS20995N.

j. Continue test in paragraph 3.2.3.17.

3.3 INSTALLED-ENGINE TEST PROCEDURES.

NOTE

Section II must be referred to for requirements of purge systems specified in steps of leak and function test procedures for installed engines unless otherwise specified.

3.3.1 ELECTRICAL TESTS FOR INSTALLED ENGINES. (See figures 3-3 through 3-5.)

3.3.1.1 Flight Instrumentation System Function Test. Test instrumentation used to perform the flight instrumentation system function test activity is provided by the Stage Contractor. The test activity when complemented by criteria referenced in section II requires no additional instructions; therefore, no recommendations are provided for the method of accomplishing this activity.

3.3.1.2. Turbopump Heater Function Test.

a. Provide instrumentation to monitor turbopump heater thermostat cycling as indicated by No. 1 bearing temperature transducer at instrumentation tap LS1.

Procedure	Result
b. Provide 190-220 vac to each turbopump heater element (J800, pins C and D, for No. 1 heater and pins E and F for No. 2 heater). Monitor and record current drain of each heater element.	Current drain must be within 7.5 ±2.5 amperes for each heater element.

NOTE

If ambient temperature is above 85° F, the heater may not cycle. Thermostats can be cooled with a spray refrigerant, Type 12 (Federal Specification BB-F-1421) applied in short bursts directly on the thermostat.

c. Allow bearing heaters to cycle 3 times. Record minimum and maximum bearing temperature.	Thermostats must pick up and drop out at a No. 1 bearing temperature of between 65° and 180° F as indicated at instrumentation tap LS1.

d. Remove ac power supply to each heater element.

e. Secure turbopump bearing heater current drain and temperature instrumentation.

3.3.1.3 Hypergol Installed Switch Function Test.

a. Provide equipment to supply and monitor 28 ±4 vdc to hypergol cartridge switch (J19, pins B and C, at engine interface).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Remove pin and closure from hypergol manifold cartridge inlet port.

WARNING

The following procedure uses dry-cleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

c. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680). Lubricate (Method A)threads with lubricant grease RB0140-012 (Rocketdyne).

CAUTION

When installing the hypergol system test tool into the hypergol manifold cartridge container inlet port, extreme care must be used to prevent damage to the hypergol cartridge follower

- The threads of the test tool cap must be clean and free of nicks to prevent galling the threads of the cap and inlet port.

d. Make sure that threads of test-tool cap are clean and free of nicks; then lubricate (Method L) cap packing with FS1281 grease (Dow Corning Corp) and carefully insert hypergol system test tool 9021279, or equivalent, into hypergol manifold cartridge container inlet port, and screw cap (clockwise) onto inlet port until cap bottoms.

e. Supply 24-30 vdc to J19, pin B. Monitor J19, pin C, for zero voltage.

f. Depress and hold lever of test tool monitor J19, pin C, for presence of 24-30 vdc.

g. Release lever. Monitor J19, pin C, for zero voltage.

h. Remove dc voltage from J19, pin B.

i. Remove hypergol system test tool.

WARNING

The following procedure uses dry-cleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

j. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680).

k. Remove packaging from hypergol manifold cartridge container inlet port closure. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp). Install closure and secure with attaching pin.

3.3.1.4 Checkout Valve Timing Test.

a. Provide instrumentation to monitor position indicators of engine checkout valve (J-18, pin r, engine return position output, and pin s, ground return position output, at engine interface).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Connect a drain hose between quick-disconnect on checkout valve return hose and a facility drain.

CAUTION

To prevent fluid flow into the engine propellant fuel system, hydraulic fluid must not be supplied to the engine hydraulic ground supply interface during this test.

Procedure	Result
c. Supply 24-30 vdc to J18, pins p (+) and t (-) at engine interface, and cycle checkout valve from ground position to engine position, and record its travel time.	Travel time is 0.5 to 3.5 seconds.
d. Supply 24-30 vdc to J18, pins q (+) and t (-) at engine interface, and cycle checkout valve from engine position to ground position, and record its travel time.	Travel time is 0.5 to 3.5 seconds.

e. Repeat steps c and d 2 additional times.

f. Remove dc voltage from J18, pin q.

g. Turn off instrumentation.

h. Remove drain hose (installed in step b) from quick-disconnect. Remove pressure cap from packaging, and install pressure cap on quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

3.3.1.5 Safety Circuits Function Test. Verify functionally or electrically that cutoff by safety circuits or red lines (listed in section II) is attained when a malfunction occurs. Refer to section II for detail requirements.

3.3.1.6 Engine Sequence Verification Test.

a. Remove protective closures from overboard drain lines and thrust chamber throat.

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Verify that stage pre-valves are closed; then vent the fuel feed system between pre-valves and engine fuel valves during this test by installing drain hoses on No. 1 and No. 2 fuel high-pressure duct drain quick-disconnects.

bA. Remove pressure cap from, and attach a drain hose to, the following quick-disconnects:

(1) Checkout valve engine return hose

CAUTION

In the following procedure, during removal of the gas generator ball valve fuel inlet quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn since a torque decrease between quick-disconnect body and adapter or adapter and gas generator ball valve fuel housing can result in seal leakage.

(2) Gas generator ball valve fuel inlet drain

c. Remove electrical connector from engine checkout valve actuator.

d. Simulate that gas generator and nozzle extension igniters are installed.

e. Remove pin and closure from hypergol manifold cartridge container inlet port.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

f. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680). Lubricate (Method A) threads with lubricant grease RB0140-012 (Rocketdyne).

CAUTION

When installing the hypergol system test tool into the hypergol manifold cartridge container inlet port, extreme care must be used to prevent damage to the hypergol cartridge follower.

- The threads of the test tool cap must be clean and free of nicks to prevent galling the threads of the cap and inlet port.

g. Make sure that threads of test-tool cap are clean and free of nicks; then lubricate (Method L) cap packing with FS1281 grease (Dow Corning Corp); and carefully insert hypergol system test tool 9021279, or equivalent, into hypergol manifold cartridge container inlet port, and screw cap (clockwise) onto inlet port until cap bottoms.

h. Simulate that hypergol cartridge is installed by depressing handle of test tool 9021279, or equivalent.

i. Remove pressure cap from and connect a gaseous nitrogen supply (MIL-P-27401) to ignition monitor valve CONTROL port quick-disconnect.

j. Turn on turbopump LOX seal purge.

Procedure	Result
k. Pressurize engine hydraulic control system to provide hydraulic fluid at 1,550 ±50 psig.	Engine hydraulic control system is pressurized.

l. Provide instrumentation for monitoring and engine propellant valves, engine control valve, redundant shutdown valve, checkout valve, and hypergol installed switch. (See figures 3-3 and 3-4.)

m. Simulate or turn on operational low-level LOX dome and gas generator LOX injector purge.

NOTE

Simulate is defined as placement of purge control valves in a position that will allow the sequencing required with purge control pressure at zero psig.

n. Simulate that engine checkout valve travels to engine position.

o. Momentarily supply 500-750 vac to each gas generator and each nozzle extension igniter simulator; then verify igniter firing voltage presence at each igniter simulator.

p. Supply 24-30 vdc to engine control valve start solenoid (J-18, pins n (+) and m (-) at engine interface). Record oxidizer valve and gas generator ball valve opening times and sequence times from engine control valve start signal.

q. Simulate hypergol burst by releasing plunger of hypergol test tool, or equivalent. Verify that hypergol installed switch is de-energized.

r. Supply gaseous nitrogen (MIL-P-27401) at 50 ±10 psig to ignition monitor valve CONTROL port. Record fuel valve opening times.

s. Supply gaseous nitrogen (MIL-P-27401) at 1,240 ±30 psig to thrust OK pressure switch checkout connection. Verify No. 1, No. 2, and No. 3 switch pickup.

t. Remove dc voltage from J-18, pin n, and supply 24-30 vdc to engine control valve stop solenoid (J-18, pin g (+) and k (-) and redundant shutdown valve solenoid (J-19, pins D (+) and L (-) at engine interface). Record fuel valves, gas generator ball valve, and oxidizer valve closing times.

u. Record time delay from engine control valve stop solenoid signal to valve movement.

v. Remove dc voltage from J-18 and J-19.

w. Vent gaseous nitrogen supply pressure from thrust OK pressure switch checkout supply system. Verify No. 1, No. 2, and No. 3 pressure switch dropout (J-20, pins E and F; J-142, pins A and B; and J-174, pins A and B).

x. Decrease gaseous nitrogen supply pressure to ignition monitor valve CONTROL port to zero, and remove nitrogen supply line. Remove pressure cap from packaging and, install pressure cap on CONTROL port quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

y. Depressurize engine hydraulic control system.

z. Turn off turbopump LOX seal purge.

aa. Turn off operational low-level LOX dome and gas generator LOX injector purge.

ab. Remove hypergol system test tool.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

ac. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680).

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

ad. Remove packaging from hypergol manifold cartridge container inlet port closure. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp). Install closure and secure with attaching pin.

ae. Reinstall overboard drain covers and thrust chamber throat security closure (paragraph 3.6.13).

af. Reinstall engine electrical connector to engine checkout valve actuator. Refer to R-3896-3 for installation method of electrical connectors. Torque connector to 60-68 in-lb. Safetywire connector with Inconel lockwire MS20995N.

ag. Remove drain hoses installed in steps b and bA. Remove pressure caps from packaging, and install pressure caps, except for gas generator ball valve fuel inlet drain, on quick-disconnects. Torque pressure caps to 30-40 ft-lb.

ah. Lubricate (Method A) threads of gas generator ball valve fuel inlet drain quick-disconnect with lubricant grease RB0140-012 (Rocketdyne) or FS1281 grease (Dow Corning Corp), and install pressure cap. Torque pressure cap to 210-230 in-lb.

ai. Safetywire all quick-disconnect pressure caps with Inconel lockwire MS20995N.

3.3.1.7 Igniter Test.

WARNING

A shorting or shielding cap must be installed on igniters at all times except during testing or igniter harness connection, to prevent accidental firing resulting in injury to personnel and damage to equipment.

NOTE

A shielding cap must be used on igniters at KSC during igniter installation and until igniter harness is connected.

a. Observe all safety precautions; wear protective clothing specified in section II.

b. Check that 6 months have not passed since igniter was removed from container. Igniter must be tagged with date of opening of hermetically sealed container.

c. Visually inspect igniter, and reject igniter if any of the following conditions exist:

(1) Igniter closure damaged

(2) Receptacle threads damaged

(3) Receptacle pins bent or loose

(4) Gasket or gasket seating surfaces nicked or scratched

(5) Overage (2 years maximum)

d. Using High-Voltage Igniter Tester G3153, or equivalent, perform a current and resistance test as outlined in steps e through j.

WARNING

The igniter must be in a vented, closed metal container or behind a protective shield during the current and resistance test to prevent injury to personnel during accidental firing of the igniter.

NOTE

Prior to the test, verification must be made that the tester has been calibrated according to the instruction plate on the tester. The igniter and tester connector ends must be dry when the igniter is tested.

Procedure	Result
e. Set tester to NO FIRE TEST position to check squib circuit (pins B to D) at 250 volts.	Meter indicates less than one milliampere.
f. Select FIRE TEST position to check squib circuit (pins B to D) at 500 volts.	Meter indicates 3.5 to 8 milliamperes.
g. Select 1 INSULATION TEST position to check pin D to shell.	Meter indicates 100 megohms minimum.

Procedure	Result
h. Select 2 position (link) to check pin C to shell.	Meter indicates 100 megohms minimum.
i. Select 3 position (link to squib) to check pin B to A.	Meter indicates 100 megohms minimum.
j. Select LINK position to check pin A to C.	Meter indicates in green area.

NOTE

To prevent overexposure of squib and diode to checkout current in the FIRE TEST position, the tester incorporates a delay timer circuit. Before rejecting an igniter, repeat steps d through j.

3.3.1.8 Inert Igniter Test.

a. Visually inspect inert igniter, and reject inert igniter if any of the following conditions exist:

(1) Igniter closure damaged

(2) Receptacle threads damaged

(3) Receptacle pins bent or loose

(4) Gasket or gasket sealing surfaces nicked or scratched

aA. Remove shorting or shielding cap and connect inert igniter to High-Voltage Igniter Tester G3153, or equivalent.

NOTE

A shielding cap must be used on igniters at KSC during igniter installation and until igniter harness is connected.

Procedure	Result
b. Turn TEST SELECT switch to NO FIRE TEST position, and press POWER and TEST switches.	POWER light comes on and FIRE/NO FIRE TEST meter indicates less than on milliampere.
c. Turn TEST SELECT switch to FIRE TEST position, and press POWER and TEST switches.	POWER light comes on and FIRE/NO FIRE TEST meter indicates less than one milliampere.
d. Turn TEST SELECT switch to 1 INSULATION TEST position, and press POWER and TEST switches.	POWER light comes on, and INSULATION/LINK TEST meter indicates 100 megohms or greater (black area).
e. Turn TEST SELECT switch to 2 position, and press POWER and TEST switches.	POWER light comes on, and INSULATION/LINK TEST meter indicates 100 megohms or greater (black area).
f. Turn TEST SELECT switch to 3 position, and press POWER and TEST switches.	POWER light comes on, and INSULATION/LINK TEST meter indicates 100 megohms or greater (black area).
g. Move TEST SELECT switch to LINK position, and press POWER and TEST switches.	POWER light comes on, and INSULATION/LINK TEST meter indicator moves to green area.

h. Move TEST select switch to OFF position, disconnect tester from inert igniter, and secure test equipment.

i. Using megohmmeter, apply 500 vdc for 5-60 seconds between pin B and case, and pins A and D. Resistance of each application must exceed 200 megohms.

3.3.1.9 Vibration Safety Cutoff Verification Test. To prepare the vibration safety cutoff (VSC) for operation, a preoperation cutoff test and a preoperation tap test of the vibration safety cutoff set must be performed. The cutoff test verifies the specific settings at which the vibration safety cutoff operates during an engine static test. During the cutoff test, if the accelerometer attenuator dial setting and the sensitivity dial setting variations become greater than 5 percent of the established recorded settings, the test must be terminated and the VSC unit removed and replaced with a calibrated unit. The defective unit must be assigned for repair.

CAUTION

In the following procedure, torque must not exceed 20 in-lb or the accelerometer may be twisted off. The accelerometer cable must be disconnected (if attached) prior to installation of the accelerometer, to prevent possible twisting. The accelerometer is a sensitive instrument that can be damaged by rough treatment, such as dropping, sharp blows, or overtorquing.

a. Verify that accelerometers are acceptable for use; then install accelerometers in taps CZA1-Y, CZA10-Y, and CZA4-Y. Torque accelerometers to 16-20 in-lb.

aA. Verify that accelerometer electrical thread protectors are installed until ready to connect accelermeter cable.

b. Connect and secure accelermeter cable. Do not secure accelerometer cable to cryogenic lines or surfaces. Verify that cable is not twisted or damaged.

NOTE

An improperly secured accelerometer cable may cause hammering signals to be transferred to the VSC system.

- Steps c through o outline the procedure for performing a preoperation cutoff test if one or two VSC systems are used. If two are used, the steps must be repeated on each VSC unit. Proceed to step p if three VSC systems are used.

c. Actuate isolation amplifier and cutoff unit power switches to ON, and allow 15 minutes for temperature stabilization.

d. Actuate cutoff unit DISABLE-ARM switch to ARM position. ARM light comes on.

e. Disconnect accelerometer cable from isolator amplifier input connector.

f. Connect signal generator and an ac voltmeter (with a minimum range of 0.10 to 3.00 volts rms, a minimum accuracy of 2 percent, and a minimum input impedance of one megohm) to isolation amplifier input connector. Set signal generator output frequency at 2,000 ±20 cps and output voltage to less than 0.25 volt rms.

g. Slowly increase signal generator output voltage until CUTOFF light comes on and ARM light goes off on VIBRATION SAFETY CUTOFF panel.

h. Voltage reading must be within 5 percent of V_1 value recorded on VSC-unit check form. If voltage reading is not as required, recalibrate VSC system as outlined in J-2 Rocket Engine Ground Support Equipment Maintenance and Repair Manual R-3825-5. The following equation may be used for computing input voltage to the isolation amplifier using accelerometer charge sensitivity data:

$$V_1 = \frac{1{,}000\ Q}{CA + Ct}\ Gc$$

V_1 = Voltage sensitivity at amplifier input in millivolts/g

Q = Charge sensitivity in picocoulomb/g (average of 5 charge sensitivities obtained from the General Electric Calibration-Maintenance Report)

Ca = Accelerometer capacitance in picofarads (obtained from the General Electricl Calibration-Maintenance Report)

Ct = Total external capacitance in picofarads (measured line capacitance plus amplifier input capacitance)

Gc = Desired g-level for cutoff

g = Gravitational constant

NOTE

The V_1 value was calculated and recorded during VSC-unit installation and checkout.

- **The recommended cutoff level is 100g rms with delay time of 45-75 milliseconds and a minimum storage time of 216 milliseconds.**

i. Verify cutoff outputs from VSC unit to test stand electrical system for engine cutoff.

j. Verify that event recorder indicates cutoff.

k. Decrease signal generator output voltage to less than 0.25 volt rms.

l. Momentarily actuate test stand VSC reset circuit. CUTOFF light goes off, and ARM light comes on.

m. Deenergize signal generator, and disconnect signal generator and ac voltmeter from isolation amplifier.

n. Reconnect accelerometer cable to isolation amplifier input connector. Momentarily depress RESET switch until CUTOFF light goes off and ARM light comes on.

o. Proceed to step an, and perform preoperation tap test.

NOTE

Steps p through am outline the procedure for performing a preoperation cutoff test of the ternary VSC system.

p. Actuate power switches on isolation amplifier and cutoff unit to ON, and allow 15 minutes for temperature stabilization.

q. Actuate cutoff unit DISABLE-ARM switch to ARM position. ARM light comes on.

r. Disconnect accelerometer cable from isolation amplifier input connector.

s. Connect signal generator and ac voltmeter (with a minimum range of 0.10 to 3.00 volts rms, a minimum accuracy of 2 percent, and a minimum input impedance of one megohm) to isolation amplifier input connector. Set signal generator output frequency at 2,000 ±20 cps and output voltage to less than 0.25 volt rms.

t. Slowly increase signal generator output voltage until CUTOFF light comes on and ARM light goes off on VIBRATION SAFETY CUTOFF panel.

u. Voltage reading must be within 5 percent of V_1 value recorded on VSC-unit check form. If this voltage reading is not as required, recalibrate VSC system as outlined in J-2 Rocket Engine Ground Support Equipment Maintenance and Repair Manual R-3825-5.

v. Verify that no cutoff signal was supplied from VSC unit to test stand electrical system. Event recorder indicates cutoff.

w. Decrease signal generator voltage to less than 0.25 volt rms.

x. Actuate VSC-unit RESET switch. CUTOFF light goes off, and ARM light comes on. Event recorder does not indicate cutoff.

y. Deenergize signal generator, and disconnect signal generator and ac voltmeter from isolation amplifier.

z. Repeat steps g through y on remaining 2 VSC systems. Results must be the same.

aa. Connect signal generator to isolation amplifier input connector of VSC units No. 1 and No. 2 using a T-connector.

ab. Verify that signal generator output voltage is set to below 0.25 volt rms.

ac. Slowly increase signal generator output voltage until an engine cutoff signal is received by test stand electrical system. CUTOFF light comes on and ARM light goes off on both VIBRATION SAFETY CUTOFF panels. Both event recorders indicate cutoff.

ad. Decrease signal generator output voltage to less than 0.25 volt rms.

ae. Momentarily actuate test stand VSC reset circuit. Both CUTOFF lights go off, and both ARM lights come on. Both event recorders do not indicate cutoff.

af. Deenergize signal generator and disconnect from VSC units No. 1 and No. 2.

ag. Connect signal generator to isolation amplifier input connector of VSC units No. 1 and No. 3 using a T-connector.

ah. Repeat steps ab through ae. Results must be the same.

ai. Deenergize signal generator and disconnect from VSC units No. 1 and No. 3.

aj. Connect signal generator to isolation amplifier input connector of VSC units No. 2 and No. 3 using a T-connector.

ak. Repeat steps ab through ae. Results must be the same.

al. Deenergize signal generator and disconnect from VSC units No. 2 and No. 3.

am. Reconnect accelerometer cables. CUTOFF light must be off, and ARM light must be on.

NOTE

Steps an through aq outline the procedure for performing a preoperation tap test. If more than one VSC system is used, the tap test must be performed on each VSC unit.

an. Connect a set of headphones to VSC unit.

ao. Using a brass hammer, tap gently on thrust chamber domes. An audible signal must be received in headphones.

NOTE

The headphone attenuator control on the VSC unit may require adjustment to provide an audible signal in the headphones.

- The VSC set is ready for operation at the conclusion of the tap test. The tap test must be performed before each static test along with the visual verification of the VSC control dial settings. The verniers of the timing and cutoff adjustment controls must be within 5 percent of their original settings.

ap. Visually verify VSC control dial settings. Delay-time control dial must be set at 276. Storage time control dial must be set at zero.

aq. If VSC unit is not to be used immediately, move power switches on isolation amplifier and cutoff unit to OFF. ARM light goes off.

3.3.1.10 Thrust OK Pressure Switch Function Test.

CAUTION

If automatic checkout equipment is used to test the pressure switches pickup and dropout value, pressurization rates must be limited to 50 psig/sec from 0-895 psig and 5 psig/sec from 895-1,200 psig. Depressurization rates must be limited to 5 psig/sec from 1,200-895 psig.

a. Provide instrumentation to monitor each thrust OK pressure switch.

b. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

c. Slowly increase gaseous nitrogen pressure to thrust OK pressure switch connection to 1,240 ±30 psig. Record pneumatic pressure at which each switch actuates.

d. Slowly decrease pressure to thrust OK pressure switch connection to zero. Record pneumatic pressure at which each switch deactuates.

e. Repeat steps c and d 2 additional times. During last 2 actuations, verify that each switch actuates at 1,060 ±65 psig and deactuates at 75 ±25 psig below actual pickup pressure.

f. Vent gaseous nitrogen pressure from engine thrust OK pressure switch checkout supply system.

g. Secure instrumentation used to monitor thrust OK pressure switches.

3.3.1.11 Igniter Harness Continuity and Insulation Resistance Test.

NOTE

If igniter harness continuity is being checked during vehicle checkout at VAB or during launch preparation, omit steps a and b and check engine installed igniter harness pin-to-pin continuity concurrently with vehicle-installed igniter harness continuity check.

a. Disconnect igniter harness plug P47 from receptacle J47, if connected.

b. Using multimeter, check that igniter harness pin-to-pin resistance does not exceed one ohm. Pin list is as follows:

From	To
P47-B	P43-B
P47-D	P43-D
P47-C	P43-A
P47-T	P43-C
P47-U	P44-C
P47-A	P44-A
P47-J	P44-D
P47-F	P44-B
P47-K	P45-B
P47-H	P45-D
P47-M	P45-C
P47-R	P45-A
P47-N	P46-C
P47-G	P46-A
P47-S	P46-B
P47-E	P46-D

c. Proceed to step e if insulation resistance test is not required.

CAUTION

An insulation resistance test must not be performed if the connectors are wet, and voltage must not be applied to interconnected contacts at the same time since a short circuit can result in damage to the equipment.

d. Perform insulation resistance test of harness as follows:

(1) Verify that harness connectors are dry.

(2) Connect pin P47-V to connector shells P43, P44, P45, P46, and P47.

(3) Using megohmmeter, apply 500 vdc for 5-60 seconds between each pin in connector P47 (except for pin V) and shell of connector P47. Resistance must exceed 200 megohms.

(4) Using megohmmeter, apply 500 vdc for 5-60 seconds between each pin and all other pins in connector P47 except pin V. Resistance must exceed 200 megohms.

(5) Disconnect pin P47-V from connector shells P43, P44, P45, P46, and P47.

e. Connect igniter harness plug P47 to receptacle J47, if disconnected, as outlined in R-3896-3.

3.3.2 LEAK AND FUNCTION TESTS FOR INSTALLED ENGINES. (See figures 3-3 through 3-8.)

3.3.2.1 Turbopump Torque Test. This procedure must not be performed when propellants are in the turbopump. Refer to paragraph 3.2.3.1 for turbopump torque test procedure.

3.3.2.2 LOX Pump Seal Purge Leak and Function Test.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Remove protective closures from nitrogen purge and oxidizer overboard drains at thrust chamber exit. When cover is first removed from oxidizer overboard drain line, verify that no evidence of fluid exists. Notify Engine Contractor if fluid exists.

NOTE

The following procedure introduces pressure into the turbopump LOX seal purge system. When pressure is first applied, the oxidizer overboard drain line and nitrogen purge line exits must be observed for evidence of fluid. Notify Engine Contractor if fluid is noted.

b. Turn on turbopump LOX seal purge.

CAUTION

Leak-test compound used in the following procedure must not be used on overboard drain line exits to preclude introducing leak-test compound into the lines.

- Leak-test compound must not be used on flex line bellows since it cannot be removed from the bellows.

Procedure	Result
c. Apply leak-test compound (MIL-L-25567) to all joints and fittings of turbopump LOX seal purge system.	No leakage is allowable.

NOTE

In the following procedure, if leakage is expected in excess of 4,000 scim, to flowtesters must be connected in parallel at each line.

- Step d is omitted at MTF.

Procedure	Result
d. Using Pneumatic Flow Tester G3104, or equivalent, simultaneously measure purge system flowrate at oxidizer and nitrogen overboard drain lines. Record results.	Maximum allowable leakage is 5,000 scim from each drain line. If zero flow exists, perform isolation test (paragraph 3.3.3.1).

NOTE

Step e is omitted at MAF and KSC.

Procedure	Result
e. Verify purge flow at oxidizer and nitrogen overboard drain lines.	If zero leakage exists, perform isolation test (paragraph 3.3.3.1).

f. Turn off turbopump LOX seal purge.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

g. Remove all leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

h. Remove packaging and install protective closures removed in step aA.

3.3.2.3 Cocoon Purge Leak and Function Test.

a. Turn on cocoon purge. Purge pressure at MAF must be 20 ±5 psig. Purge pressure at KSC must be within interface acceptability limits specified in section II.

b. Verify gaseous nitrogen flow through cocoon purge system by audible flow from manifold or by feeling supply line.

CAUTION

In the following procedure, leak-test compound must not be used on purge manifold exits to preclude introducing leak-test compound into the manifold.

Procedure	Result
c. Using leak-test compound (MIL-L-25567), check all joints of cocoon purge system for leakage.	Fuzz leakage (as defined in section II) is allowable at coupling nut and flanged joints.

NOTE

Step d is omitted at MAF.

d. Verify by instrumentation indication that purge temperature at engine interface is within limits of section II.

e. Turn off cocoon purge.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

f. Remove all leak-test compound from joints and fittings with a clean, dry cloth or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.3.2.4 Heat Exchanger Helium System Leak Test.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Provide a pneumatic source of gaseous nitrogen (MIL-P-27401), a mixture of gaseous nitrogen (MIL-P-27401) and refrigerant, Type 12 (Federal Specification BB-F-1421), or helium (Bureau of Mines, Grade A), as specified by requirements of section I, to heat exchanger helium system.

Procedure	Result
b. Pressurize heat exchanger helium system to 200 ±10 psig.	Heat exchanger helium system is pressurized.

c and d. (Deleted)

CAUTION

Leak-test compound must not be used on flex line bellows since it cannot be removed from the bellows.

Procedure	Result
e. Apply leak-test compound (MIL-L-25567) to all flanges, fittings, instrumentation lines, and bellows in heat exchanger helium system.	No leakage is allowable except at joints listed in step eA.
eA. Verify leakage using leak-test compound (MIL-L-25567), or equivalent, when leakage is suspected at the following joints:	Fuzz leakage (as defined in section II) is allowable.

(1) Helium supply duct (heat exchanger end) to heat exchanger

(2) Heat exchanger to helium return duct (heat exchanger end)

(3) Helium bypass hose to helium return duct (heat exchanger end)

(4) Helium return duct (heat exchanger end) to helium wrap-around duct

(5) Heat exchanger helium outlet instrumentation hose to helium return duct instrumentation tap HH3a (on engines not incorporating MD96 change)

(6) Heat exchanger helium outlet instrumentation hose to transducer (on engines not incorporating MD96 change)

(7) Heat exchanger helium outlet temperature transducer to helium outlet duct instrumentation tap HH3b (on engines not incorporating MD96 change)

NOTE

Step f is performed only at MAF.

Procedure	Result
f. Using Halogen Leak Detector 5797934-G1 (General Electric), or equivalent, monitor exhaust system manifold for presence of refrigerant, Type 12 (helium coil leakage).	No leakage is allowable.

NOTE

When external pneumatic source is helium, leak detector Uson Model 500 (Uson Corp) must be used to monitor exhaust system manifold for presence of helium.

g. Depressurize heat exchanger helium system.

h. Disconnect pneumatic system from heat exchanger helium system. Remove pressure caps from packaging, and install pressure caps on open ports.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

i. Remove all leak-test compound from joints and fittings with a clean, dry cloth or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.3.2.5 Heat Exchanger LOX System Leak Test.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Provide a pneumatic source of gaseous nitrogen (MIL-P-27401), or a mixture of gaseous nitrogen (MIL-P-27401) and refrigerant, Type 12 (Federal Specification BB-F-1421), as specified by requirements of section I, to heat exchanger oxidizer system.

NOTE

Steps b and c are performed only at MAF.

b. Install thrust chamber throat plug (paragraph 3.6.15). Install a ground half quick-disconnect on throat plug quick-disconnect.

CAUTION

In the following step, the gaseous nitrogen supply hose must be supported to prevent the weight on the seal valve stem from damaging the seal.

bA. Connect a source of gaseous nitrogen to throat plug seal. Using a suitable material, support the gaseous nitrogen supply hose to relieve all weight of hose from seal valve stem.

Procedure	Result
c. Pressurize throat plug seal to 50 (+5, -10) psig. Maintain pressure during remainder of test.	Thrust chamber throat plug seal is pressurized.
d. At MAF and KSC, slowly pressurize heat exchanger LOX system to 300 ±10 psig.	Heat exchanger LOX system is pressurized.
dA. At MTF, slowly pressurize heat exchanger LOX system to 1,000 ±50 psig.	Heat exchanger LOX system is pressurized.

NOTE

Step e is performed only at MAF.

Procedure	Result
e. Using Pneumatic Flow Tester G3104, or equivalent, at adapter on throat plug quick-disconnect, measure and record reverse-flow leakage past heat exchanger check valve gate.	Maximum allowable leakage is 50 scim.

f and g. (Deleted)

CAUTION

Leak-test compound used in the following procedure must not be used on overboard drain line exits to preclude introducing leak-test compound into the lines.

- Leak-test compound must not be used on flex line bellows since it cannot be removed from the bellows.

Procedure	Result
h. Apply leak-test compound (MIL-L-25567) to all flanges, fittings, instrumentation lines, and bellows in heat exchanger oxidizer system.	At MAF and KSC, no leakage is allowable except at heat exchanger to GOX duct (heat exchanger end) joint and oxidizer bypass hose to GOX duct (heat exchanger end) joint, where fuzz leakage (as defined in section II) is allowable. At MTF, no leakage is allowable except at heat exchanger to GOX duct (heat exchanger end) joint, oxidizer bypass hose to GOX duct (heat exchanger end) joint, and GOX duct (heat exchanger end) to heat exchanger GOX wrap-around duct joint, where fuzz leakage (as defined in section II) is allowable.

NOTE

Steps i and j are performed only at MAF subsequent to engine static test.

Procedure	Result
i. Using Halogen Leak Detector 5797934-G1 (General Electric), or equivalent, monitor exhaust system manifold for presence of refrigerant, Type 12 (oxidizer coil leakage).	No leakage is allowable.

j. Depressurize thrust chamber throat plug seal to zero

k. Depressurize heat exchanger LOX system to zero.

l. Disconnect pneumatic system from heat exchanger LOX system. Remove pressure caps from packaging, and install pressure caps on open ports.

m. Remove thrust chamber throat plug, if installed (paragraph 3.6.16).

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

n. Remove all leak-test compound from joints and fittings with a clean, dry cloth or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.3.2.6 Ignition Monitor Valve Diaphragm Leak Test.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Remove pressure cap or engine checkout adapter 9022007-11, as applicable, from ignition monitor valve CONTROL port quick-disconnect, and install engine checkout valve high-pressure adapter 9022038-21, or equivalent, on CONTROL port quick-disconnect.

b. Provide a gaseous nitrogen (MIL-P-27401) source to adapter.

c. Verify that stage fuel pre-valves are closed, then vent the fuel feed system between pre-valves and engine fuel valves during this test by removing pressure cap from, and installing drain hoses on, No. 1 and No. 2 fuel high-pressure duct drain quick-disconnects.

d. Disconnect ignition monitor valve drain tube from ignition monitor valve ATMOS REF port.

NOTE

Steps dA through dC are optional.

dA. Remove attaching hardware that secures ignition monitor valve sense tube clamp to bracket on thrust chamber fuel inlet manifold. Retain attaching hardware for reinstallation if acceptable for reuse in accordance with requirements of section II.

dB. Remove attaching hardware that secures ignition monitor valve sense tube to thrust chamber fuel inlet manifold; carefully separate flanges, and remove seal plate. Retain attaching hardware for reinstallation if acceptable for reuse in accordance with requirements of section II.

dC. Install pressure test fixture T-5043436, or equivalent, on thrust chamber fuel inlet manifold between ignition monitor valve sense tube flange and fuel inlet manifold flange. Torque nuts to 47-57 in-lb. Connect a red streamer to test fixture.

e. Verify that engine checkout valve is in ground position. Verify that hypergol test tool, or equivalent, is not installed and that hypergol cartridge installed switch is not picked up.

f. Remove thrust chamber exit closure and security closure or thrust chamber throat closure, if installed.

g. Supply gaseous nitrogen at 1,400 ±20 psig to ignition monitor valve CONTROL port.

h. Using Pneumatic Flow Tester G3104, or equivalent, measure and record leakage at ignition monitor valve ATMOS REF port. No leakage is allowable.

i. Decrease gaseous nitrogen supply pressure to ignition monitor valve CONTROL port to zero.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

j. Remove plugs, lubricate (Method A) fitting and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne), and install ignition monitor valve drain tube. Torque coupling nuts to 270-345 in-lb.

k. Supply gaseous nitrogen at 1,400 ±20 psig to ignition monitor valve CONTROL port.

l. Apply leak-test compound (MIL-L-25567) to all pressurized joints of ignition monitor valve. No leakage is allowable.

m. Depressurize ignition monitor valve CONTROL port and disconnect gaseous nitrogen supply.

NOTE

Steps mA through mD are required only if the ignition monitor valve sense tube was blanked off.

mA. Verify that ignition monitor valve sense tube clamp is disconnected; then remove fasteners that secure ignition monitor valve sense tube to thrust chamber fuel inlet manifold, and remove blank plate from between flanges.

mB. Verify alinement of ignition monitor valve sense tube as outlined in R-3896-3.

mC. Remove seal plate from packaging, and install seal plate between ignition monitor valve sense tube and thrust chamber fuel inlet manifold. Secure tube to manifold with 4 bolts, 8 washers, and 4 nuts. Torque nuts to 47-57 in-lb.

mD. Install clamp securing ignition monitor valve sense tube to bracket on thrust chamber fuel inlet manifold. Torque clamp fasteners to 24-30 in-lb.

n. Remove engine checkout valve high-pressure adapter. Remove pressure cap from packaging, and install pressure cap on ignition monitor valve CONTROL port quick-disconnect fingertight.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

o. Remove all leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.3.2.7 <u>Hypergol Manifold Leak and Function Test</u>. When flowtesters are specified in this procedure, Pneumatic Flow Tester G3104, or equivalent, must be used.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Remove pin and closure from hypergol manifold cartridge container inlet port. Store closure in a clean plastic bag.

WARNING

The following procedure uses dry-cleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

b. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680). Lubricate (Method A) threads with lubricant grease RB0140-012 (Rocketdyne).

CAUTION

When installing hypergol simulator into the hypergol manifold cartridge container inlet port, extreme care must be used to prevent damage to the hypergol cartridge follower.

- The threads of the hypergol simulator cap must be clean and free of nicks, to prevent galling the threads of the cap and inlet port.

c. Make sure that threads of cap on hypergol simulator T-5029716, or equivalent, are clean and free of nicks; then lubricate (Method L) simulator shaft O-ring with FS1281 grease (Dow Corning Corp), and carefully insert simulator into hypergol manifold cartridge container inlet port, and screw simulator (clockwise) onto inlet port until simulator bottoms.

d. Verify that pressure cap is installed on union in simulator cap.

e. Connect a gaseous nitrogen supply (MIL-P-27401) to hypergol manifold drain quick-disconnect.

f. Remove igniter fuel valve vent drain tube, and ignition monitor valve drain tube.

g. Verify that stage fuel pre-valves are closed; then vent fuel feed system between pre-valves and engine fuel valves by installing drain lines on No. 1 and No. 2 fuel high-pressure duct quick-disconnects.

Procedure	Result
h. Slowly supply gaseous nitrogen at 200 ±10 psig to reverse side of igniter fuel valve poppet through hypergol manifold drain quick-disconnect.	Hypergol manifold is pressurized to 200 ±10 psig.

NOTE

If igniter fuel valve relieves prior to attaining 190 psig, supply pressure must be reduced until valve reseats, since steps i through k must be performed at a pressure level below valve opening pressure.

Procedure	Result
i. Using flowtester, measure and record poppet reverse-flow leakage past hypergol manifold purge quick-disconnects.	Maximum allowable leakage for each quick-disconnect is 3 scim.
j. Using flowtester, measure leakage past igniter fuel valve piston shaft O-ring at igniter fuel valve vent port.	Maximum allowable leakage is 0.25 scim.
k. Using flowtester, measure leakage past cam follower O-ring at ATMOS REF port.	Maximum allowable leakage is 0.25 scim.
l. Decrease gaseous nitrogen supply pressure to zero.	Hypergol manifold is depressurized.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

m. Remove plugs, lubricate (Method A) fittings and (Method G) tubes with lubricant grease RB0140-012 (Rocketdyne), and install ignition monitor valve drain and igniter fuel valve vent drain tubes. Torque coupling nuts to 270-345 in-lb.

n. Remove pressure cap from packaging, and install pressure cap on hypergol manifold purge quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

Procedure	Result
o. Slowly apply gaseous nitrogen at 200 ±10 psig to reverse side of igniter fuel valve poppet through hypergol manifold drain quick-disconnect.	Hypergol manifold is pressurized to 200 ±10 psig.

NOTE

If igniter fuel valve relieves prior to attaining 190 psig, supply pressure must be reduced until valve reseats, since step p must be performed at a pressure level below valve opening pressure.

p. Apply leak-test compound (MIL-L-25567) to all pressurized joints and ports of hypergol manifold.	No leakage is allowable.
q. Slowly increase gaseous nitrogen pressure until igniter fuel valve relieves or a maximum of 280 psig is reached. Record relieving pressure.	Maximum igniter fuel valve relieving pressure is 270 psig.
r. Decrease gaseous nitrogen supply pressure to zero.	Hypergol manifold is depressurized.

s. Repeat steps q and r 2 additional times.

t. Disconnect gaseous nitrogen supply from hypergol manifold drain quick-disconnect. Remove pressure cap from packaging, and install pressure cap on quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

u. Remove hypergol simulator T-5029716, or equivalent, from hypergol manifold cartridge container inlet port.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

v. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680).

w. Remove hypergol manifold cartridge container inlet port closure from packaging. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp) and install closure. Secure closure with attaching pin.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

x. Remove all leak-test compound from joints and fittings with a clean, dry cloth or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.3.2.8 <u>Hydraulic Control System Leak and Function Test at MTF (Prior to Static Test) and at KSC.</u> This test contains procedures for leak testing the hydraulic control system, cycling engine propellant valves, determining ignition monitor valve shuttle pressure, and testing the ignition monitor valve interflow. If surface wetting is noted at any time during the test, refer to section II to determine if the condition is acceptable.

a. Verify that stage fuel pre-valves are closed; then vent the fuel feed system between pre-valves and engine fuel valves by installing drain hoses on No. 1 and No. 2 fuel high-pressure duct quick-disconnects.

aA. Verify that checkout valve is in ground return position.

aB. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3. 1A when performing this test.

b. Attach drain hoses at quick-disconnect of the following:

CAUTION

> In the following procedure during removal of No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn or damage to the quick-disconnect body can result.

(1) No. 1 thrust chamber fuel inlet manifold

(2) No. 2 thrust chamber fuel inlet manifold

(3) Engine control valve supply tube

(4) Checkout valve engine return hose

CAUTION

> In the following procedure, during removal of the gas generator ball valve fuel inlet quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn since a torque decrease between quick-disconnect body and adapter or adapter and gas generator ball valve fuel housing can result in seal leakage.

(5) Gas generator ball valve fuel inlet drain

bA. Remove closure from fuel overboard drain line.

bB. On center engine, remove pressure cap from actuator return line drain quick-disconnect.

c. Connect an external supply of gaseous nitrogen (MIL-P-27401), capable of being regulated and monitored from 0-100 psig, to ignition monitor valve CONTROL port quick-disconnect.

d. Provide instrumentation to monitor propellant valve position indicators (position switches and potentiometers when applicable).

e. Provide instrumentation to monitor hydraulic pressure at engine interface.

NOTE

Step f is omitted at KSC.

f. Install a blank plate between thrust chamber fuel inlet manifold and ignition monitor valve sense tube as follows:

(1) Remove attaching hardware that secures ignition monitor valve sense tube clamp to bracket on thrust chamber fuel inlet. Retain attaching hardware for reinstallation, if acceptable for reuse in accordance with requirements of section II.

(2) Remove attaching hardware that secures ignition monitor valve sense tube to thrust chamber fuel inlet manifold. Carefully separate flanges and remove seal plate. Retain attaching hardware for reinstallation, if acceptable for reuse in accordance with requirements of section II.

(3) Install pressure test fixture T-5043436, or equivalent, on thrust chamber fuel inlet manifold between ignition monitor valve sense tube flange and fuel inlet manifold flange. Torque nuts to 47-57 in-lb. Connect a red streamer to test fixture.

g. Remove pin and closure from hypergol manifold cartridge container inlet port.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

h. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680). Lubricate (Method A)threads with lubricant grease RB0140-012 (Rocketdyne).

CAUTION

When installing the hypergol system test tool into the hypergol manifold cartridge container inlet port, extreme care must be used to prevent damage to the hypergol cartridge follower.

- The threads of the test tool cap must be clean and free of nicks to prevent galling the threads of the cap and inlet port.

i. Make sure that threads of test tool cap are clean and free of nicks: then lubricate (Method L) cap packing with FS1281 grease (Dow Corning Corp)and carefully insert hypergol system test tool 9021279 or equivalent, into hypergol manifold cartridge container inlet port, and screw cap (clockwise)onto inlet port until cap bottoms.

Procedure	Result
j. Slowly pressurize engine hydraulic control system to 1,800 ±50 psig.	Hydraulic control system is pressurized to 1,800 ±50 psig.
k. Inspect all hydraulic fittings, joints, lines, and components, including instrumentation system, for leakage.	No external leakage is allowable.

NOTE

In the following step, previously recorded component leakage should be used as a guide for determining component isolation sequence. When leakage is accounted for, no further isolation is required. If necessary, refer to paragraph 3.3.3.2 for isolation procedures.

l. Monitor fuel overboard drain line, at thrust chamber exit, for fuel leakage. Any leakage requires isolation from fuel overboard drain line and recording of leakage rate of the following components:

Procedure	Result
(1) Redundant shutdown valve	2 cc/m fuel leakage maximum from drain port
(2) Ignition monitor valve	5 cc/m fuel leakage maximum from drain port
(3) Engine control valve	5 cc/m fuel leakage maximum from override drain port
(4) All other components common to this drain system	No leakage is allowable.
m. Monitor engine hydraulic supply check valve leakage at engine control valve supply tube drain quick-disconnect drain hose.	2 cc/m maximum
n. Monitor checkout valve ball seal leakage at checkout valve engine return hose drain quick-disconnect drain hose.	2 cc/m maximum

o through q. (Deleted)

Procedure	Result
r. Decrease hydraulic pressure to 1,550 ±50 psig.	Hydraulic control system is pressurized to 1,550 ±50 psig.
rA. Monitor and record actuator return line drain quick-disconnect poppet leakage (center engine only).	5 drops per minute maximum

CAUTION

Engine control valve start or stop solenoid must not be actuated with a hydraulic pressure of less than 900 psig, since damage to the engine control valve can occur.

Procedure	Result
s. Momentarily supply 24-30 vdc to engine control valve start solenoid (J-18, pins n (+) and m (-) at engine interface).	Gas generator ball valve and No. 1 and No. 2 oxidizer valves open.
t. Pressurize ignition monitor valve CONTROL port with gaseous nitrogen to 50 ±10 psig.	No. 1 and No. 2 fuel fuel valves open.
u. (Deleted)	
v. Slowly increase hydraulic supply pressure to 1,800 ±50 psig.	Hydraulic control system is pressurized to 1,800 ±50 psig.
w. Repeat steps k through n.	
x. Decrease hydraulic supply pressure to 1,550 ±50 psig.	Hydraulic control system is pressurized to 1,550 ±50 psig.

CAUTION

Engine control valve start or stop solenoid must not be actuated with a hydraulic pressure of less than 900 psig, since damage to the engine control valve can occur.

Procedure	Result
y. Momentarily supply 24-30 vdc to engine control valve stop solenoid (J-18, pins g (+) and k (-) at engine interface).	Gas generator ball valve, No. 1 and No. 2 oxidizer valves, and No. 1 and No. 2 fuel valves close.

z. Vent pressure from ignition monitor valve CONTROL port.

NOTE

Steps aa through ag are omitted at MTF prior to engine static test.

Procedure	Result
aa. Momentarily provide 24-30 vdc to engine control valve start solenoid (J-18, pins n (+) and m (-) at engine interface).	Gas generator ball valve and No. 1 and No. 2 oxidizer valve open.
ab. Slowly supply gaseous nitrogen to ignition monitor valve CONTROL port until No. 1 or No. 2 fuel valve leaves closed position.	Record pneumatic supply pressure at time either fuel valve leaves closed position. Fuel valve movement must occur at 20 ±4 psig at ignition monitor valve CONTROL port when ignition monitor valve sense tube is blanked off. When sense tube is not blanked off fuel valve movement must occur at 21 ±4 psig.
ac. Momentarily provide 24-30 vdc to engine control valve stop solenoid (J-18, pins g (+) and K (-) at engine interface).	Gas generator ball valve, No. 1 and No. 2 oxidizer valves, and No. 1 and No. 2 fuel valves close.

ad. Vent gaseous nitrogen supply pressure from ignition monitor valve CONTROL port.

Procedure	Result
ae. Repeat steps aa through ad one additional time; then repeat steps aa and ab, and proceed to step af.	Each ignition monitor valve shuttle pressure must occur within ±2 psig of the other shuttle pressures.

WARNING

The following procedure energizes the redundant shutdown valve solenoid, which causes the valve housing to heat up. After electrical power has been applied continuously, the valve solenoid case temperature can cause injury to personnel touching the case.

- If the redundant shutdown valve is kept energized for more than 15 minutes, the solenoid temperature buildup will cause the valve to actuate slower.

Procedure	Result
af. Momentarily provide 24-30 vdc to redundant shutdown valve solenoid (J-19, pins D (+) and L (-) at engine interface).	Gas generator ball valve, No. 1 and No. 2 oxidizer valves and No. 1 and No. 2 fuel valves close.

ag. Vent gaseous nitrogen pressure from ignition monitor valve CONTROL port.

Procedure	Result
ah. Depress and hold lever on hypergol test tool.	Hypergol cartridge installation is simulated.
ai. Momentarily supply 24-30 vdc to engine control valve start solenoid (J-18, pins n (+) and m (-) at engine interface).	Gas generator ball valve and No. 1 and No. 2 oxidizer valves open.

CAUTION

The following procedure pressurizes the ignition monitor valve CONTROL port. If pressure in excess of 100 psig is applied to ignition monitor valve CONTROL port, damage to the valve cartridge follower can result.

aj. Slowly supply gaseous nitrogen at 28 ±2 psig to ignition monitor valve CONTROL port. Wait 5 minutes; then verify by instrumentation indication that No. 1 and No. 2 fuel valves remain closed. Record verification.

ak. Vent gaseous nitrogen supply pressure from ignition monitor valve CONTROL port.

al. Release lever of hypergol test tool.

Procedure	Result
am. Momentarily supply 24-30 vdc to engine control valve stop solenoid (J-18, pins g (+) and k (-) at engine interface).	Gas generator ball valve and No. 1 and No. 2 oxidizer valves close.

an. Depressurize hydraulic control system.

ao. Disconnect drain hoses from the following quick-disconnects. Remove pressure caps from packaging, and install pressure caps on quick-disconnects. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

CAUTION

In the following procedure, during installation of the No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn, since damage to the quick-disconnect body can result.

(1) No. 1 thrust chamber fuel inlet manifold drain

(2) No. 2 thrust chamber fuel inlet manifold drain

(3) No. 1 fuel high-pressure duct drain

(4) No. 2 fuel high pressure duct drain

(5) Engine control valve supply tube drain

(6) Checkout valve engine return hose drain

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

aoA. Remove drain hose from gas generator ball valve fuel inlet drain, lubricate (Method A) threads of quick-disconnect with lubricant grease RB0140-012 (Rocketdyne) or FS1281 grease (Dow Corning Corp). Remove pressure caps from packaging and install pressure cap. Torque pressure cap to 210-230 in-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

aoB. On center engine, remove pressure cap from packaging and install pressure cap on actuator return line drain quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

ap. Remove hypergol system test tool.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

aq. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680).

ar. Remove hypergol manifold cartridge container inlet port closure from packaging. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp) and install closure. Secure closure with attaching pin.

as. Verify that ignition monitor valve sense tube clamp is disconnected; then remove fasteners that secure ignition monitor valve sense tube to thrust chamber fuel inlet manifold, and remove blank plate from between flanges.

at. Verify alinement of ignition monitor valve sense tube as outlined in R-3896-3.

au. Remove seal plate from packaging; then install seal plate between ignition monitor valve sense tube and thrust chamber fuel inlet manifold. Secure tube to manifold with 4 bolts, 8 washers, and 4 nuts. Torque nuts to 47-57 in-lb.

av. Install clamp securing ignition monitor valve sense tube to bracket on thrust chamber fuel inlet manifold. Torque clamp fasteners to 24-30 in-lb.

3.3.2.8A Hydraulic Control System Leak and Function Test at MTF Subsequent to Static Test. This test contains procedures for leak-testing the closed side of the hydraulic control system. If surface wetting is noted at anytime during the test, refer to section II to determine if the condition is acceptable.

a. Verify that checkout valve is in ground return position.

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aB. Remove pressure caps and attach drain hoses to engine control valve supply tube drain quick-disconnect and to checkout valve engine return hose drain quick-disconnect.

aC. On center engine, remove pressure cap from actuator return line drain quick-disconnect.

aD. Remove closure from fuel overboard drain line.

Procedure	Result
b. Slowly pressurize engine hydraulic control system to 1,800 ±50 psig.	Hydraulic control system is pressurized to 1,800 ±50 psig.
c. Inspect all hydraulic fittings, joints, lines, and components, including instrumentation system, for leakage.	No external leakage is allowable.

NOTE

In the following step, previously recorded component leakage should be used as a guide for determining component isolation sequence. When leakage is accounted for, no further isolation is required. If necessary, refer to paragraph 3.3.3.2 for isolation procedures.

d. Monitor fuel overboard drain line, at thrust chamber exit, for fuel leakage. Any leakage requires isolation from fuel overboard drain line and recording of leakage rate of the following components:

Procedure	Result
(1) Redundant shutdown valve	2 cc/m fuel leakage maximum from drain port
(2) Ignition monitor valve	5 cc/m fuel leakage maximum from drain port
(3) Engine control valve	5 cc/m fuel leakage maximum from override drain port
(4) All other components common to this drain system	No leakage is allowable.
e. Monitor engine hydraulic supply check valve leakage at engine control valve supply tube drain quick-disconnect drain hose.	2 cc/m maximum
f. Monitor checkout valve ball seal leakage at checkout valve engine return hose drain quick-disconnect drain hose.	2 cc/m maximum
g. Monitor actuator return line drain quick-disconnect poppet leakage (center engine only).	5 drops per minute maximum

h. Depressurize hydraulic control system.

i. Disconnect drain hoses from engine control valve supply tube drain quick-disconnect and checkout valve engine return hose drain quick-disconnect. Remove pressure caps from packaging, and install pressure caps on quick-disconnects. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

j. On center engine, remove pressure caps from packaging, and install pressure cap on actuator return line drain quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

3.3.2.8B Hydraulic Control System Leak and Function Test at MAF. This test contains procedures for leak-testing the closed and open sides of the hydraulic control system. If surface wetting is noted at anytime during the test, refer to section II to determine if the condition is acceptable.

a. Verify that stage fuel pre-valves are closed; then vent the fuel feed system between pre-valves and engine fuel valves by installing drain hoses on No. 1 and No. 2 fuel high-pressure duct drain quick-disconnects.

b. Verify that checkout valve is in ground return position.

bA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

c. Remove plugs from the following instrumentation taps, and allow fluid to drain.

(1) On engine installed in position 101, remove plugs from taps IF2 and PF3a-2. Use a suction pump to remove fluid from PF3a-2.

(2) On engine installed in position 102, remove plug from tap KF6d-2.

(3) On engine installed in position 103, remove plug from tap KF7a-1.

(4) On engine installed in position 104, remove plug from tap IF2.

(5) On engine installed in position 105, remove plug from tap PF3a-2. Use a suction pump to remove fluid from PF3a-2.

d. Attach drain hoses at quick-disconnects of the following:

CAUTION

In the following procedure, during removal of the No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn, since damage to the quick-disconnect body can result.

(1) No. 1 thrust chamber fuel inlet manifold

(2) No. 2 thrust chamber fuel inlet manifold

(3) Engine control valve supply tube

(4) Checkout valve engine return hose

dA. On center engine, remove pressure cap from actuator return line drain quick-disconnect.

e. Connect an external supply of gaseous nitrogen (MIL-P-27401), capable of being regulated and monitored from 0-100 psig, to ignition monitor valve CONTROL port quick-disconnect.

f. Provide instrumentation to monitor propellant valve position indicators (position switches and potentiometers, when applicable).

g. Provide instrumentation to monitor hydraulic pressure at engine interface.

h. Install a blank plate between thrust chamber fuel inlet manifold and ignition monitor valve sense tube as follows:

(1) Remove attaching hardware that secures ignition monitor valve sense tube clamp to bracket on thrust chamber fuel inlet. Retain attaching hardware for reinstallation if acceptable for reuse in accordance with requirements of section II.

(2) Remove attaching hardware that secures ignition monitor valve sense tube to thrust chamber fuel inlet manifold. Carefully separate flanges, and remove seal plate. Retain attaching hardware for reinstallation if acceptable for reuse in accordance with requirements of section II.

(3) Install pressure test fixture T-5043436, or equivalent, on thrust chamber fuel inlet manifold between ignition monitor valve sense tube flange and fuel inlet manifold flange. Torque nuts to 47-57 in-lb. Connect a red streamer to test fixture.

Procedure	Result
i. Slowly pressurize engine hydraulic control system to 1,800 ±50 psig.	Hydraulic control system is pressurized to 1,800 ±50 psig.
j. Inspect all hydraulic fittings, joints, lines, and components, including instrumentation system, for leakage.	No external leakage is allowable.
k through m. (Deleted)	
n. Decrease hydraulic pressure to 1,550 ±50 psig.	Hydraulic control system is pressurized to 1,550 ±50 psig.

Procedure	Result
nA. Monitor and record actuator return line drain quick-disconnect poppet leakage (center engine only)	5 drops per minute maximum

CAUTION

The engine control valve start or stop solenoid must not be actuated with a hydraulic pressure of less than 900 psig, since damage to the engine control valve can occur.

Procedure	Result
o. Momentarily supply 24-30 vdc to engine control valve start solenoid (J-18, pins n (+) and m (-) at engine interface).	Gas generator ball valve and No. 1 and No. 2 oxidizer valves open.
p. Pressurize ignition monitor valve CONTROL port with gaseous nitrogen to 50 ±10 psig.	No. 1 and No. 2 fuel valves open.
q. Slowly increase hydraulic supply pressure to 1,800 ±50 psig.	Hydraulic control system is pressurized to 1,800 ±50 psig.
r. Inspect all hydraulic fittings, joints, lines, and components, including instrumentation system, for leakage.	No external leakage is allowable.
s. (Deleted)	
t. Decrease hydraulic supply pressure to 1,550 ±50 psig.	Hydraulic control system is pressurized to 1,550 ±50 psig.

WARNING

The following procedure energizes the redundant shutdown valve solenoid, which causes the valve housing to heat up. After electrical power has been applied continuously, the valve solenoid case temperature can cause injury to personnel touching the case.

- If the redundant shutdown valve is kept energized for more than 15 minutes, the solenoid temperature buildup will cause the valve to actuate slower.

CAUTION

The engine control valve start or stop solenoid must not be actuated with a hydraulic pressure of less than 900 psig, since damage to the engine control valve can occur.

Procedure	Result
u. Momentarily supply 24-30vdc to engine control valve stop solenoid (J-18, pins g (+) and k (-) and redundant valve solenoid (J-19, pins D (+) and L (-) at engine interface).	Gas generator ball valve, No. 1 and No. 2 oxidizer valves, and No. 1 and No. 2 fuel valves close.

v. Vent pressure from ignition monitor valve CONTROL port.

w. Depressurize hydraulic control system.

x. Disconnect drain hoses from the following quick-disconnects. Remove pressure caps from packaging, and install pressure caps on quick-disconnects. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

CAUTION

In the following procedure, during installation of the No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn, since damage to the quick-disconnect body can result.

(1) No. 1 thrust chamber fuel inlet manifold drain

(2) No. 2 thrust chamber fuel inlet manifold drain

(3) No. 1 fuel high-pressure duct drain

(4) No. 2 fuel high-pressure duct drain

(5) Engine control valve supply tube drain

(6) Checkout valve engine return hose drain

xA. On center engine, remove pressure cap from packaging and install pressure cap on actuator return line drain quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

y. Remove fasteners that secure ignition monitor valve sense tube to thrust chamber fuel inlet manifold, and remove blank plate from between flanges.

z. Verify alinement of ignition monitor valve sense tube as outlined in R-3896-3.

aa. Install seal plate between ignition monitor valve sense tube and thrust chamber fuel inlet manifold. Secure tube to manifold with 4 bolts, 8 washers, and 4 nuts. Torque nuts to 47-57 in-lb.

ab. Install clamp that secures ignition monitor valve sense tube to bracket, on thrust chamber fuel inlet manifold. Torque clamp fasteners to 24-30 in-lb.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

ac. Remove plugs and packings from packaging, and install plugs AN814-4CL and packings RD262-3001-0004 as follows:

(1) On engine installed in position 101, lubricate (Method J) packings and (Method A) threads of plugs with lubricant grease RB0140-012 (Rocketdyne) and install plugs and packings in taps IF2 and PF3a-2. Torque plug in tap IF2 to 40-65 in-lb and plug in tap PF3a-2 to 100 +5 in-lb. Safetywire plugs with Inconel lockwire MS20995N.

(2) On engine installed in position 102, lubricate (Method J) packing and (Method A) threads of plug with lubricant grease RB0140-012 (Rocketdyne) and install plug and packing in tap KF6d-2. Torque plug to 40-65 in-lb. Safetywire plug with Inconel lockwire MS20995N.

(3) On engine installed in position 103, lubricate (Method J) packing and (Method A) threads of plug with lubricant grease RB0140-012

(Rocketdyne) and install plug and packing in tap KF7a-1. Torque plug to 40-65 in-lb. Safetywire plug with Inconel lockwire MS20995N.

(4) On engine installed in position 104, lubricate (Method J) packing and (Method A) threads of plug with lubricant grease RB0140-012 (Rocketdyne) and install plug and packing in tap IF2. Torque plug to 40-65 in-lb. Safetywire plug with Inconel lockwire MS20995N.

(5) On engine installed in position 105, lubricate (Method J) packing and (Method A) threads of plug with lubricant grease RB0140-012 (Rocketdyne) and install plug and packing in tap PF3a-2. Torque plug to 100 ±5 in-lb. Safetywire plug with Inconel lockwire MS20995N.

3.3.2.9 Valve Timing Test.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Verify that stage fuel pre-valves are closed; then vent the fuel feed system between pre-valves and engine valves by installing drain hoses on No. 1 and No. 2 fuel high-pressure duct quick-disconnects.

b. Verify that pneumatic system is connected to ignition monitor valve CONTROL port (paragraph 3.3.2.8).

Procedure	Result
c. Slowly pressurize engine hydraulic control system to 1,550 +50 psig, and circulate hydraulic fluid for a minimum of 15 minutes before proceeding to next step.	Engine hydraulic control system is pressurized.

d. Provide instrumentation for recording engine propellant valve times and sequence of events.

Procedure	Result
e. Momentarily supply 24-30 vdc to engine control valve start solenoid (J-18, pins n (+) and m (-) at engine interface).	Gas generator ball valve and No. 1 and No. 2 oxidizer valves open.
f. Supply gaseous nitrogen at 50 ±10 psig to ignition monitor valve CONTROL port.	No. 1 and No. 2 fuel valves open.
g. Momentarily supply 24-30 vdc to both engine control valve stop solenoid (J-18, pins g (+) and k (-) at engine interface) and redundant shutdown valve solenoid (J-19, pins D (+) and L (-) at engine interface).	Verify that valve times meet limits and that sequence of events occurs as listed in section I.

h. Vent gaseous nitrogen pressure from ignition monitor valve CONTROL port.

i. Repeat steps e through h two additional times.

j. (Deleted)

k. Repeat steps e and f.

Procedure	Result
l. Momentarily supply 24-30 vdc to redundant shutdown valve solenoid (J-19, pins D (+) and L (-) at engine interface).	Gas generator ball valve, No. 1 and No. 2 oxidizer valves, and No. 1 and No. 2 fuel valves close.

m. Vent gaseous nitrogen pressure from ignition monitor valve CONTROL port.

n. Secure instrumentation.

o. Depressurize hydraulic control system.

p. Disconnect drain hose from No. 1 and No. 2 fuel high-pressure duct quick-disconnects. Remove pressure caps from packaging, and install pressure caps on quick-disconnects. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

3.3.2.10 Fuel Feed System Leak Test. When flowtesters are specified, Pneumatic Flow Tester G3104, or equivalent, must be used.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. If engines are horizontal, remove protective closure from fuel overboard drain line at thrust chamber exit.

aA-1. If engines are horizontal, remove polyethylene bag from Y-fitting on fuel overboard drain line and install pressure cap on Y-fitting.

NOTE

Steps aB through e are omitted at MTF.

aB. If engines are vertical, remove polyethylene bag from fuel overboard drain line at thrust chamber exit.

b. If engines are vertical, disconnect cross to lateral drain tube between cross and fuel overboard drain line Y-fitting. Install pressure cap AN929-16C on fuel overboard drain line.

c. Remove plug from hypergol manifold instrumentation tap IF3.

d. Remove fuel drain manifold cover plate and seal plate from fuel drain manifold, and install fuel seal drain manifold adapter 9020907. Torque fasteners to 43-47 in-lb.

e. Remove plugs from INLET and PRIMARY ports on adapter.

eA. Install thrust chamber throat plug (paragraph 3.6.15). Install an open adapter with a drain hose on throat plug quick-disconnect. Vent hose outside of thrust chamber with hose outlet pointed away from personnel.

eB. Remove pin and closure from hypergol manifold cartridge container inlet port.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

eC. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680). Lubricate (Method A) threads with lubricant grease RB0140-012 (Rocketdyne).

CAUTION

When installing hypergol simulator into the hypergol manifold cartridge container inlet port, extreme care must be used to prevent damage to the hypergol cartridge follower.

- The threads of the hypergol simulator cap must be clean and free of nicks, to prevent galling the threads of the cap and inlet port.

eD. Make sure that threads of cap on hypergol simulator T-5020716, or equivalent, are clean and free of nicks; then lubricate (Method I) simulator shaft O-ring with FS1281 grease (Dow Corning Corp), and carefully insert simulator into hypergol manifold cartridge container inlet port. Screw simulator clockwise until it bottoms.

eE. Verify that pressure cap is installed on union in simulator cap.

NOTE

The fuel system leak test may be conducted without hydraulic pressure applied to the hydraulic control system. However, in the event that propellant valve leakage is excessive, apply hydraulics and reperform leak test.

Procedure	Result
f. Supply hydraulic fluid at 1,550 ±50 psig to engine ground hydraulic interface.	No external leakage is allowable in hydraulic control system.

NOTE

If hydraulic pressure is not supplied to engine hydraulic control system, it must be verified that each oxidizer valve, each fuel valve, and the gas generator ball valve are in the closed position prior to performing steps fA and g.

- Step fA is omitted at MTF.

fA. Supply gaseous nitrogen (MIL-P-27401) as specified in requirements of section I, at 10 ±1 psig to LOX feed system.

g. Supply gaseous nitrogen (MIL-P-27401) or a mixture of gaseous nitrogen (MIL-P-27401) and refrigerant, Type 12 (Federal Specification BB-F-1421), as specified by requirements of section I, at 10 ±1 psig to fuel feed system.

NOTE

Steps h through l are omitted at MTF.

h. Remove pressure caps from the following quick-disconnects:

(1) No. 1 and No. 2 fuel high-pressure duct drains

(2) No. 1 and No. 2 fuel pump inlet drains

(3) Engine control valve supply tube drain

(4) Checkout valve to engine return hose drain

CAUTION

In the following procedure, during removal of the gas generator ball valve fuel inlet drain quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn, since torque decrease between quick-disconnect and adapter and adapter and gas generator ball valve fuel housing can result in seal leakage.

(5) Gas generator ball valve fuel inlet drain

Procedure	Result
i. Using flowtester, measure and record poppet reverse-flow leakage at each quick-disconnect listed in step h.	Leakage at each quick-disconnect must not exceed 3 scim.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

j. Remove pressure caps from packaging and install pressure caps on quick-disconnects listed in step h. Torque 3/8-inch pressure caps to 30-40 ft-lb and 3/4-inch pressure caps to 70-75 ft-lb. On engines incorporating MD168 change, lubricate (Method A) threads of gas generator ball valve fuel inlet drain quick-disconnect with lubricant grease RB0140-012 (Rocketdyne) or FS1281 grease (Dow Corning Corp), and install pressure cap. Torque pressure cap to 210-230 in-lb. Safetywire all quick-disconnect pressure caps with Inconel lockwire MS20995N.

k and l. (Deleted)

CAUTION

Leak-test compound used in the following procedure must not be used on overboard drain line exits, to preclude introducing leak-test compound into the lines.

- Leak-test compound must not be used on flex line bellows since cannot be removed from the bellows.

Procedure	Result
m. Apply leak-test compound (MIL-L-25567) to all flanges, fittings, or instrumentation lines connected to the following:	No leakage is allowable.

(1) No. 1 and No. 2 fuel inlet elbows

(2) No. 1 and No. 2 fuel high-pressure ducts

(3) No. 1 and No. 2 fuel valves

(4) Gas generator fuel duct

(5) Gas generator ball valve fuel side

(6) Fuel volute lube feed tube

(7) Igniter fuel supply tube

(8) Turbopump fuel impeller balance cavity supply and return tubes

(9) Engine control valve supply tube

(10) Checkout valve to engine return hose

NOTE

Steps n through nE are omitted at MTF.

n. Using flowtester, measure and record leakage at the following:

Procedure	Result
(1) Fuel drain tube disconnected in step b	No leakage past gas generator ball valve fuel shaft seal is allowable.
(2) Fuel overboard drain line at thrust chamber exit	Leakage past bearing coolant control valve poppets must not exceed 2 scim.
(3) INLET port on adapter. (Rotate turbopump shaft to determine maximum leakage whether rotating or stationary.)	Leakage past turbopump fuel inlet seal must not exceed 50 scim.
(4) PRIMARY port on adapter. (Rotate turbopump shaft to determine maximum leakage whether rotating or stationary.)	Leakage past primary fuel seal must not exceed 50 scim.
(5) Igniter fuel valve seat leakage from instrumentation tap IF3.	Leakage past igniter fuel valve seat must not exceed 0.5 scim.

nA. Using flowtester, measure flow at drain hose on adapter installed on thrust chamber throat plug and record as combined leakage of No. 1 and No. 2 fuel valves and No. 1 and No. 2 oxidizer valves.

nB. Depressurize fuel feed system.

nC. Using flowtester, measure flow at drain hose on adapter installed on thrust chamber throat plug and record as combined leakage of No. 1 and No. 2 oxidizer valves.

Procedure	Result
nD. Calculate delta flow as difference between flow recorded in step nA and flow recorded in step nC. Record flow as combined leakage of No. 1 and No. 2 fuel valves.	Combined leakage of No. 1 and No. 2 fuel valves must not exceed 15 scim.

nE. If hydraulic control system is not pressurized and leakage in step nD is excessive, perform steps f, fA, and nA through nC. When hydraulic control system is pressurized, combined leakage in excess of 15 scim requires isolation of No. 1 fuel valve from No. 2 fuel valve. Maximum leakage from either valve is 15 scim.

o. Depressurize LOX feed system.

p. Depressurize hydraulic control system, if applicable.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

q. Remove all leak-test compound from all joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

NOTE

Steps r through t are omitted at MTF.

r. Remove fuel seal drain manifold adapter from fuel drain manifold. Remove cover plate and seal plate from packaging and install fuel drain manifold cover plate and seal plate. Torque bolts to 44-47 in-lb. Safetywire bolts with Inconel lockwire MS20995N.

s. If engines are horizontal, install protective cover on fuel overboard drain line. Torque closure fasteners fingertight plus 1/4 turn.

sA. If engines are horizontal, install a polyethylene bag (one gallon minimum volume) on fuel overboard drain line Y-fitting (paragraph 3.6.23.1).

sB. If engines are vertical, install a polyethylene bag (one gallon minimum volume) on fuel overboard drain line at thrust chamber exit (paragraph 3.6.23.3).

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

t. Remove plug and packing from packaging. Lubricate (Method J) packing and (Method A) plug with lubricant grease RB0140-012 (Rocketdyne) and install plug and packing in instrumentation tap IF3. Torque plug to 40-65 in-lb. Safetywire plug with Inconel lockwire MS20995N.

u. Remove hypergol simulator T-5029716, or equivalent, from hypergol manifold cartridge container inlet port.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

v. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680).

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

w. Remove hypergol manifold cartridge container inlet port closure from packaging. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp). Install closure and secure with attaching pin.

3.3.2.11 <u>LOX Feed System Leak Test.</u> When flowtesters are specified, Pneumatic Flow Tester G3104, or equivalent, must be used.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

NOTE

Steps aA and b are omitted at MTF.

aA. Disconnect actuator rod seal vent tubes from OXID VENT port on No. 1 and No. 2 oxidizer valves.

b. Install thrust chamber throat plug (paragraph 3.6.15). Install an adapter with a drain hose on throat plug quick-disconnect. Vent hose outside of thrust chamber to atmosphere. Secure hose with hose outlet pointed away from personnel.

NOTE

The LOX feed system leak test may be conducted without hydraulic pressure applied to the hydraulic control system. However, in the event that propellant valve leakage is excessive, apply hydraulics and reperform test.

Procedure	Result
c. Supply hydraulic fluid at 1,550 ±50 psig to engine hydraulic control system.	Hydraulic control system is pressurized. No leakage is allowable.

NOTE

If hydraulic pressure is not supplied to the engine hydraulic control system at 1,550 +50 psig, it must be verified that each oxidizer valve and the gas generator ball valve are in the closed position prior to performing step d.

d. Supply gaseous nitrogen (MIL-P-27401) or a mixture of gaseous nitrogen (MIL-P-27401) and refrigerant, Type 12 (Federal Specification BB-F-1421), as specified in requirements of section I, at 10 ±1 psig to LOX feed system.

NOTE

Steps e through m are omitted at MTF.

Procedure	Result
e. Using flowtester, measure and record leakage at actuator rod seal OXID VENT port No. 1 and NO. 2 oxidizer valves.	Leakage past each valve bottom rod lip seal must not exceed 30 scim.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

f. Reconnect tubes removed from OXID VENT ports to No. 1 and No. 2 oxidizer valves. Lubricate (Method A)fitting and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne). Torque coupling nuts to 135-185 in-lb.

g. Disconnect gas generator ball valve shaft oxidizer seal vent tube at actuator housing banjo fitting.

Procedure	Result
h. Using flowtester, measure and record leakage from banjo fitting.	Leakage past gas generator ball valve shaft oxidizer seal must not exceed 10 scim.
i. Using flowtester at drain hose on adapter installed on throat plug quick-disconnect, measure combined leakage past No. 1 and No. 2 oxidizer valve poppets.	Combined leakage past No. 1 and No. 2 oxidizer valve poppets must not exceed 56 scim. Leakage in excess of 56 scim requires isolation of No. 1 oxidizer valve from No. 2 oxidizer valve. Maximum leakage from either valve is 56 scim.

j. Disconnect nitrogen overboard drain line at thrust chamber exit, and pressure-cap engine side with plug AN806-8C.

Procedure	Result
k. Using flowtester, measure and record maximum leakage from oxidizer overboard drain line. (Slowly rotate turbopump shaft to determine maximum leakage, whether rotating or stationary.)	Leakage past turbopump primary LOX seal must not exceed 500 scim.

l. Remove plug from nitrogen overboard drain line. Reconnect nitrogen overboard drain line at thrust chamber exit. Lubricate (Method A) fitting and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne). Torque coupling nut to 450-525 in-lb.

m and n. (Deleted)

CAUTION

Leak-test compound used in the following procedure must not be used on overboard drain line exits to preclude introducing leak-test compound into the lines.

- Leak-test compound must not be used on flex line bellows since it cannot be removed from the bellows.

Procedure	Result
o. Using leak-test compound (MIL-L-25567), monitor leakage at flanges, gimbal yoke bellows, fittings, and instrumentation lines on or connected to the following:	No leakage is allowable, except on engines not incorporating MD128 change where fuzz leakage (as defined in section II) is allowable between gas generator ball valve oxidizer housing and actuator cavity housing joint.

(1) Oxidizer pump

(2) No. 1 and No. 2 oxidizer high-pressure ducts

(3) No. 1 and No. 2 oxidizer valves

(4) Gas generator oxidizer feed line

(5) Gas generator ball valve oxidizer side

(6) Oxidizer pump inlet to oxidizer pump volute

(7) Gas generator ball valve oxidizer side to actuator housing

p. Depressurize LOX feed system.

q. Depressurize hydraulic control system.

NOTE

Steps r and s are omitted at MTF.

- The method for applying lubricant in the following procedure is outlined in R-3896-3.

r. Remove plugs, lubricate (Method A) fitting and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne), and install gas generator ball valve shaft oxidizer seal vent tube at actuator housing banjo fitting. Torque coupling nut to 135-185 in-lb.

s. Remove thrust chamber throat plug (paragraph 3.6.16).

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

t. Remove all leak-test compound from joints and fittings with a clean, dry cloth or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.3.2.12 Exhaust System Leak Test. When flowtesters are specified in this procedure, Pneumatic Flow Tester G3104, or equivalent, must be used.

a. Install turbine exhaust exit pressure test fixture (paragraph 3.6.17).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Disconnect oxidizer dome purge wraparound hose at stage purge interface, and plug hose with a suitable plug capable of mating with hose coupling nut MF818C12Y (MSFC specification).

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

c. Install engine exhaust system supply adapter 9022043, or equivalent, in gas generator instrumentation tap GO2a. Lubricate (Method J) adapter packing and (Method A) adapter union with lubricant grease RB0140-012 (Rocketdyne). Torque union to 55-80 in-lb.

d. Connect an external supply source of gaseous nitrogen (MIL-P-27401), capable of being regulated and monitored from 0-60 psig, to adapter installed in step c.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

e. Install engine exhaust system monitor adapter 9025299, or equivalent, in a gas generator IGNITER boss. Lubricate (Method J) adapter packing and (Method A) adapter union with lubricant grease RB0140-012 (Rocketdyne). Torque union nut to 225-275 in-lb.

f. Connect a tee to adapter installed in step e, attach a hand bleed valve to one end of tee, and close valve. Connect a 0-60 psig monitor system to other end of tee.

g. Remove marmon clamp holding turbopump turbine and heat exchanger antifirex shield; then remove shield.

Procedure	Result
h. Verify that exhaust system manifold seal at thrust chamber exit is inflated to specified pressure.	Seal must remain inflated during remainder of test.
i. Slowly supply gaseous nitrogen at 10 ±1 psig to engine exhaust system through line installed in step d.	Engine exhaust system is pressurized as verified by monitor gage.

NOTE

Step j is omitted at KSC.

Procedure	Result
j. Remove closure from oxidizer overboard drain line, and using flowtester, measure and record reverse-flow leakage past gas generator oxidizer purge check valve gate.	Maximum allowable leakage is 25 scim.
k. Remove plugs, and using flowtester, measure and record leakage rates at the following static seal monitoring ports:	Leakage must not exceed:
(1) Turbine to heat exchanger (on heat exchanger flange)	10 scim
(2) Heat exchanger to exhaust manifold (on exhaust manifold)	10 scim

l. Using flowtester at vent hose outlets, measure and record leakage from the following static seal monitoring ports:

Procedure	Result
(1) Gas generator combustor to turbine manifold inlet (on gas generator flange)	10 scim
(2) Gas generator injector to combustor	10 scim

CAUTION

Leak-test compound used in the following procedure must not be used on overboard drain lines to preclude introducing leak-test compound into the lines.

- Leak-test compound must not be used on flex line bellows since it cannot be removed from the bellows.

Procedure	Result
m. Apply leak-test compound (MIL-L-25567) to all flanges, fittings, and instrumentation lines except as listed in steps n and nA.	No external leakage is allowable.

n. Using leak-test compound (MIL-L-25567), leak-test the following flanges with leakage-monitoring port plugs removed.

Procedure	Result
(1) Gas generator injector to combustor	No leakage is allowable.
(2) Combustor to turbine manifold inlet	No leakage is allowable.
(3) Turbine manifold outlet to heat exchanger inlet	Fuzz leakage (as defined in section II) is allowable.
(4) Heat exchanger outlet to hot-gas manifold	Fuzz leakage (as defined in section II) is allowable.

nA. Using leak-test compound (MIL-L-25567), leak-test the following flanges:

(1) Turbine manifold temperature transducer to turbine manifold instrumentation tap TG4a (on engines not incorporating MD176 change)	Fuzz leakage (as defined in section II) is allowable.
(2) Cover plate to turbine manifold instrumentation tap TG4a (on engines incorporating MD176 change)	No leakage is allowable.
(3) Turbine outlet pressure transducer hose to heat exchanger instrumentation tap TG5c	Fuzz leakage (as defined in section II) is allowable.

CAUTION

The exhaust system must be depressurized as outlined in steps o and p, to prevent contamination of the engine.

o. Turn off pneumatic source.

p. Depressurize exhaust system by opening hand bleed valve on IGNITER boss adapter until monitor gage indicates zero.	Exhaust system is depressurized.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

q. Remove from packaging, lubricate (Method A), and install monitoring port plugs removed in step k. (See figure 3-8.)

r. Install turbopump turbine and heat exchanger antifirex shield. Position marmon clamp coupling joints within 3 degrees of a line extending from the center of the fuel inlet elbows through the turbopump aft support. Torque marmon clamp coupling joint nuts to 85-95 in-lb.

s. Remove monitor system from adapter in gas generator IGNITER boss. Remove hand bleed valve from adapter, and remove adapter.

sA. Remove plug and washer, or gasket, as applicable, from packaging. Clean and inspect threads of plug ST3950122RKL001 for adequate silver plating. Replace plug if silver plating is not adequate. Install washer 651912-3 on plug. Do not lubricate plug. Install plug in gas generator igniter boss and torque to 600-650 in-lb. Safetywire 2 igniter plugs together with Inconel lockwire MS20995N. As an alternate, plug MS9015-08 with washer 651912-3 or gasket AN901-8C may be used. If washer 651912-3 is used, install plug MS9015-08 in igniter boss and torque to 150-200 in-lb. If gasket AN901-8C is used, screw plug MS9015-08 fingertight into igniter boss. Check that gasket seats in recessed groove on igniter boss. Torque plug to 150-200 in-lb. Safetywire plug with Inconel lockwire MS20995N.

t. Disconnect pneumatic source from adapter in gas generator instrumentation port GO2a, and remove adapter.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

u. Remove plug and K-seal from packaging. Lubricate (Method A) plug threads with lubricant grease RB0140-012 (Rocketdyne), and install plug and K-seal 12100CR4 in instrumentation tap GO2a. Torque plug to 80-90 in-lb. Safetywire plug with Inconel lockwire MS20995N.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

v. Remove all leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

w. Remove turbine exhaust exit pressure test fixture (paragraph 3. 6. 18).

3. 3. 2. 13 Turbopump Bearing Coolant System Leak and Function Test.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3 1A when performing this test.

aA. Remove protective covers from oxidizer overboard drain and nitrogen overboard drain lines. Verify that no liquid is present in covers when covers are removed. Notify Engine Contractor if liquid is present.

b. Remove polyethylene bag, as applicable, from fuel overboard drain line at thrust chamber exit; then install pressure test fixture T-5039241, or equivalent, on line.

bA. Connect an external supply source of gaseous nitrogen (MIL-P-27401) capable of being regulated and monitored from 0-15 psig, to test fixture installed in step b.

c. Verify that cross-to-lateral drain tube is removed and that a pressure cap is installed on fuel overboard drain line Y-fitting (paragraph 3.3.2.10).

d. Turn on turbopump LOX seal purge system.

e. Verify gaseous nitrogen flow through purge system at exit ends of lines listed in step a.

Procedure	Result
f. Slowly increase supply pressure to fuel overboard drain line to 10 ±1 psig. Do not exceed 15 psig.	Fuel overboard drain line and fuel drain manifold and lines are pressurized up to bearing coolant control valve outlet port.

CAUTION

Leak-test compound must not be used on flex line bellows since it cannot be removed from the bellows.

g. Apply leak-test compound (MIL-L-25567) to all fittings and joints on bearing coolant control valve outlet, turbine bearing lube feed line hose, and drain lines.	No leakage is allowable.
h. Decrease pressure to fuel overboard drain line to zero.	System is depressurized.

i. Decrease turbopump LOX seal purge system pressure to zero.

j. Install protective covers removed in step a.

k. Disconnect gaseous nitrogen system; then remove pressure test fixture installed in step b.

kA. If engines are horizontal, install protective cover on fuel overboard drain line at thrust chamber exit. Torque cover fasteners finger-tight plus 1/4 turn.

kB. If engines are horizontal, remove pressure cap from fuel overboard drain line Y-fitting and install a polyethylene bag (one gallon minimum volume) on Y-fitting (paragraph 3.6.23.1).

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

l. If engines are vertical, remove pressure cap from fuel overboard drain line Y-fitting. Lubricate (Method A) fitting and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne) and reinstall cross-to-lateral drain tube. Torque tube coupling nuts to 1,200-1,400 in-lb.

lA. If engines are vertical, install a polyethylene bag (one gallon minimum volume) on fuel overboard drain line at thrust chamber exit (paragraph 3.6.23.3).

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

m. Remove all leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.3.2.14 Thrust Chamber Pneumatic Leak Test. When flowtesters are specified in this procedure, Pneumatic Flow Tester G3104, or equivalent, must be used.

a. Remove thrust chamber throat security closure (paragraph 3.6.14), if installed.

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Install thrust chamber throat plug (paragraph 3.6.15).

c. Remove pin and closure from hypergol manifold cartridge container inlet port.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

d. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680). Lubricate (Method A) threads with lubricant grease RB0140-012 (Rocketdyne).

CAUTION

When installing the hypergol system test tool into the hypergol manifold cartridge container inlet port, extreme care must be used to prevent damage to the hypergol cartridge follower.

- The threads of the test tool cap must be clean and free of nicks to prevent galling the threads of the cap and inlet port.

e. Make sure that threads of test tool cap are clean and free of nicks; then lubricate (Method L) cap packing with FS1281 grease (Dow Corning Corp) and carefully insert hypergol system test tool 9021279, or equivalent, into hypergol manifold cartridge container inlet port, and screw cap (clockwise) onto inlet port until cap bottoms.

f. Install an oxidizer-clean adapter incorporating a check valve and a union AN815-8C in thrust chamber dome PURGE 1B port.

g. Connect an external source of gaseous nitrogen (MIL-P-27401), capable of being regulated and monitored from 0-100 psig and filtered through a 40-micron (or smaller) filter, to adapter of thrust chamber dome PURGE 1B port. Attach filter as close as possible to engine attach point.

h. Connect a monitor gage and bleed valve to quick-disconnect of thrust chamber throat plug.

i. Connect a monitor gage and bleed valve to a suitable instrumentation tap on heat exchanger check valve.

CAUTION

A blank plate must be installed in the stage GOX line between the engine interface and the stage oxidizer tank to prevent overpressurization of the oxidizer tank during test.

j. Remove pressure caps from the following quick-disconnects:

CAUTION

In the following procedure, during removal of the No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn or damage to the quick-disconnect body can result.

(1) No. 1 and No. 2 thrust chamber fuel inlet manifold drains

(2) Hypergol manifold drain

(3) Hypergol manifold purge

(4) Ignition monitor valve drain

(5) No. 1 and No. 2 fuel valve purge

NOTE

Step k is omitted at MTF and KSC.

k. Verify that oxidizer dome purge wrap-around hose is disconnected from stage interface and plugged (paragraph 3.3.2.12).

l. Disconnect prefill wrap-around hose from stage interface.

CAUTION

In the following step, the gaseous nitrogen supply hose must be supported to prevent the weight on the seal valve stem from damaging the seal.

lA. Connect a source of gaseous nitrogen to throat plug seal. Using a suitable material, support the gaseous nitrogen supply hose to relieve all weight of hose from seal valve stem.

Procedure	Result
m. Pressurize throat plug seal to 50 (+5, -10) psig. Maintain pressure during remainder of test.	Thrust chamber throat plug seal is pressurized.

WARNING

The following procedure pressurizes the thrust chamber and can be extremely hazardous. All personnel must be kept clear of the thrust chamber exit during this test.

Procedure	Result
n. Slowly supply gaseous nitrogen at 30 (+0, -3) psig to thrust chamber through chamber dome PURGE 1B port.	Thrust chamber is pressurized. Monitor gages indicate 30 (+0, -3) psig.
o. Using flowtester, measure and record reverse-flow leakage past inert prefill check valve gate at prefill wrap-around hose interface.	Maximum allowable leakage is 50 scim.
p. Using flowtester, measure and record poppet reverse-flow leakage at each of the quick-disconnects listed in step j.	Leakage at each quick-disconnect must not exceed 3 scim.

NOTE

Step q is omitted at KSC.

Procedure	Result
q. Remove closure from oxidizer overboard drain line and, using flowtester, measure and record reverse-flow leakage of No. 1 and No. 2 oxidizer dome purge check valve gates.	Maximum allowable leakage is 10 scim. If leakage exceeds 10 scim, perform oxidizer dome purge check valve isolation leak test as outlined in paragraph 3.3.3.4.

r. (Deleted)

CAUTION

Leak-test compound used in the following procedure must not be used on overboard drain line exits to preclude introducing leak-test compound into the lines.

- Leak-test compound must not be used on flex line bellows since it cannot be removed from the bellows.

Procedure	Result
s. Apply leak-test compound (MIL-L-25567) to all flanges, fittings, and connections on or connected to the following: (Record results.)	No leakage is allowable.

(1) Oxidizer valves and fuel valves (downstream of poppets)

(2) Ignition monitor valve sense tube

(3) Hypergol manifold outlet hose

(4) Joints between thrust chamber dome and injector and between injector and thrust chamber body

(5) No. 1 and No. 2 oxidizer dome purge check valves

(6) Thrust chamber dome and gas generator oxidizer purge tubes

(7) Externally exposed thrust chamber tube surfaces

(8) Thrust chamber dome purge ports PURGE 1A, PURGE 2A, PURGE 2B, NO. 3 PURGE, and NO. 4 PURGE

CAUTION

The thrust chamber must be depressurized as outlined in steps t through u to prevent contamination of the engine oxidizer system.

NOTE

Steps t through uA are performed only at KSC.

t. Open hand bleed valve on quick-disconnect of thrust chamber throat plug until pressure starts venting.

Procedure	Result
u. Slowly depressurize thrust chamber to 10 ±1 psig; then close hand bleed valve on quick-disconnect of thrust chamber throat plug as supply pressure is adjusted to maintain pressure as indicated on monitor gage.	Thrust chamber pressure decreases to 10 ±1 psig as indicated on monitor gage.
uA. Apply leak-test compound (MIL-L-25567) to internal thrust chamber tube surfaces between throat plug and exit manifold.	No leakage is allowable.

CAUTION

The thrust chamber must be depressurized as outlined in steps uB through v to prevent contamination of the engine oxidizer system.

Procedure	Result
uB. Completely open hand bleed valve on quick-disconnect of thrust chamber throat plug.	Thrust chamber pressure vents.
uC. Turn off thrust chamber pressure pneumatic source.	Supply pressure to thrust chamber decreases to zero, and monitor gage on thrust chamber throat plug quick-disconnect indicates zero.

Procedure	Result
v. Slowly open hand bleed valve on instrumentation tap of heat exchanger oxidizer supply hose.	Heat exchanger oxidizer system is depressurized.

w. Remove monitor gage and hand bleed valve from heat exchanger check valve.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

wA. Remove from packaging, lubricate (Method A) plug threads with lubricant grease RB0140-012 (Rocketdyne), and install plug and K-seal 12100CR4 in instrumentation tap on heat exchanger check valve. Torque plug to 180 ±10 in-lb. Safetywire plug with Inconel lockwire MS20995N.

x. Remove monitor gage and hand bleed valve from quick-disconnect of thrust chamber throat plug.

y. Remove source of gaseous nitrogen and adapter from thrust chamber dome PURGE 1B port. Lubricate (Method A) plug with lubricant grease RB0140-012 (Rocketdyne) and (Method R) seal with lubricant grease RB0140-012 (Rocketdyne) or fluorinated oil Krytox 143AZ (Du Pont) and install plug and seal. Torque to 350 ±15 in-lb, and record plug installation torque value. Safetywire plug with Inconel lockwire MS20995N.

z. Depressurize thrust chamber throat plug seal.

aa. Remove thrust chamber throat plug (paragraph 3.6.16).

CAUTION

In the following procedure during installation of the No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn or damage to the quick-disconnect body can result.

ab. Remove pressure caps from packaging, and install pressure caps on quick-disconnects listed in step j. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

ac. Install thrust chamber throat security closure (paragraph 3.6.13).

ad. Remove plug from oxidizer dome purge wrap-around hose, and connect hose to stage purge interface. Use customer criteria for installation data and for leak test of connection.

ae. Connect prefill wrap-around hose to stage prefill interface. Use customer criteria for installation data and for leak-test of the connection.

af. Remove pin that secures hypergol test tool cap, and carefully unscrew cap and remove tool from manifold.

WARNING

The following procedure uses dry-cleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

ag. Clean threads of hypergol manifold cartridge container inlet port with dry-cleaning solvent (Federal Specification P-D-680).

ah. Remove hypergol manifold cartridge container inlet port closure from packaging. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp) and install closure. Secure with attaching pin.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

ai. Remove all leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.3.2.15 Thrust Chamber Prefill Line Leak Test.

a. Remove thrust chamber throat security closure (paragraph 3.6.14).

b. Supply gaseous nitrogen (MIL-P-27401) at 40 ±5 psig to prefill fluid stage interface.

c. Verify gaseous nitrogen flow through prefill check valve by feeling prefill lines, or audibly from thrust chamber exit. If there is no flow through check valve, perform prefill check valve isolation test (paragraph 3.3.3.3).

Procedure	Result
d. Using leak-test compound (MIL-L-25567), check all joints of the prefill supply system for leakage.	No external leakage is allowable.

e. Decrease nitrogen supply pressure to zero.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

f. Remove all leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

g. Reinstall thrust chamber throat security closure (paragraph 3.6.13).

3.3.2.16 LOX Dome and Gas Generator LOX Injector Purge Leak and Function Test.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Remove plug from either gas generator igniter boss.

b. Make sure that thrust chamber exit is clear.

c. Turn on operational low-level LOX dome and gas generator LOX injector purge.

d. Verify gaseous nitrogen flow through system at gas generator igniter port and thrust chamber injector.

e. Verify that purge bypass fixed orifice is not plugged by checking for free flow of gaseous nitrogen through oxidizer overboard drain line.

CAUTION

Leak-test compound used in the following procedure must not be used on overboard drain line exits to preclude entry of leak-test compound into the line.

Procedure	Result
f. Apply leak-test compound (MIL-L-25567) to all joints and fittings of LOX dome and gas generator LOX injector purge system.	No external leakage is allowable.

g. Turn off operational low-level LOX dome and gas generator LOX injector purge.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

h. Remove all leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

i. Remove plug and washer, or gasket, as applicable, from packaging. Clean and inspect threads of plug ST3950122RKL001 for adequate silver plating. Replace plug if not present. Install washer 651912-3 on plug. Do not lubricate plug. Install plug in gas generator igniter boss and torque to 600-650 in-lb. Safetywire 2 igniter plugs together with Inconel lockwire MS20995N. As an alternate, plug MS9015-08 with washer 651912-3 or gasket AN901-8C may be used. If washer 651912-3 is used, install plug MS9015-08 in igniter boss and torque to 150-200 in-lb. If gasket AN901-8C is used, screw plug MS9015-08 fingertight into igniter boss. Check that gasket seats in recessed groove on igniter boss. Torque plug to 150-200 in-lb. Safetywire plug with Inconel lockwire MS20995N.

3.3.2.17 Thrust Chamber Liquid Leak Test.

a. If engine environmental cover is installed, untie rope that secures exit end of cover, and turn up and secure end of cover.

aA. Perform, as applicable, comtamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Remove thrust chamber throat security closure (paragraph 3.6.14).

NOTE

Step c may be omitted if the stage pre-valves are to be open and the fuel tank is to be pressurized a minimum of 2 psig during this procedure.

c. Remove pressure cap from, and attach a drain line to, drain quick-disconnects on No. 1 and No. 2 fuel high-pressure ducts.

CAUTION

In the following procedures, drain line must be monitored. If drainage is observed from either line, the source of fluid must be determined before proceeding.

d. Connect thrust chamber fuel jacket purge system to each fuel valve.

e. Make sure that thrust chamber exit manifold drain plugs are in closed position.

WARNING

The following procedure may use trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

CAUTION

In the following procedure, during removal of the No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnect pressure caps, the quick-disconnect body must not be allowed to turn since camage to the quick-disconnect body can result.

NOTE

Step f is omitted if ethylene glycol RB0210-017 (Rocketdyne) is used as the leak-test solution.

f. Remove pressure cap from, and connect a source of trichloroethylene, meeting requirements of section II, or deionized water, to each thrust chamber fuel inlet manifold quick-disconnect.

NOTE

Step g may be omitted if the stage pre-valves are open and the LOX and fuel tanks pressurized a minimum of 2 psig.

g. Pressurize hydraulic control system to 1,550 +50 psig.

h. Pressurize operational low-level LOX dome and gas generator LOX injector purge system.

WARNING

If trichloroethylene is used in the following procedure, inhalation of its vapors or prolonged contact with the liquid must be avoided, since it is a toxic solvent and can cause serious injury or death.

i. Fill thrust chamber to injector overflow with trichloroethylene or ethylene glycol, meeting requirements of section II, or deionized water, as applicable, to injector overflow; then turn off prefill system.

j. Turn off operational low-level LOX dome and gas generator LOX injector purge system.

k. Visually inspect thrust chamber tubes for evidence of fluid leakage. Mark and record location of any leakage.

l. Remove lockwire from thrust chamber exit manifold drain plugs, and install drain tools from Fuel Drainage Kit G2037 at drain plug using gasket RD262-3001-0010 between tool and drain plug adapter. Check that drain tool extension hex wrench is extended outward when installing tool, and drain ports of tool are positioned aft. Torque drain tool to 36-60 in-lb.

m. Install drain hoses on tools.

n. Open drain plugs by inserting drain tool extension hex wrench into head of drain plug and rotating wrench counterclockwise.

o. Turn on operational high-level LOX dome and gas generator LOX injector purge system, and audibly verify purge operation at thrust chamber exit.

p. Pressurize thrust chamber fuel jacket purge system and verify operation of purge by monitoring emission of vapor from thrust chamber.

q. Allow thrust chamber fuel jacket purge to flow for a minimum of 3 minutes and to continue until all vapors cease to be emitted from thrust chamber.

r. Depressurize thrust chamber fuel jacket purge system.

s. Turn off operational high-level LOX dome and gas generator LOX injector purge system.

t. Depressurize hydraulic control system, if applicable.

CAUTION

In the following procedure, during installation of pressure caps on quick-disconnects, the quick-disconnect body must not be allowed to turn, or damage to the body can result.

NOTE

Step u is omitted if ethylene glycol was used as the leak-test fluid.

u. Disconnect prefill system from No. 1 and No. 2 thrust chamber fuel inlet manifold quick-disconnects. Remove pressure caps from packaging and install pressure cap on each quick-disconnect. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

v. Remove drain tools.

w. Remove drain plugs, and reinstall them using new K-seals 12100AA3. Torque drain plugs to 8-12 ft-lb. Safetywire plugs with Inconel lockwire MS20995N.

x. Disconnect pneumatic source from fuel jacket purge quick-disconnect on each fuel valve. Remove pressure caps from packaging, and install pressure cap on each quick-disconnect. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

NOTE

Step y may be omitted if stage prevalves were open and fuel tank was pressurized.

y. Disconnect drain hose from, and install pressure cap on, each fuel high-pressure duct quick-disconnect. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

z. Drain ignition monitor valve sense line (paragraph 3.5.9).

3.3.2.18 Ignition Monitor Valve Poppet Position Verification Test.

a. Verify that hypergol system test tool 9021279, or equivalent, is not installed in hypergol manifold cartridge container port.

b. Verify that gaseous nitrogen system is not connected to ignition monitor valve CONTROL port.

c. Provide instrumentation to monitor propellant valve position indicators (position switches and potentiometers when applicable).

NOTE

Step d may be omitted if test is being performed before completion of LOX dome and gas generator LOX injector flush.

d. Turn on operational low-level LOX dome and gas generator LOX injector purge.

Procedure	Result
e. Slowly pressurize engine hydraulic control system to 1,500 ±50 psig.	Hydraulic control system is pressurized to 1,500 ±50 psig.

CAUTION

The engine control valve start or stop solenoid must not be actuated with a hydraulic pressure of less than 900 psig, since damage to the engine control valve can occur.

f. Momentarily supply 24-30 vdc to engine control valve start solenoid (J-18, pins n (+) and m (-) at engine interface).	Gas generator ball valve and No. 1 and No. 2 oxidizer valves open.

Procedure	Result
g. Verify by fuel valve position switch indication for a minimum of 3 minutes that fuel valves remain closed.	Fuel valve closed position switches must remain on. Fuel valve open position switches must not come on.

CAUTION

The engine control valve start or stop solenoid must not be actuated with a hydraulic pressure of less than 900 psig, since damage to the engine control valve can occur.

h. Momentarily supply 24-30 vdc to engine control valve stop solenoid (J-18, pins g (+) and k (-) at engine interface).	Gas generator ball valve and No. 1 and No. 2 oxidizer valves close.

NOTE

Step i may be omitted if test is being performed before completion of LOX dome and gas generator LOX injector flush.

i. Turn off operational low-level LOX dome and gas generator LOX injector purge.

j. Depressurize hydraulic control system.

3.3.3 ISOLATION TESTS FOR INSTALLED ENGINES.

3.3.3.1 LOX Pump Seal Isolation Test. This test is required only in the event flow past the turbopump intermediate seal is zero. This test determines if the purge supply or the system overboard drain lines are obstructed. Zero flow of the seal is acceptable.

a. With turbopump LOX pump seal purge system pressurized, rotate turbopump shaft approximately 2 revolutions and repeat leakage measurement at overboard drain lines. If leakage is within limits, continue test (paragraph 3.3.2.2).

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. If leakage is not experienced from both sides of turbopump intermediate seal, decrease turbopump LOX seal purge pressure to zero, and backflow the turbopump intermediate seal from LOX side as follows:

(1) Disconnect oxidizer seal vent tube from oxidizer drain tube. Loosen tube clamps, as required to gain access to oxidizer drain tube.

CAUTION

In the following procedure, the pressurization supply line must not be attached to the oxidizer overboard drain tube at the thrust chamber exit.

(2) Connect a gaseous nitrogen supply (MIL-P-27401) to oxidizer drain tube. (Do not attach supply line to drain tube at thrust chamber exit.)

(3) Disconnect turbopump LOX seal purge at interface.

(4) Supply gaseous nitrogen at 10 ±1 psig to LOX propellant feed system.

(5) Supply gaseous nitrogen at 6 +1 psig to oxidizer drain tube, and backflow turbopump intermediate seal from LOX side, allowing flow to go overboard through nitrogen purge overboard drain tube and turbopump LOX seal purge interface.

(6) Verify flow from turbopump LOX seal purge interface and nitrogen overboard drain tube.

(7) Vent gaseous nitrogen pressure from oxidizer drain tube and from LOX propellant feed system.

(8) Disconnect gaseous nitrogen supply from oxidizer drain tube.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

(9) Remove packaging from oxidizer seal vent tube. Lubricate (Method A) threads of oxidizer drain tube and (Method G) oxidizer seal vent tube with lubricant grease RB0140-012 (Rocketdyne), and install oxidizer seal vent tube. Torque tube coupling nut to 1,500-1,800 in-lb. Secure clamp, as required.

(10) Reconnect turbopump LOX seal purge at stage interface. Use Stage Contractor criteria for installation data and for leak test of the connection.

(11) Verify leakage from both sides of turbopump intermediate seal (paragraph 3.3.2.2).

3.3.3.2 Fuel Overboard Drain Line Isolation Test. This test is required only in event of excessive leakage from fuel overboard drain line.

Procedure	Result
a. Depressurize hydraulic control system to zero.	Hydraulic control system is depressurized.
b. Depressurize ignition monitor valve CONTROL port.	Ignition monitor valve CONTROL port is depressurized.

bA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

c. Remove redundant shutdown valve override line from between redundant shutdown valve and engine control valve as follows:

(1) Remove attaching hardware that secures line to redundant shutdown valve, and remove seal plate. (Refer to R-3896-3 for handling information.) Retain attaching hardware for reinstallation, if acceptable for reuse in accordance with section II.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

(2) Install pressure test fixture T-5041521 on redundant shutdown valve OUT port. Lubricate (Method J) fixture O-ring with lubricant grease RB0140-012 (Rocketdyne). Torque fasteners to 85-95 in-lb.

(3) Disconnect line from engine control valve OVERRIDE port.

NOTE

Line may be left clamped to engine.

d. Remove control valve override drain tube from between tee and redundant shutdown valve DRAIN port.

e. Disconnect ignition monitor valve drain tube from ignition monitor valve ATMOS REF port.

Procedure	Result
f. Slowly pressurize ignition monitor valve CONTROL port to 50 ±5 psig.	Ignition monitor valve CONTROL port is pressurized.

Procedure	Result
g. Slowly increase hydraulic control system pressure to 1,550 ±50 psig. Maintain this pressure for 5 minutes minimum while performing step h.	Hydraulic control system is pressurized.

h. Monitor and record hydraulic fluid leakage at the following ports:

(1) Ignition monitor valve ATMOS REF	5 cc/m maximum
(2) Engine control valve OVERRIDE	5 cc/m maximum
(3) Redundant shutdown valve DRAIN	2 cc/m maximum

i. Verify that hydraulic fluid has circulated for a minimum of 15 minutes to remove entrapped air from hydraulic control system before proceeding with test.

j. Momentarily supply 24-30 vdc to engine control valve start solenoid (J-18, pins n(+) and m(-) at engine interface).	Gas generator ball valve, No. 1 and No. 2 oxidizer valves, and No. 1 and No. 2 fuel valves open.
k. Repeat step h.	As specified in step h.
l. Slowly increase hydraulic control system pressure to 1,800 ±50 psig.	Hydraulic control system pressure is increased.
m. Repeat step h.	As specified in step h.
n. Slowly decrease hydraulic control system pressure to 1,550 ±50 psig.	Hydraulic control system pressure decreases and stabilizes.

WARNING

The following procedure energizes the redundant shutdown valve solenoid, which causes the valve housing to heat up. After electrical power has been applied continuously, the valve solenoid case temperature can cause injury to personnel touching the case.

CAUTION

If the redundant shutdown valve is kept energized for more than 15 minutes, the solenoid temperature buildup will cause the valve to actuate slower.

Procedure	Result
o. Supply 24-30 vdc to redundant shutdown valve solenoid (J-10, pins D(+) and L(-) at engine interface).	Redundant shutdown valve is energized.
p. After hydraulic system has been pressurized for 2 minutes minimum, monitor and record fluid leakage at redundant shutdown DRAIN port.	Leakage past drain port seal must not exceed 2 cc/m.
q. Deenergize redundant shutdown valve solenoid.	Redundant shutdown valve is deenergized.
r. Supply 24-30 vdc to engine control valve stop solenoid (J-18, pins g (+) and k (-) at engine interface) and monitor OVERRIDE port for leakage; then deenergize stop solenoid.	Leakage past OVERRIDE port must not exceed 5 cc/m.
s. Depressurize hydraulic control system to zero.	Hydraulic control system is depressurized.
t. Depressurize ignition monitor valve CONTROL port to zero.	Ignition monitor valve CONTROL port is depressurized.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

u. Remove plugs, lubricate (Method A) fittings and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne), and install control valve override drain tube between tee and redundant shutdown valve DRAIN port. Torque tube coupling nuts to 135-185 in-lb.

v. Remove pressure test fixture T-5041521; then install redundant shutdown valve override line as follows:

(1) Remove seal plate from packaging, and install seal plate between line flange and redundant shutdown valve OUT port. Secure line to valve with 4 bolts and washers. Torque bolts to 85-95 in-lb. Safetywire bolts with Inconel lockwire MS20995N.

(2) Connect line to engine control valve OVERRIDE port. Torque coupling nut. During last 1/2 turn prior to seating flare, record maximum torque. Torque must be 50-200 in-lb. Continue to torque coupling nut to 270-340 in-lb above recorded torque.

Procedure	Result
w. Increase hydraulic control system pressure to 1,550 ±50 psig.	Hydraulic control system pressure is increased.

WARNING

The following procedure energizes the redundant shutdown valve solenoid, which causes the valve housing to heat up. After electrical power has been applied continuously, the valve solenoid case temperature can cause injury to personnel touching the case.

CAUTION

If the redundant shutdown valve is kept energized for more than 15 minutes, the solenoid temperature buildup will cause the valve to actuate slower.

x. Supply 24-30 vdc to redundant shutdown valve solenoid (J-18, pins D(+) and L(-) at engine interface).	Engine control valve override port is pressurized.
y. Monitor redundant shutdown valve override line connection for leakage.	No leakage is allowable.
z. Increase hydraulic control system pressure to 1,800 ±50 psig.	Hydraulic control system pressure is increased.
aa. Repeat step y.	As specified in step y.
ab. Decrease hydraulic control system pressure to 1,500 ±50 psig.	Hydraulic control system pressure decreases and stabilizes.

CAUTION

The following procedure deenergizes the redundant shutdown valve which will cause approximately 25 cc of hydraulic fluid to be expelled from the fuel overboard drain line. Personnel must be kept clear of the fuel overboard drain line.

ac. Deenergize redundant shutdown valve solenoid.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

ad. Remove plugs, lubricate (Method A) fitting and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne), and install ignition monitor valve drain tube. Torque coupling nut to 270-345 in-lb.

3.3.3.3 Prefill Check Valve Isolation Test. This test is required only in the event that flow through the prefill check valve is zero during leak and function testing when the supply pressure from the stage is interconnected to all engines.

a. Decrease pressure to prefill fluid engine interface to zero.

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Disconnect thrust chamber jacket prefill line from stage interface; then remove prefill line from engine as outlined in R-3896-3.

c. Install inlet port half of pressure test fixture T-5037801.

d. Connect a source of gaseous nitrogen (MIL-P-27401) to pressure test fixture T-5037801.

e. Slowly supply gaseous nitrogen pressure to prefill check valve inlet at 15 (+5, -0) psig.

f. Verify flow through check valve at thrust chamber exit by audible indication or by feeling supply line.

g. Decrease supply pressure to check valve inlet to zero, disconnect supply, and remove pressure test fixture from prefill check valve inlet.

h. Absence of flow through prefill check valve requires replacement of prefill check valve. If flow through prefill check valve is verified, reinstall thrust chamber jacket prefill line on engine as outlined in R-3896-3. Connect thrust chamber jacket prefill line to stage interface, using Stage Contractor criteria for installation data and leak test of the connection, then repeat leak test of line joints (paragraph 3.3.2.15).

3.3.3.4 Oxidizer Dome Purge Check Valve Isolation Leak Test.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Remove clamp that secures No. 2 oxidizer dome purge line to support bracket. Retain attaching hardware for reinstallation, if acceptable for reuse in accordance with requirements outlined in section II.

c. Remove attaching hardware that secures No. 2 oxidizer dome purge line to No. 2 oxidizer dome purge check valve, and carefully remove orifice plate. Retain attaching hardware for reinstallation, if acceptable for reuse in accordance with requirements of section II.

Procedure	Result
d. Using Pneumatic Flow Tester G3104, measure reverse-flow leakage of No. 2 oxidizer dome purge check valve at check valve to line interface.	Maximum allowable leakage is 10 scim.

e. If leakage in step d is more than 10 scim, replace No. 2 oxidizer dome purge check valve as outlined in R-3896-3.

f. Subtract leakage obtained in step d for No. 2 oxidizer dome purge check valve gate from leakage obtained in thrust chamber pneumatic leak test (paragraph 3.3.2.14, step q) to obtain leakage for No. 1 oxidizer dome purge check valve gate. If leakage of No. 1 oxidizer dome purge check valve gate is more than 10 scim, replace No. 1 oxidizer dome purge check valve gate as outlined in R-3896-3.

g. Remove packaging and install No. 2 oxidizer valve dome purge line as follows:

(1) Verify alinement of line as outlined in R-3896-3.

(2) Install same orifice plate as removed between line and oxidizer dome purge check valve. Secure line to valve with 4 bolts and washers. Torque bolts to 33-39 in-lb. Safetywire bolts with Inconel lockwire MS20995N.

h. Continue test in paragraph 3.3.2.14.

3.4 STORAGE PREPARATION.

3.4.1 Storage preparation activities specified in section I, when complemented by criteria referenced in section II, require no additional instructions: therefore, no recommendations are provided for the method of accomplishing storage preparation activities.

3.5 SERVICING.

3.5.1 LOX DOME AND GAS GENERATOR LOX INJECTOR FLUSH. This procedure contains instructions for flushing the thrust chamber oxidizer dome and gas generator oxidizer injector.

NOTE

When performing this procedure with the engine environmental cover installed, the rope that secures the exit end of the cover must be untied and the end of the cover turned up and secured to prevent trichloroethylene from accumulating in the cover. At the completion of the procedure, the cover must be lowered and secured in accordance with paragraph 3.6.5.

- In steps requiring hose coupling torques in excess of torque required for fittings, fittings must be held to avoid overtorquing.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Remove pin and closure from hypergol manifold cartridge container inlet port.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

b. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680). Lubricate (Method A) threads with lubricant grease RB0140-012 (Rocketdyne).

CAUTION

When installing the hypergol system test tool into the hypergol manifold cartridge container inlet port, extreme care must be used to prevent damage to the hypergol cartridge follower.

- The threads of the test tool cap must be clean and free of nicks to prevent galling the threads of the cap and inlet port.

c. Make sure that threads of test tool cap are clean and free of nicks, lubricate (Method L) cap packing with FS1281 grease (Dow Corning Corp); then carefully insert hypergol system test tool 9021279 into hypergol cartridge container inlet port, and screw cap (clockwise) onto inlet port until it bottoms.

NOTE

During oxidizer dome flushing, the engine must be maintained in null position with stage and engine in vertical position.

- If heat exchanger check valve is pressurized at 4-psig minimum, proceed to step e.

d. Remove heat exchanger check valve, and install a suitable test plate on thrust chamber oxidizer dome outlet port.

e. Verify that any test instrumentation lines that could trap trichloroethylene during flush are disconnected and ports capped off

f. Install Oxidizer Dome Flushing Kit G2030 (paragraph 3.5.1.1).

g. Remove pressure cap from, and connect thrust chamber fuel jacket purge system to, fuel jacket purge quick-disconnect on each fuel valve. If thermal insulation is installed, gain access to fuel jacket purge quick-disconnect on No. 1 fuel valve by loosening insulator 145510 as outlined in paragraph 3.5.16.

h. Remove pressure cap from, and connect hypergol servicing purge system to, hypergol purge quick-disconnect.

i. Remove pressure cap from, and connect an oxidizer-clean source of gaseous nitrogen (MIL-P-27401) capable of supplying 175 ±25 psig under flow conditions to, flushing kit manifold GN_2 inlet port.

j. Remove pressure cap from, and connect LOX dome and gas generator LOX injector flushing system to, flushing kit manifold trichloroethylene inlet nipple.

k. Remove thrust chamber throat security closure (paragraph 3. 6. 14).

l. Remove plug from gas generator combustor drain port and connect a suitable drain hose to port.

m. Pressurize flushing kit pneumatic system to 175 ±25 psi as indicated on flushing kit GN_2 gage.

n. Pressurize hypergol servicing purge system to 150 ±50 psig.

o. Pressurize thrust chamber fuel jacket purge system to 300 ±100 psig.

WARNING

The following procedure uses trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause injury or death.

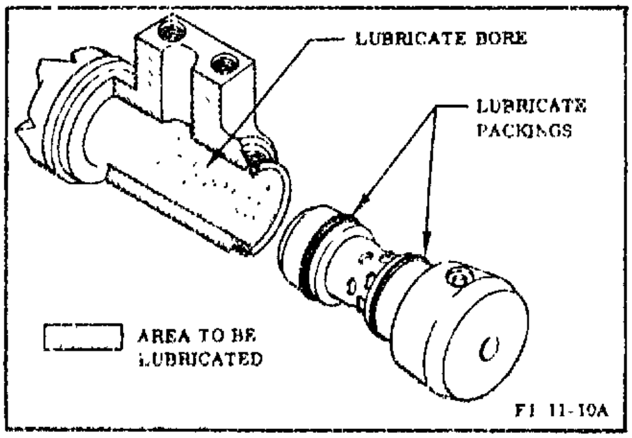


Figure 3-9. Lubricating Hypergol Manifold Bore

p. Pressurize LOX dome and gas generator LOX injector trichloroethylene flushing system to 90 ±10 psi as indicated on flushing kit trichloroethylene gage, flush thrust chamber oxidizer dome and gas generator oxidizer injector cavity for a minimum of 30 seconds, and verify flow through drain hose installed in step l. Depressurize flushing kit trichloroethylene system, and wait 2 minutes before proceeding to next step.

q. Depressurize thrust chamber fuel jacket purge system.

r. Depressurize hypergol servicing purge system.

s. Depressurize flushing kit pneumatic system.

t. Disconnect LOX dome and gas generator LOX injector flushing system from flushing kit manifold trichloroethylene inlet quick-disconnect, and reinstall pressure cap.

u. Pressurize flushing kit pneumatic system to 175 ±25 psig.

v. Pressurize hypergol servicing purge system to 150 ±50 psig.

w. Pressurize thrust chamber fuel jacket purge system to 300 ±100 psig.

x. Allow purges to flow for 5 minutes minimum, continue until all vapors are expelled from thrust chamber before proceeding to next step.

y. Depressurize thrust chamber fuel jacket purge system.

z. Depressurize hypergol servicing purge system.

aa. Depressurize flushing kit pneumatic system.

ab. Disconnect 4 hoses from thrust chamber oxidizer dome; then remove reducers and adapter manifolds, if applicable, from bosses on thrust chamber oxidizer dome, and reinstall reducers on hoses. Install pressure caps on reducers to prevent entry of contaminants.

ac. See figure 3-10, and temporarily disconnect dome flushing kit bracket 9012790 from thermal insulation bracketry to gain access to oxidizer side of gas generator. Support bracket while disconnected.

ad. Remove 3 bolts that secure flushing kit adapter to gas generator ball valve. Remove adapter from ball valve. Install cover on adapter to prevent entry of contaminants.

ae. Install gas generator purge check valve as follows:

(1) Remove test plate and protective closure, and install gas generator purge check valve, oxidizer purge tube, and seal RD261-3010-0009 on gas generator ball valve with 3 bolts and washers. Torque bolts to 40-50 in-lb. Safetywire bolts with Inconel lockwire MS20995N.

(2) Insert seal 19-406332-5 between gas generator oxidizer purge tube and purge manifold, and verify that seal 19-406332-5 is between manifold and purge tube; then connect purge tube to manifold with 4 bolts and washers. Torque bolts to 70-80 in-lb. Safetywire bolts with Inconel lockwire MS20995N.

af. See figure 3-10, and reconnect dome flushing kit bracket 9012790 to thermal insulation bracketry.

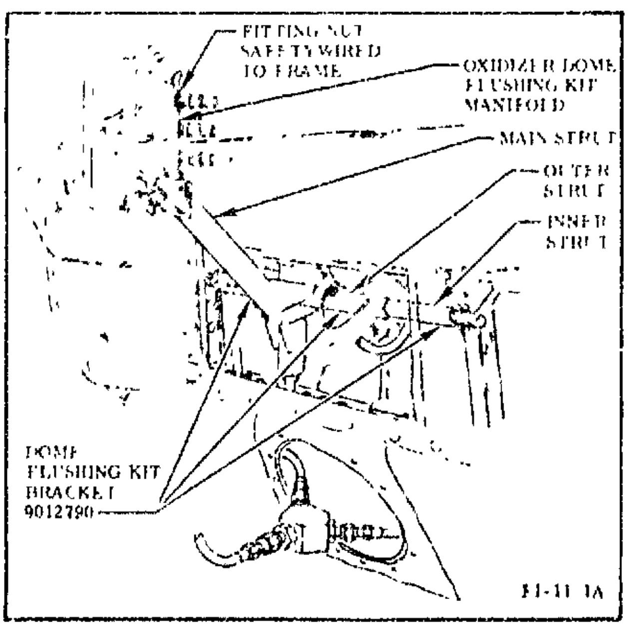


Figure 3-10. Oxidizer Dome Flushing Kit Manifold Bracket Installation

ag. Remove any plugs installed in step e.

ah. Turn on operational high-level LOX dome and gas generator LOX injector purge system.

ai. Pressurize flushing kit pneumatic system to 175 ±25 psig.

aj. Pressurize hypergol servicing purge system to 150 ±50 psig.

ak. Pressurize thrust chamber fuel jacket purge system to 300 ±100 psig.

CAUTION

Leak-test compound must not be used on flex line bellows since it cannot be removed from the bellows.

al. Using leak-test compound (MIL-L-25567), leak-test gas generator oxidizer purge manifold joints and gas generator purge check valve to gas generator ball valve joint. No leakage is allowable.

am. Allow purges to flow for 5 minutes minimum; continue until all vapors are expelled from thrust chamber exit and gas generator drain port before proceeding to next step.

an. Depressurize hypergol servicing purge system.

ao. Depressurize thrust chamber fuel jacket purge system.

ap. Depressurize flushing kit pneumatic system.

aq. Turn off operational high-level LOX dome and gas generator LOX injector purge system.

ar. If heat exchanger check valve was removed in step d, remove thrust chamber oxidizer dome outlet port cover and reinstall heat exchanger check valve as outlined in R-3896-3.

as. Disconnect pneumatic system from hypergol purge quick-disconnect. Remove packaging and install pressure cap. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

at. Disconnect pneumatic system from each fuel jacket purge quick-disconnect. Remove packaging and install pressure caps. Torque pressure caps to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

atA. If thermal insulation is installed, secure insulator 145510 as outlined in paragraph 3.5.16.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

au. Remove combustor drain hose. Remove plugs and seals from packaging. Lubricate (Method A) threads of plug with lubricant grease RB0140-012 (Rocketdyne), and install plug RD273-6003-0004 and K-seal 12100AA4 in combustor drain boss. Torque plug to 200-240 in-lb. Safetywire plug with Inconel lockwire MS20995N.

av. Remove plugs and seals from packaging. Lubricate (Method A) plugs with lubricant grease RB0140-012 (Rocketdyne) and (Method R) new K-seals with lubricant grease RB0140-012 (Rocketdyne) or fluorinated oil Krytox 143AZ (Du Pont), and install 6 plugs and K-seals in thrust chamber oxidizer dome purge ports. Install plugs AN814-8JL and K-seals 12100CR8 in bosses PURGE 1A, PURGE 1B, PURGE 2A, and PURGE 2B. Torque plugs to 350 ±15 in-lb. Install plugs AN814-12CL and K-seals 12100CR12 in bosses NO. 3 PURGE and NO. 4 PURGE. Torque plugs to 80 ±10 ft-lb. Safetywire plugs with Inconel lockwire MS20995N.

aw. Remove oxidizer dome flushing kit G2030 (paragraph 3.5.1.2).

ax. Remove hypergol system test tool.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

ay. Clean threads of hypergol cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680).

az. Remove hypergol cartridge container inlet port closure from packaging. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp) and install closure. Secure closure with attaching pin.

ba. Remove plugs and install any instrumentation lines removed in step e.

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

bb. Remove all leak-test compound from all joints and fittings with a clean, dry cloth or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.5.1.1 <u>Oxidizer Dome Flushing Kit Installation for LOX Dome and Gas Generator LOX Injector Flush.</u> The following procedure may be used on engines with or without thermal insulation panels installed but with thermal insulation bracketry installed. See figure 2-5, and install oxidizer dome flushing kit as follows:

a. If thermal insulation panels are installed on engine, see figure 2-15 and remove the following thermal insulation panels:

(1) Thrust OK pressure switches and oxidizer dome purge and flush ports

(2) No. 1 oxidizer dome flush and purge ports

(3) No. 2 oxidizer dome flush and purge ports

(4) Gas generator oxidizer purge check valve

(5) Gas generator igniters

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Verify that nut on fitting installed in oxidizer dome flushing kit No. 5 0800 port is safetywired to frame and that aluminum seal is installed. If lockwire or aluminum seal is missing, verify that oxidizer dome flushing kit is correctly assembled and leak tested as outlined in R-3896-5, prior to proceeding with test.

c. On uninstalled engines, install flushing kit manifold adapter 9022108 as follows:

(1) Remove 4 bolts, 4 washers, and seal plate that secures gas generator oxidizer purge tube to purge manifold.

(2) Remove 3 bolts, 3 washers, and seal that secures gas generator purge check valve to gas generator ball valve; then remove check valve together with gas generator oxidizer purge tube.

(3) Install protective closures on purge tube and check valve.

(4) Install flushing kit manifold adapter 9022108 in gas generator oxidizer purge port. Torque the 3 mounting bolts to 40-50 in-lb.

(5) Connect hose R3806-12-0800 to adapter 9022108. See figure 2-5 for hose routing when thermal insulation is installed. Torque hose coupling nuts to 900-1,100 in-lb. Protect loose end of hose from contamination.

NOTE

Step cA is required only for first flushing operation on installed engines.

cA. On installed engines, to prevent frosting of gas generator purge check valve during flushing, perform the following.

(1) On all engines, remove gas generator purge check valve and gas generator oxidizer purge tube as follows:

(a) Remove 4 bolts, 4 washers, and seal plate that secures gas generator oxidizer purge tube to purge manifold.

(b) Remove 3 bolts, 3 washers, and seal that secures gas generator purge check valve to gas generator ball valve; then remove check valve together with gas generator oxidizer purge tube.

(2) On all engines, install test plate T-5047892 on purge manifold using bolts, washers, and seal plate removed in substep 1, a. Install bolts fingertight; then on engines not being flushed, torque bolts to 70-80 in-lb.

(3) On engines not being flushed, install closures on gas generator oxidizer purge port.

(4) On engines being flushed, install flushing kit manifold adapter 9022108 as follows:

(a) Install flushing kit manifold adapter 9022108 in gas generator oxidizer purge port. Torque the 3 mounting bolts to 40-50 in-lb.

(b) Connect hose R3806-12-0800 to adapter 9022108. See figure 2-5 for hose routing when thermal insulation is installed. Torque hose coupling nuts to 900-1,000 in-lb. Protect loose end of hose from contamination.

NOTE

Step cB is required only after first flushing operation on installed engines.

cB. On engine to be flushed, remove closure from gas generator oxidizer purge port and install flushing kit manifold adapter 9022108 as follows:

(1) Install flushing kit manifold adapter 9022108 in gas generator oxidizer purge port. Torque the 3 mounting bolts to 40-50 in-lb.

(2) Connect hose R3806-12-0800 to adapter 9022108. See figure 2-5 for hose routing when thermal insulation is installed. Torque hose coupling nuts to 900-1,000 in-lb. Protect loose end of hose from contamination.

d. See figure 3-10, and position dome flushing kit bracket 9012790 in thermal insulation bracketry holes. When thermal insulation is installed, position main strut of bracket as far from gas generator as thermal insulation access door will permit. Secure bracket in place by securing inner strut to outer strut with attached pin.

e. Position oxidizer dome flushing kit manifold on dome flushing kit bracket and secure with attached pin.

f. See figure 2-5, and connect hoses between oxidizer dome flushing kit manifold and engine as follows:

(1) Remove plugs from thrust chamber oxidizer dome bosses PURGE 1A and PURGE 1B.

NOTE

In the following procedure, in steps requiring hose coupling torque in excess of torque required for unions or reducers, unions or reducers must be held to avoid overtorquing.

- The method for applying lubricant in the following procedure is outlined in R-3896-3.

(2) Lubricate (Method A) reducer with lubricant grease RB0140-012 (Rocketdyne) and (Method B) K-seal with lubricant grease RB0140-012 (Rocketdyne) or fluorinated oil Krytox 143AZ (Du Pont), and install reducer AN919-15C, K-seal 12100CR8, and adapter 9024153 from adapter kit 9024165 in thrust chamber oxidizer dome bosses PURGE 1A and PURGE 1B. Torque reducer to purge boss connections to 300-720 in-lb. Torque hose coupling nuts to reducer to 650-750 in-lb.

(3) Install hose R3806-12-0500 between adapter manifold in bosses PURGE 1A and PURGE 1B and flushing kit manifold port No. 1 0500. Torque hose coupling nuts 900-1,100 in-lb.

(4) Remove plugs from thrust chamber oxidizer dome bosses PURGE 2A and PURGE 2B.

(5) Lubricate (Method A) reducer with lubricant grease RB0140-012 (Rocketdyne) and (Method R) K-seal with lubricant grease RB0140-012 (Rocketdyne) or fluorinated oil Krytox 143AZ (Du Pont), and install reducer AN919-15C, K-seal 12100CR8, and adapter 9024153 in thrust chamber oxidizer dome bosses PURGE 2A and PURGE 2B. Torque reducer to purge boss connection to 300-720 in-lb. Torque coupling nuts at reducer to 650-750 in-lb.

(6) Install hose R3806-12-1000 between adapter manifold in bosses PURGE 2A and PURGE 2B and flushing kit manifold port No. 2 1000. Torque hose coupling nuts to 900-1,100 in-lb.

(7) Remove plug from thrust chamber oxidizer dome boss NO. 3 PURGE.

(8) Lubricate (Method A) reducer with lubricant grease RB0140-012 (Rocketdyne) and (Method R) K-seal with lubricant grease RB0140-012 (Rocketdyne) or fluorinated oil Krytox 143AZ (Du Pont), and install union AN815-12C and K-seal 12100CR12 in thrust chamber dome boss NO. 3 PURGE. Torque union to 420-600 in-lb.

(9) Install hose R3806-12-0600 between union in thrust chamber oxidizer dome boss NO. 3 PURGE and flushing kit manifold port No. 3 0600. Torque hose coupling nuts to 900-1,100 in-lb.

(10) Remove plug from thrust chamber oxidizer dome boss NO. 4 PURGE.

(11) Lubricate (Method A) reducer with lubricant grease RB0140-012 (Rocketdyne) and (Method R) K-seal with lubricant grease RB0140-012 (Rocketdyne) or fluorinated oil Krytox 143AZ (Du Pont), and install union AN832-12J and K-seal 12100CR12 in thrust chamber oxidizer dome boss NO. 4 PURGE. Torque union to 420-600 in-lb.

(12) Install hose R3806-12-1080 between union in thrust chamber oxidizer dome boss NO. 4 PURGE and flushing kit manifold port No. 4 1080. Torque hose coupling nuts to 900-1,100 in-lb.

(13) Install hose R3806-12-0800 between adapter 9022108 and flushing kit manifold port No. 5 0800. Torque hose coupling nuts to 900-1,100 in-lb.

(14) Remove plugs from taps GF2a and GF2b.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

(15) Install flushing kit manifold diffusers 9023934 with K-seals 12100AA4 in taps GF2a and GF2b. Lubricate (Method A) diffuser with lubricant grease RB0140-012 (Rocketdyne). Torque diffusers to 200-240 in-lb.

(16) Connect hoses 19-9014938-11 at flushing kit manifold 9025254 to diffusers. Torque hose coupling nut to 270-345 in-lb.

3.5.1.2 Oxidizer Dome Flushing Kit Removal for LOX Dome and Gas Generator LOX Injector Flush.

a. Disconnect hoses from flushing kit manifold 9025254. Install pressure caps on manifold fittings and plugs in end of hoses.

b. Remove flushing kit manifold 9025254 from dome flushing kit bracket 9012790: then disconnect dome flushing kit bracket from thermal insulation bracketry.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

c. Remove diffusers from taps GF2a and GF2b. Remove plugs and K-seals from packaging. Lubricate (Method A) plug threads with lubricant grease RB0140-012 (Rocketdyne), and install plugs RD273-6003-0004 and K-seals 12100AA4 in instrumentation taps GF2a and GF2b. Torque plugs to 200-240 in-lb. Safety-wire plugs with Inconel lockwire MS20995N.

3.5.2 LOX DOME FLUSH. This procedure contains instructions for flushing the thrust chamber oxidizer dome.

NOTE

When performing this procedure with the engine environmental cover installed, the rope that secures the exit end of the cover must be untied and the end of the cover turned up and secured to prevent trichloroethylene from accumulating in the cover. At the completion of the procedure, the cover must be lowered and secured in accordance with paragraph 3.6.5.

- In steps requiring hose coupling torque in excess of torque required for fittings, fittings must be held to avoid overtorquing.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

aA. Remove pin and closure from hypergol manifold cartridge container inlet port.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

b. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680). Lubricate (Method A) threads with lubricant grease RB0140-012 (Rocketdyne). See figure 3-9, and lubricate bore of container with FS1281 grease (Dow Corning Corp).

CAUTION

When installing the hypergol system test tool into the hypergol manifold cartridge container inlet port, extreme care must be used to prevent damage to the hypergol cartridge follower.

- The threads of the test tool cap must be clean and free of nicks to prevent galling the threads of the cap and inlet port.

c. Make sure that threads of test tool cap are clean and free of nicks, lubricate (Method L) cap packing with FS1281 grease (Dow Corning Corp); then carefully insert hypergol system test tool 9021279 into hypergol cartridge container inlet port, and screw cap (clockwise) onto inlet port until it bottoms.

NOTE

During oxidizer dome flushing the engine must be maintained in a null position with stage and engine in a vertical position.

- If heat exchanger check valve is pressurized at 4-psig gaseous nitrogen pressure, proceed to step e.

d. Remove heat exchanger check valve, and install a suitable test plate on thrust chamber oxidizer dome outlet port.

e. Verify that any test instrumentation lines that could trap trichloroethylene during flush are disconnected and ports capped off.

f. Install Oxidizer Dome Flushing Kit G2030 (paragraph 3. 5. 2. 1).

g. Remove pressure cap from, and connect thrust chamber fuel jacket purge system to, fuel jacket purge quick-disconnect on each fuel valve. If thermal insulation is installed, gain access to fuel jacket purge quick-disconnect on No. 1 fuel valve by loosening insulator 145510 as outlined in paragraph 3. 5. 16.

h. Remove pressure cap from, and connect hypergol servicing purge system to, hypergol purge quick-disconnect.

i. Remove pressure cap from, and connect an oxidizer-clean source of gaseous nitrogen (MIL-P-27401) capable of supplying 175 ±25 psig under flow conditions to, flushing kit manifold GN_2 inlet port.

j. Remove pressure cap from, and connect LOX dome and gas generator LOX injector flushing system to, flushing kit manifold trichloroethylene inlet nipple.

k. Remove thrust chamber throat security closure (paragraph 3. 6. 14).

l. Pressurize flushing kit pneumatic system to 175 ±25 psi as indicated on flushing kit GN_2 gage.

m. Pressurize hypergol servicing purge system to 150 ±50 psig.

n. Pressurize thrust chamber fuel jacket purge system to 300 ±100 psig.

WARNING

The following procedure uses trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause injury or death.

o. Pressurize LOX dome and gas generator LOX injector trichloroethylene flushing system to 90 ±10 psi as indicated on flushing kit trichloroethylene gage, and flush thrust chamber oxidizer dome for a minimum of 30 seconds. Depressurize flushing kit trichloroethylene system, and wait 2 minutes before proceeding to next step.

p. Depressurize thrust chamber fuel jacket purge system.

q. Depressurize hypergol servicing purge system.

r. Depressurize flushing kit pneumatic system.

s. Disconnect LOX dome and gas generator LOX injector flushing system from flushing kit manifold trichloroethylene inlet quick-disconnect, and reinstall pressure cap.

t. Pressurize flushing kit pneumatic system to 175 ±25 psig.

u. Pressurize hypergol servicing purge system to 150 ±50 psig.

v. Pressurize thrust chamber fuel jacket purge system to 300 ±100 psig.

w. Allow purges to flow for 5 minutes minimum; continue until all vapors are expelled from thrust chamber before proceeding to next step.

x. Depressurize thrust chamber fuel jacket purge system.

y. Depressurize hypergol servicing purge system.

z. Depressurize flushing kit pneumatic system.

aa. Disconnect 4 hoses from thrust chamber oxidizer dome; then remove reducers and adapter manifolds, if applicable, from bosses on thrust chamber oxidizer dome, and reinstall reducers on hoses. Install pressure caps on reducers to prevent entry of contaminants.

ab. Remove any plugs installed in step e.

ac. Turn on operational high-level LOX dome and gas generator LOX injector purge system.

ad. Pressurize hypergol servicing purge system to 150 ±50 psig.

ae. Pressurize thrust chamber fuel jacket purge system to 300 +100 psig.

af. Allow purges to flow for 5 minutes minimum; continue until all vapors are expelled from thrust chamber exit.

ag. Depressurize hypergol servicing purge system.

ah. Depressurize thrust chamber fuel jacket purge system.

ai. (Deleted)

aj. Turn off operational high-level LOX dome and gas generator LOX injector purge system.

ak. If heat exchanger check valve was removed in step d, remove thrust chamber oxidizer dome outlet port cover and reinstall heat exchanger check valve as outlined in R-3896-3.

al. Disconnect pneumatic system from hypergol purge quick-disconnect. Remove pressure cap from packaging, and install pressure cap. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

am. Disconnect pneumatic system from each fuel jacket purge quick-disconnect. Remove pressure caps from packaging, and install pressure caps. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

amA. If thermal insulation is installed, secure insulator 145510 as outlined in paragraph 3.5.16.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

an. Remove plugs and K-seals from packaging. Lubricate (Method A) plugs with lubricant grease RB0140-012 (Rocketdyne) and (Method R) new K-seals with lubricant grease RB0140-012 (Rocketdyne) or fluorinated oil Krytox 143AZ (Du Pont), and install 6 plugs and K-seals in thrust chamber oxidizer dome purge ports. Install plugs AN814-8CL and K-seals 12100CR8 in bosses PURGE 1A, PURGE 1B, PURGE 2A, and PURGE 2B. Torque plugs to 350 ±15 in-lb. Install plugs AN814-12CL and K-seals 12100CR12 in bosses NO. 3 PURGE and NO. 4 PURGE. Torque plugs to 80 ±10 ft-lb. Safetywire plugs with Inconel lockwire MS20995N.

ao. Remove oxidizer dome flushing kit G2030 (paragraph 3.5.2.2).

ap. Remove hypergol system test tool.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

aq. Clean threads of hypergol cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680).

ar. Remove hypergol cartridge container inlet port closure. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp) and install closure. Secure closure with attaching pin.

as. Remove plugs and install any instrumentation line removed in step e.

3.5.2.1 Oxidizer Dome Flushing Kit Installation for LOX Dome Flush. The following procedure may be used on engines with or without thermal insulation panel installed but with bracketry installed. See figure 2-5, and install oxidizer dome flushing kit as follows:

a. If thermal insulation panels are installed on engine, see figure 2-15 and remove the following thermal insulation panels.

(1) Thrust OK pressure switches and oxidizer dome purge and flush ports

(2) No. 1 oxidizer dome flush and purge ports

(3) No. 2 oxidizer dome flush and purge ports

(4) Gas generator oxidizer purge check valve

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Verify that nut on fitting installed in oxidizer dome flushing kit No. 5 0800 port is safetywired to frame and that aluminum seal is installed. If lockwire of aluminum seal is missing, verify that oxidizer dome flushing kit is correctly assembled and leak tested as outlined in R-3896-5, prior to proceeding with test.

c. See figure 3-10, and position dome flushing kit bracket 9012790 in thermal insulation bracketry holes. Secure bracket in place by securing inner strut to outer strut with attached pin.

d. Position oxidizer dome flushing kit manifold on dome flushing kit bracket and secure with attached pin.

e. See figure 2-5, and connect hose between oxidizer dome flushing kit manifold and engine as follows:

(1) Remove plugs from thrust chamber oxidizer dome bosses PURGE 1A and PURGE 1B.

NOTE

In the following procedure, in steps requiring hose coupling torque in excess of torque required for unions or reducers, unions or reducers must be held to avoid overtorquing.

- The method for applying lubricant in the following procedure is outlined in R-3896-3.

(2) Lubricate (Method A) reducer with lubricant grease RB0140-012 (Rocketdyne) and (Method B) K-seal with lubricant grease RB0140-012 (Rocketdyne) or fluorinated oil Krytox 143AZ (Du Pont), and install reducer AN919-15C, K-seal 12100CR8, and adapter 9024153 from adapter kit 9024165 in thrust chamber oxidizer dome bosses PURGE 1A and PURGE 1B. Torque reducer to purge boss connections to 300-720 in-lb. Torque hose coupling nuts to reducer to 650-750 in-lb.

(3) Install hose R3806-12-0500 between adapter manifold in bosses PURGE 1A and PURGE 1B and flushing kit manifold port No. 1 0500. Torque hose coupling nuts to 900-1,100 in-lb.

(4) Remove plugs from thrust chamber dome bosses PURGE 2A and PURGE 2B.

(5) Lubricate (Method A) reducer with lubricant grease RB0140-012 (Rocketdyne) and (Method B) K-seal with lubricant grease RB0140-012 (Rocketdyne) or fluorinated oil Krytox 143AZ (Du Pont), and install reducer AN919-15C, K-seal 12100CR8, and adapter 9024153 in thrust chamber oxidizer dome bosses PURGE 2A and PURGE 2B. Torque reducer to purge boss connection to 300-720 in-lb. Torque coupling nuts at reducer to 650-750 in-lb.

(6) Install hose R3806-12-1000 between adapter manifold in bosses PURGE 2A and PURGE 2B and flushing kit manifold port No. 2 1000. Torque hose coupling nuts to 900-1,100 in-lb.

(7) Remove plug from thrust chamber dome boss NO. 3 PURGE.

(8) Lubricate (Method A) reducer with lubricant grease RB0140-012 (Rocketdyne) and (Method B) K-seal with lubricant grease RB0140-012 (Rocketdyne) or fluorinated oil Krytox 143AZ (Du Pont), and install union AN815-12C and K-seal 12100CR12 in thrust chamber dome boss NO. 3 PURGE. Torque union to 420-600 in-lb.

(9) Install hose R3806-12-0600 between union in oxidizer dome boss NO. 3 PURGE and flushing kit manifold port No. 3 0600. Torque hose coupling nuts to 900-1,100 in-lb.

(10) Remove plug from thrust chamber dome boss NO. 4 PURGE.

(11) Lubricate (Method A) reducer with lubricant grease RB0140-012 (Rocketdyne) and (Method B) K-seal with lubricant grease RB0140-012 (Rocketdyne) or fluorinated oil Krytox 143AZ (Du Pont), and install union AN832-12J and K-seal 12100CR12 in thrust chamber dome boss NO. 4 PURGE. Torque union to 420-600 in-lb.

(12) Install hose R3806-12-1080 between union in thrust chamber dome boss NO. 4 PURGE and flushing kit manifold port No. 4 1080. Torque hose coupling nuts to 900-1,100 in-lb.

f. See figure 2-15, and connect hoses between oxidizer dome flushing kit manifold and a suitable facility drain as follows:

NOTE

In the following procedure, in steps requiring hose coupling torque in excess of torque required for unions or reducers, unions or reducers must be held to avoid overtorquing.

(1) Install hose R3806-12-0800 between adapter 9022108 and flushing kit manifold port No. 5 0800. Torque hose coupling nuts to 900-1,100 in-lb.

(2) Connect hoses 19-9014938-11 at flushing kit manifold 9025254 to diffusers. Torque hose coupling nut to 270-345 in-lb.

(3) Position outlets of adapter 9022108 and diffusers 9023934 into a suitable facility drain and secure hoses to prevent whipping when flowing gaseous nitrogen or trichloroethylene.

(4) Notify personnel, as applicable, to keep clear of hose exits during flushing operation.

3.5.2.2 Oxidizer Dome Flushing Kit Removal for LOX Dome Flush.

a. Disconnect hoses from flushing kit manifold 9025254 and install caps on manifold fittings. Install pressure caps on manifold fittings and plugs in end of hoses.

b. Remove flushing kit manifold 9025254 from dome flushing kit bracket 9012790; then disconnect dome flushing kit bracket from thermal insulation bracketry.

c. Disconnect diffusers from adapter 9024153 and install caps on open lines, as applicable.

3.5.3 GAS GENERATOR LOX INJECTOR FLUSH. This procedure contains instructions for flushing the gas generator oxidizer injector.

NOTE

When performing this procedure with the engine environmental cover installed, the rope that secures the exit end of the cover must be untied and the end of the cover turned up and secured to prevent trichloroethylene from accumulating in the cover. At the completion of the procedure, the cover must be lowered and secured in accordance with paragraph 3.6.5.

- In steps requiring hose coupling torque in excess of torque required for fittings, fittings must be held to avoid overtorquing.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

aA. Install Oxidizer Dome Flushing Kit G2030 (paragraph 3.5.3.1).

b. Remove pressure cap from, and connect an oxidizer-clean source of gaseous nitrogen (MIL-P-27401) capable of supplying 175 ± 25 psig under flow conditions to, flushing kit manifold GN_2 inlet port.

c. Remove pressure cap from, and connect LOX dome and gas generator LOX injector flushing system to, flushing kit manifold trichloroethylene inlet nipple.

d. Remove plug from gas generator combustor drain port and connect a suitable drain hose to port.

e. Remove thrust chamber throat security closures (paragraph 3.6.14).

f. Pressurize flushing kit pneumatic system to 175 ± 25 psi as indicated on flushing kit GN_2 gage.

WARNING

The following procedure uses trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause injury or death.

g. Pressurize LOX dome and gas generator LOX injector trichloroethylene flushing system to 90 +10 psi as indicated on flushing kit trichloroethylene gage, flush gas generator oxidizer injector cavity for 30 seconds minimum, and verify flow through drain hose installed in step d; then depressurize flushing kit trichloroethylene system.

h. Depressurize flushing kit pneumatic system.

i. Disconnect LOX dome and gas generator LOX injector flushing system from flushing kit manifold trichloroethylene inlet quick-disconnect, and reinstall pressure cap.

j. Pressurize flushing kit pneumatic system to 175 ±25 psig.

k. Allow purges to flow for 5 minutes minimum; continue until all vapors are expelled from turbine exhaust manifold before proceeding to next step.

l. Depressurize flushing kit pneumatic system.

m. See figure 3-10, and temporarily disconnect dome flushing kit bracket 9012790 from thermal insulation bracketry to gain access to oxidizer side of gas generator. Support bracket while disconnected.

n. Remove 3 bolts that secure flushing kit adapter to gas generator ball valve. Remove adapter from ball valve. Install cover on adapter to prevent entry of contaminants.

o. Install gas generator purge check valve as follows.

(1) Remove test plate and protective closure, and install gas generator purge check valve, oxidizer purge tube, and seal RD261-3010-0009 on gas generator ball valve with 3 bolts and washers. Torque bolts to 40-50 in-lb. Safetywire bolts with Inconel lockwire MS20995N.

(2) Insert seal 19-406332-5 between gas generator oxidizer purge tube and purge manifold, and verify that seal 19-406332-5 is between manifold and purge tube; then connect purge tube to manifold with 4 bolts and washers. Torque bolts to 70-80 in-lb. Safetywire bolts with Inconel lockwire MS20995N.

p. See figure 3-10, and reconnect dome flushing kit bracket 9012790 to thermal insulation bracketry.

q. Turn on operational high-level LOX dome and gas generator LOX injector purge system.

r. Pressurize flushing kit pneumatic system to 175 +25 psig.

CAUTION

Leak-test compound must not be used on flex line bellows since it cannot be removed from the bellows.

s. Using leak-test compound (MIL-L-25567), leak-test gas generator oxidizer purge manifold joints and gas generator purge check valve to gas generator ball valve joint. No leakage is allowable.

t. Allow purges to flow for 5 minutes minimum; continue until all vapors are expelled from turbine exhaust manifold and gas generator drain port before proceeding to next step.

u. Depressurize flushing kit pneumatic system.

v. Turn off operational high-level LOX dome and gas generator LOX injector purge system.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

w. Remove combustor drain hose. Remove plug and K-seal from packaging. Lubricate (Method A) plug threads with lubricant grease RB0140-012 (Rocketdyne), and install plug RD273-6003-0004 and K-seal 12100AA4 in combustor drain boss. Torque plug to 200-240 in-lb. Safetywire plug with Inconel lockwire MS20995N.

x. Remove oxidizer dome flushing kit G2030 (paragraph 3. 5. 3. 2).

WARNING

The following procedure uses cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

y. Remove all leak-test compound from all joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.5.3.1 Oxidizer Dome Flushing Kit Installation for Gas Generator LOX Injector Flush. The following procedure may be used on engines with or without thermal insulation panels installed but with bracketry installed. See figure 2-5, and install oxidizer dome flushing kit as follows:

a. If thermal insulation panels are installed on engine, see figure 2-15, and remove the following thermal insulation panels:

(1) Gas generator oxidizer purge check valve

(2) Gas generator igniters

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

b. Verify that nut on fitting installed in oxidizer dome flushing kit No. 5 0800 port is safetywired to frame and that aluminum seal is installed. If lockwire of aluminum seal is missing, verify that oxidizer dome flushing kit is correctly assembled and leak tested as outlined in R-3896-5, prior to proceeding with test.

c. On uninstalled engines, install flushing kit manifold adapter 9022108 as follows:

(1) Remove 4 bolts, 4 washers, and seal plate that secures gas generator oxidizer purge tube to purge manifold.

(2) Remove 3 bolts, 3 washers, and seal that secures gas generator purge check valve to gas generator ball valve; then remove check valve together with gas generator oxidizer purge tube.

(3) Install protective closures on purge tube and check valve.

(4) Install flushing kit manifold adapter 9022108 in gas generator oxidizer purge port. Torque the 3 mounting bolts to 40-50 in-lb.

(5) Connect hose R3806-12-0800 to adapter 9022108. See figure 2-5 for hose routing when thermal insulation is installed. Torque hose coupling nuts to 900-1,100 in-lb. Protect loose end of hose from contamination.

NOTE

Step cA is required only for first flushing operation on installed engines.

cA. On installed engines, to prevent frosting of gas generator purge check valve during flushing, perform the following.

(1) On all engines, remove gas generator purge check valve and gas generator oxidizer purge tube as follows:

(a) Remove 4 bolts, 4 washers, and seal plate that secures gas generator oxidizer purge tube to purge manifold.

(b) Remove 3 bolts, 3 washers, and seal that secures gas generator purge check valve to gas generator ball valve; then remove check valve together with gas generator oxidizer purge tube.

(2) On all engines, install test plate T-5047892 on purge manifold using bolts, washers, and seal plate removed in substep 1, a. Install bolts fingertight; then on engines not being flushed, torque bolts to 70-80 in-lb.

(3) On engines not being flushed, install closures on gas generator oxidizer purge port.

(4) On engine being flushed, install flushing kit manifold adapter 9022108 as follows:

(a) Install flushing kit manifold adapter 9022108 in gas generator oxidizer purge port. Torque the 3 mounting bolts to 40-50 in-lb.

(b) Connect hose R3806-12-0800 to adapter 9022108. See figure 2-5 for hose routing when thermal insulation is installed. Torque hose coupling nuts to 900-1,000 in-lb. Protect loose end of hose from contamination.

NOTE

Step cB is required only after first flushing operation on installed engines.

cB. On engine to be flushed, remove closure from gas generator oxidizer purge port and install flushing kit manifold adapter 9022108 as follows:

(1) Install flushing kit manifold adapter 9022108 in gas generator oxidizer purge port. Torque the 3 mounting bolts to 40-50 in-lb.

(2) Connect hose R3806-12-0800 to adapter 9022108. See figure 2-5 for hose routing when thermal insulation is installed. Torque hose coupling nuts to 900-1,000 in-lb. Protect loose end of hose from contamination.

d. See figure 3-10, and position dome flushing kit bracket 9021790 in thermal insulation bracketry holes. When thermal insulation is installed, position main strut of bracket as far from gas generator as thermal insulation access door will permit. Secure bracket in place by securing inner strut to outer strut with attached pin.

e. Position oxidizer dome flushing kit manifold on dome flushing kit bracket and secure with attached pin.

f. See figure 2-5, and connect hoses ' etween oxidizer dome flushing kit and gas generator as follows:

NOTE

The following procedure, in steps requiring hose coupling torque in excess of torque required for unions or reducers, unions or reducers must be held to avoid overtorquing.

(1) Install hose R3806-12-0800 between adapter 9022108 and flushing kit manifold port No. 5 0800. Torque hose coupling nuts to 900-1,100 in-lb.

(2) Remove plugs from taps GF2a and GF2b.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

(3) Install flushing kit manifold diffusers 9023934 with K-seal 12100AA4 in taps GF2a and GF2b. Lubricate (Method A) diffuser with lubricant grease RB0140-012 (Rocketdyne). Torque diffusers to 200-240 in-lb.

(4) Connect hoses 19-9014938-11 at flushing kit manifold 9025254 to diffusers. Torque hose coupling nut to 270-345 in-lb.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

g. Connect hoses including all their attachments (see figure 2-5) between flushing kit manifold and a suitable facility drain. Lubricate (Method A) fittings, as applicable, with lubricant grease RB0140-012 (Rocketdyne). Torque hose coupling nuts to 900-1,100 in-lb.

h. Notify personnel, as applicable, to keep clear of hose exits during flushing operation.

3.5.3.2 Oxidizer Dome Flushing Kit Removal for Gas Generator LOX Injector Flush.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

aA. Disconnect hoses from flushing kit manifold 9025254 and install caps on manifold fittings. Install pressure caps on manifold fittings and plugs in end of hoses.

b. Remove flushing kit manifold 9025254 from dome flushing kit bracket 9012790; then disconnect dome flushing kit bracket from thermal insulation bracketry.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

c. Remove diffusers from taps GF2a and GF2b. Remove plugs and K-seals from packaging. Lubricate (Method A) plug threads with lubricant grease RB0140-012 (Rocketdyne), and install plugs RD273-6003-0004 and K-seals 12100AA4 in instrumentation taps GF2a and GF2b. Torque plugs to 200-240 in-lb. Safety-wire plugs with Inconel lockwire MS20995N.

3.5.4 THRUST CHAMBER FUEL JACKET FLUSH. This procedure contains instructions for removing residual fuel from the thrust chamber fuel inlet manifold, thrust chamber fuel jacket, fuel valves, and fuel injection cavities, and provides a liquid leak test of the thrust chamber fuel jacket. The engine must be maintained in the vertical position with hydraulic pressure applied to the gimbal actuators or the gimbal actuator locks installed during this procedure.

NOTE

When performing this procedure with the engine environmental cover installed, the rope that secures the exit end of the cover must be untied and the end of the cover turned up and secured to prevent trichloroethylene from accumulating in the cover. At the completion of the procedure, the cover must be lowered and secured in accordance with paragraph 3.6.5.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

NOTE

If stage pre-valves are to be open and the fuel tank pressurized during this procedure, step aA must be omitted.

aA. Remove pressure cap from, and attach a drain hose to, drain quick-disconnect on No. 1 and No. 2 fuel high-pressure ducts.

b. Connect thrust chamber fuel jacket purge system to fuel jacket purge quick-disconnect on each fuel valve. If thermal insulation is installed, gain access to fuel jacket purge quick-disconnect on No. 1 fuel valve by loosening insulator 145510 as outlined in paragraph 3.5.16.

c. Check that thrust chamber exit manifold drain plugs are in closed position.

WARNING

The following procedure uses trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

CAUTION

In the following procedure, during removal of the No. 1 and No. 2 thrust chamber fuel inlet manifold drain quick-disconnect cap, the quick-disconnect body must not be allowed to turn since damage to the quick-disconnect body can result.

d. Remove pressure cap from, and connect thrust chamber fuel jacket flushing system to, each thrust chamber fuel inlet manifold drain quick-disconnect.

CAUTION

In the following procedure, drain hoses must be monitored during flushing of the thrust chamber. If drainage is observed from either fuel high pressure duct drain hoses, the source of the fluid must be determined before proceeding.

e. Pressurize hydraulic control system to 1,550 ±50 psig.

f. Turn on operational low-level LOX dome and gas generator LOX injector purge system.

WARNING

The following procedure uses trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

NOTE

To accomplish proper flushing of the thrust chamber, trichloroethylene must remain in the thrust chamber for at least one hour during steps g through p if this procedure is performed at post-test.

g. Turn on thrust chamber fuel jacket flushing system, and fill thrust chamber fuel jacket to injector overflow. Allow overflow to continue for 30 seconds.

h. Turn off thrust chamber fuel jacket flushing system.

i. (Deleted)

j. Pressurize thrust chamber fuel jacket purge system.

k. Allow purges to flow until all heavy vapor ceases to be emitted from thrust chamber exit.

l. Depressurize thrust chamber fuel jacket purge system.

m. Repeat steps g through l 2 additional times.

WARNING

The following procedure uses trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

n. Turn on thrust chamber fuel jacket flushing system, and fill thrust chamber fuel jacket to injector overflow. Allow overflow to continue for 5 seconds minimum.

o. Disconnect thrust chamber fuel jacket flushing system from each thrust chamber fuel inlet manifold drain quick-disconnect.

p. Attach a drain hose to each thrust chamber fuel inlet manifold drain quick-disconnect.

q. Turn off operational low-level LOX dome and gas generator LOX injector purge system.

r. Remove lockwire from thrust chamber exit manifold drain plugs, and install drain tools from Fuel Drainage Kit G2037 at drain plug using gasket RD262-3001-0010 between tool and drain plug adapter. Check that drain tool extension hex wrench is extended outward when installing tool, and drain ports of tool are positioned aft. Torque drain tool to 36-60 in-lb.

s. Install drain hoses on tools.

t. Open drain plugs by inserting drain tool extension hex wrench into head of drain plug and rotating wrench counterclockwise.

u. Turn on operational low- level LOX dome and gas generator LOX injector purge system.

v. Pressurize thrust chamber fuel jacket purge system, and verify operation of purge by monitoring emission of vapor from thrust chamber.

w. Allow thrust chamber fuel jacket purge to flow for 3 minutes minimum and to continue until all vapors cease to be emitted from thrust chamber.

x. Depressurize thrust chamber fuel jacket purge system.

y. Depressurize operational low-level LOX dome and gas generator LOX injector purge system.

z. Depressurize hydraulic control system.

CAUTION

In the following procedure, during installation of the No. 1 or No. 2 thrust chamber fuel inlet manifold drain quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn since damage to the quick-disconnect body can result.

aa. Remove fuel drain hose from each thrust chamber fuel inlet manifold drain quick-disconnect. Remove pressure caps from packaging, and install pressure cap on each quick-disconnect. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

ab. Remove drain tools.

ac. Remove drain plugs, and reinstall plugs using new K-seals 12100AA3. Torque drain plugs to 8-12 ft-lb. Safetywire plugs with Inconel lockwire MS20995N.

acA. Retorque thrust chamber return manifold drain adapters to 47-53 ft-lb without replacing seal. Safetywire adapter with Inconel lockwire MS20995N.

ad. Disconnect thrust chamber fuel jacket purge system from fuel jacket purge quick-disconnect on each fuel valve. Remove pressure caps from packaging, and install pressure cap on each quick-disconnect. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

adA. If thermal insulation is installed, secure insulator 145510 as outlined in paragraph 3.5.16.

ae. Disconnect drain hose from each fuel high-pressure duct quick-disconnect. Remove pressure caps from packaging, and install pressure cap on each quick-disconnect. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

af. Drain ignition monitor valve sense line (paragraph 3.5.9).

3.5.4A <u>THRUST CHAMBER POST-FLUSH PNEUMATIC LEAK TEST AT KSC</u>. This procedure contains instructions for leak testing joints invalidated during the LOX dome and gas generator LOX injector flush and the thrust chamber fuel jacket flush except for the thrust chamber fuel inlet manifold drain quick-disconnects and the thrust chamber dome PURGE 1D port used during this test.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this test.

b. Install thrust chamber throat plug (paragraph 3.6.15).

c. Remove pin and closure from hypergol manifold cartridge container inlet port

WARNING

The following procedure specifies drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

NOTE

The method for applying lubricant is outlined in R-3896-3.

d. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680). Lubricate (Method A) threads with lubricant grease RB0140-012 (Rocketdyne).

CAUTION

When installing the hypergol system test tool into the hypergol manifold cartridge container inlet port, extreme care must be used to prevent damage to the hypergol cartridge follower.

- The threads of the test tool cap must be clean and free of nicks to prevent galling the threads of the cap and inlet port.

e. Make sure that threads of test tool cap are clean and free of nicks; then lubricate (Method L) cap packing with FS1281 grease (Dow Corning Corp) and carefully insert hypergol system test tool 9021279, or equivalent, into hypergol manifold cartridge container inlet port, and screw cap (clockwise) onto inlet port until cap bottoms.

f. Install an oxidizer-clean adapter incorporating a check valve and a union AN815-8C in thrust chamber dome PURGE 1B port.

g. Connect an external source of gaseous nitrogen (MIL-P-27401), capable of being regulated and monitored from 0-100 psig and filtered through a 40-micron (or smaller) filter, to adapter of thrust chamber dome PURGE 1B port. Attach filter as close as possible to engine attach point.

h. Connect a monitor gage and bleed valve to quick-disconnect of thrust chamber throat plug.

CAUTION

The gaseous nitrogen supply hose to the throat plug seal must be supported to prevent the weight on the seal valve stem from damaging the seal.

i. Connect a source of gaseous nitrogen to throat plug seal. Using a suitable material, support the gaseous nitrogen supply hose to relieve all weight of hose from seal valve stem.

Procedure	Result
j. Pressurize throat plug seal to 50 (+5, -10) psig. Maintain pressure during remainder of test.	Thrust chamber throat plug seal is pressurized.
k. Slowly supply gaseous nitrogen at 9 ±1 psig to thrust chamber through chamber dome PURGE 1B port.	Thrust chamber is pressurized. Monitor gage indicates 9 ±1 psig.
l. Apply leak-test compound (MIL-L-25567) to thrust chamber dome purge ports PURGE 1A, PURGE 2A, PURGE 2B, NO. 3 PURGE, and NO. 4 PURGE and to any other joint invalidated during the LOX dome and gas generator LOX injector flush and the thrust chamber fuel jacket flush. Record results.	No leakage is allowed.

CAUTION

The thrust chamber must be depressurized as outlined in steps m and n to prevent contamination of the engine oxidizer system.

Procedure	Result
m. Completely open hand bleed valve on quick-disconnect of thrust chamber throat plug.	Thrust chamber pressure vents.
n. Turn off thrust chamber pressure pneumatic source.	Supply pressure to thrust chamber decreases to zero, and monitor gage on thrust chamber throat plug quick-disconnect indicates zero.

NOTE

The method for applying lubricant is outlined in R-3896-3.

o. Remove source of gaseous nitrogen and adapter from thrust chamber dome PURGE 1B port. Lubricate (Method A) plug with lubricant grease RB0140-012 (Rocketdyne) and (Method B) seal with lubricant grease RB0140-012 (Rocketdyne) or fluorinated oil Krytox 143AZ (Du Pont) and install plug and seal. Torque to 350 ±15 in-lb, and record plug installation torque value. Safetywire plug with Inconel lockwire MS20995N.

p. Remove monitor gage and hand bleed valve from quick-disconnect of thrust chamber throat plug.

q. Depressurize thrust chamber throat plug seal.

r. Remove thrust chamber throat plug (paragraph 3.6.16).

s. Remove pin that secures hypergol test tool cap, and carefully unscrew cap and remove tool from manifold.

WARNING

The following procedure specifies drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

t. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680).

u. Remove hypergol manifold cartridge container inlet port closure from packaging. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp) and install closure. Secure with attaching pin.

WARNING

The following procedure specifies cleaning compound (MIL-C-81302), which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

v. Remove all leak-test compound from joints and fittings with a clean, dry cloth, or by flushing inaccessible areas with cleaning compound (MIL-C-81302).

3.5.5 ENGINE RESIDUAL FLUID REMOVAL.

NOTE

Omit steps a through c at KSC unless engine is to be removed from stage or stage is to be recycled through VAB.

a. Remove section of thermal insulation that covers turbine bearing thermocouple cover.

b. Remove turbine bearing thermocouple access cover from manifold shield.

c. Using a suction pump, remove residual fluids from turbine manifold shield (internal and external). If internal fluid is evident, flush with water; then remove water with suction pump.

d. Using suction pump, remove residual fluids from top of thrust chamber oxidizer dome, from area between thrust chamber oxidizer dome and thrust chamber fuel manifold, and from cavity at both fuel pump inlet elbows at inlet to fuel pump.

NOTE

When thermal insulation is installed, there is no access to cavity between No. 1 fuel pump inlet elbow at inlet to fuel pump.

- Omit steps e and f at KSC unless engine is to be removed from stage or stage is to be recycled through VAB.

e. Reinstall turbine bearing thermocouple access cover on turbine manifold shield. Torque cover bolts to 60-80 in-lb.

f. Reinstall thermal insulation to thermocouple access cover. Safetywire with Inconel lockwire MS20995N32.

g. Remove residual fluids from exterior of engine.

3.5.6 ADMITTING PREFILL TO ENGINE.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

NOTE

Omit step b if engine fuel feed system is pressurized to 2 psig minimum during this procedure.

b. Remove pressure caps from, and install drain hoses on, the following quick-disconnects.

(1) No. 1 fuel high-pressure duct drain

(2) No. 2 fuel high-pressure duct drain

c. If engine environmental cover is installed, untie exit end of cover, roll cover clear of exit end of nozzle extension, and secure cover.

d. Turn on operational low-level LOX dome and gas generator LOX injector purge system.

e. Admit prefill fluid, meeting requirements of section II, to thrust chamber fuel jacket until injector overflows.

f. Monitor prefill system connections for leakage while admitting prefill fluid. No leakage is allowable.

g. Turn off operational low-level LOX dome and gas generator LOX injector purge system.

NOTE

If the engine is to be gimbaled after prefilling the thrust chamber fuel jacket, the operational low-level LOX dome and gas generator LOX injector purge system must be turned on before and during the gimbaling operation, and the thrust chamber must be topped off with prefill to the injector overflow subsequent to completion of the last gimbal operation.

h. Monitor prefill fluid leakage from fuel overboard drain line. No leakage is allowable.

NOTE

Omit step i if engine fuel feed system was pressurized to 2 psig during the procedure.

i. Disconnect drain hose from each fuel high-pressure duct quick-disconnect. Remove pressure caps from packaging, and install pressure cap on each quick-disconnect. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

3.5.7 ADMITTING FUEL TO ENGINE.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

CAUTION

In the following procedure, during removal of the No. 1 or No. 2 thrust chamber fuel inlet manifold drain quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn since damage to the quick-disconnect body can result.

b. Remove pressure caps and install drain hoses at the following quick-disconnects and allow fluid to drain:

(1) No. 1 thrust chamber fuel inlet manifold drain

(2) No. 2 thrust chamber fuel inlet manifold drain

c. Provide a suitable container for catching fluid; then remove gas generator combustor drain plug. If thermal insulation is installed, gain access to gas generator area by removing necessary lockwiring and screws at gas generator insulator access door. (See figure 2-15.)

d. Continuously monitor gas generator ball valve and fuel valves for closed indication before, during, and after fuel is in fuel feed system.

e. Admit fuel, meeting requirements of section II, to fuel feed system.

NOTE
Omit step f at KSC.

f. Visually monitor fuel feed system for external leakage. No leakage is allowable.

g. During and after admitting fuel to fuel feed system, monitor drain hoses installed in step b for fuel leakage. Record fluid leakage from each drain hose. Maximum allowable leakage from each drain hose is 500 cc/m. Repeat inspection every 24 hours as long as drain hoses are installed. Leave drain hoses installed until last time access to engine area is available.

h. If no fuel leakage occurred in step g, omit steps i through m and proceed to step o.

i. If fuel leakage occurred in step g, turn on operational low-level LOX dome and gas generator LOX injector purge, pressurize engine hydraulic control system to 415-1,850 psig, and allow all fluid to drain from fuel inlet manifold. Monitor drain hoses for fuel leakage for one hour minimum. No leakage is allowable.

j. If no fuel leakage occurred in step i, omit steps k through m; depressurize engine hydraulic control system, turn off operational low-level LOX dome and gas generator LOX injector purge, and proceed to step o.

k. If leakage was observed in step g, perform thrust chamber fuel jacket drain (paragraph 3.5.13), thrust chamber fuel jacket flush (paragraph 3.5.4), and admit prefill to engine (paragraph 3.5.6); then proceed to step l.

l. Perform step b after a minimum of 1.5 hours with fuel in engine, and obtain samples of drained prefill solution.

m. Visually verify that no fuel leakage exists in drained prefill solution.

n. When it is verified that no fuel leakage exists in drained prefill solution, depressurize engine hydraulic control system and turn off operational low-level LOX dome and gas generator LOX injector purge.

o. Inspect for fuel leakage from gas generator combustor drain port within one hour after fuel is admitted to engine. No leakage is allowable. Repeat inspection every 24 hours for as long as combustor drain plug is removed. Leave drain plug uninstalled until last time access to engine area is available.

p. Monitor nitrogen purge overboard drain line at thrust chamber exit, for fuel leakage. No leakage is allowable.

q. Monitor fuel overboard drain line at thrust chamber exit, for fuel leakage. Leakage in excess of that recorded during hydraulic control system leak and function test requires isolation of overboard drain system components. Maximum allowable component leakage into fuel overboard drainage system is as follows:

(1) Maximum allowable leakage from redundant shutdown valve drain port is 2 cc/m.

(2) Maximum allowable leakage from ignition monitor valve drain port is 5 cc/m.

(3) Maximum allowable leakage from engine control valve override drain port is 5 cc/m.

CAUTION

In the following procedure, during removal and installation of No. 1 or No. 2 thrust chamber fuel inlet manifold drain quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn since damage to the quick-disconnect body can result.

r. Remove drain hoses from No. 1 and No. 2 thrust chamber fuel inlet manifold drain quick-disconnects. Remove pressure caps from packaging, and install pressure caps on quick-disconnects. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

s. Remove plug and K-seal from packaging. Lubricate (Method A)plug threads with thread compound C-5A (Felt Products), and install plug RD273-6003-0004 and new K-seal 12100AA4 in combustor drain boss. Torque plug to 200-240 in-lb. Record actual torque value of plug. Safetywire plug with Inconel lockwire MS20995N.

t. Reinstall thermal insulation, if required. (See figure 2-15.) Torque screws to 22-28 in-lb. Safetywire screws with Inconel lockwire MS20995N40.

u. Admit prefill fluid, meeting requirements of section II, to thrust chamber fuel jacket until injector overflows.

3.5.8 ADMITTING LOX TO ENGINE.

a. Provide turbopump heater power to engine.

b. Verify that turbopump LOX seal purge is turned on. (Purge must be maintained whenever LOX is in engine LOX feed system.)

c. Verify that hydraulic control system is pressurized to 1,450-1,850 psig. (During and after admitting LOX to engine, maintain hydraulic pressure at 1,450-1,850 psig. After admitting LOX to engine, maintain hydraulic temperature within limits of section II.)

d. Continuously monitor gas generator ball valve and oxidizer valve closed positions prior to, during, and after LOX is in engine LOX feed system.

e. Admit LOX, meeting requirements of section II, to LOX feed system.

f. Monitor engine ambient temperature as outlined in section II, and on engines with thermal insulation installed, maintain cocoon ambient temperature as outlined in section II, after admitting LOX to LOX feed system.

g. Monitor No. 1 bearing temperature as outlined in section II, after admitting LOX to LOX feed system.

h. Monitor oxidizer overboard drain line for LOX leakage. No liquid leakage is allowable.

i. Monitor thrust chamber exit for LOX leakage. No leakage is allowable.

3.5.9 IGNITION MONITOR VALVE SENSE LINE DRAIN.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

aA. Remove pressure cap from, and attach fuel drain hose to, quick-disconnect located on ignition monitor valve CONTROL port.

b. Allow all drainage to cease.

c. Disconnect fuel drain line from ignition monitor valve CONTROL port quick-disconnect. Remove pressure cap from packaging, and install pressure cap on quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

3.5.10 RESIDUAL FUEL DRAIN.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

aA. Use caution while draining fuel propellant feed system to prevent fuel spillage on other engine systems.

b. Inspect engine and surrounding area to make sure that no hazardous condition exists.

c. Pressurize turbopump LOX seal purge system during performance of this procedure.

d. See figure 3-11, and install fuel drain vent adapter on ball valve fuel inlet drain quick-disconnect as follows.

(1) Verify that adapter is assembled as outlined in R-3896-5.

(2) Connect Stage-Contractor-supplied drain tubing to adapter.

CAUTION

During removal of ball valve fuel inlet drain quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn, since the installation between the quick-disconnect and ball valve may loosen and cause leakage.

(3) Provide countertorque on quick-disconnect body, and remove pressure cap from ball valve fuel inlet drain quick-disconnect.

(4) (Deleted)

(5) Position fuel drain vent adapter, orienting check valve above horizontal on ball valve fuel drain quick-disconnect as shown in figure 3-11.

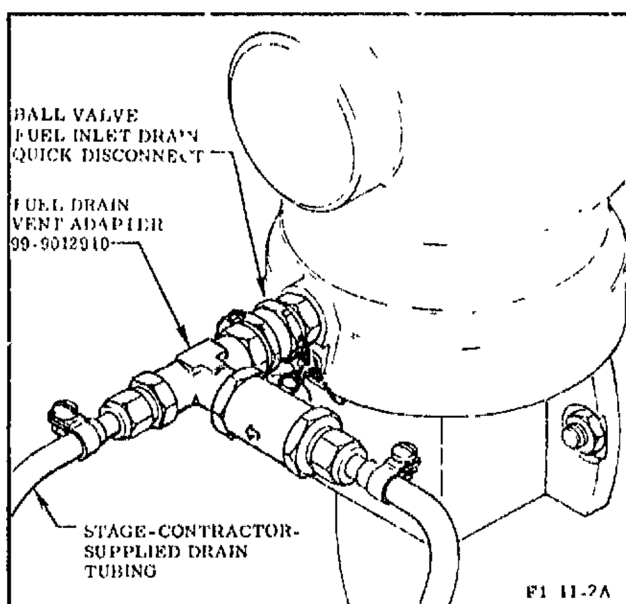


Figure 3-11. Fuel Drain Vent Adapter Installation

e. Remove pressure cap from, and attach a fuel drain hose to, each of the following quick-disconnects:

(1) Turbopump No. 1 fuel inlet elbow drain (applicable only on engines that do not have thermal insulation installed)

(2) Turbopump No. 2 fuel inlet elbow drain

(3) No. 1 fuel high-pressure duct drain

(4) No. 2 fuel high-pressure duct drain

f. Allow residual fuel to drain.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

g. Remove fuel drain vent adapter. Remove pressure cap from packaging, and install pressure cap on quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N. On engines incorporating MD168 change, lubricate (Method A) threads of ball valve fuel inlet drain quick-disconnect with lubricant grease RB0140-012 (Rocketdyne), and install pressure cap. Torque pressure cap to 210-230 in-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

h. Remove all drain hoses. Remove pressure cap from packaging, and install pressure cap on each quick-disconnect listed in step e. Torque 3/8-inch pressure caps to 30-40 ft-lb and 3/4-inch pressure caps to 70-75 ft-lb. Safetywire all pressure caps with Inconel lockwire MS20995N.

i. Depressurize turbopump LOX seal purge system.

3.5.11 FUEL FEED SYSTEM DRAIN.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

aA. Use caution when draining thrust chamber or fuel feed system to prevent spillage on engine.

b. Verify that no hazardous conditions exist around engine or surrounding area.

NOTE

Steps c through e are omitted at MTF and KSC when performing drain immediately after stage rotation to vertical position.

c. Pressurize hydraulic control system to 415-1,850 psig.

d. Turn on turbopump LOX seal purge system.

e. See figure 3-11, and install fuel drain vent adapter on ball valve fuel inlet drain quick-disconnect as follows:

(1) Verify that adapter is assembled as outlined in R-3896-5.

(2) Connect Stage-Contractor-supplied drain tubing to adapter.

CAUTION

During removal of ball valve fuel inlet drain quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn, since the installation between the quick-disconnect and ball valve may loosen and cause leakage.

(3) Provide countertorque on quick-disconnect body, and remove pressure cap from each valve fuel inlet drain quick-disconnect.

(4) (Deleted)

(5) Position fuel drain vent adapter, orienting check valve above horizontal on ball valve fuel inlet drain quick-disconnect as shown in figure 3-11.

f. Drain fuel upstream of fuel valves by removing pressure cap from, and attaching a fuel drain hose to, each of the following quick-disconnects:

(1) Turbopump No. 1 fuel inlet elbow drain (only applicable on engines that do not have thermal insulation installed)

(2) Turbopump No. 2 fuel inlet elbow drain

(3) No. 1 fuel high-pressure duct drain

(4) No. 2 fuel high-pressure duct drain

(5) Hypergol manifold drain

g through n. (Deleted)

o. Turn off turbopump LOX seal purge system.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

p. Remove fuel drain vent adapter. Remove pressure cap from packaging, and install pressure cap on quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N. On engines incorporating MD168 change, lubricate (Method A) threads of ball valve fuel inlet drain quick-disconnect with lubricant grease RB0140-012 (Rocketdyne), and install pressure cap. Torque pressure cap to 210-230 in-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

q. Remove all drain hoses. Remove pressure caps from packaging, and install pressure cap on each quick-disconnect listed in step f. Torque 3/8-inch pressure caps to 30-40 ft-lb and 3/4-inch pressure caps to 70-75 ft-lb. Safetywire all quick-disconnect pressure caps with Inconel lockwire MS20995N.

CAUTION

In the following procedure, during removal and installation of No. 1 or No. 2 thrust chamber fuel inlet manifold drain quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn since damage to the quick-disconnect body can result.

NOTE

Steps r through t must be omitted when performing drain immediately after stage rotation to vertical position.

r. Disconnect pneumatic system from each fuel inlet manifold drain quick-disconnect. Remove pressure caps from packaging, and install pressure cap on each quick-disconnect. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

s. Close drain plugs by rotating drain tool extension hex wrench clockwise. Torque drain plugs to 8-12 ft-lb.

t. Remove drain tools. Safetywire drain plugs with Inconel lockwire MS20995N.

3.5.12 GAS GENERATOR COMBUSTOR DRAIN.

a. If thermal insulation is installed, attain access to gas generator area by removing necessary lockwiring and screws at gas generator insulator access door. (See figure 2-15.)

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

b. Remove plug, and inspect and remove any obstruction in gas generator combustor drain port. Allow any residual fluid to drain from combustor into a suitable container. After residual fluid drainage, monitor port for leakage for 5 minutes. No leakage is allowable.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

c. Remove plug and K-seal from packaging. Lubricate (Method A)plug threads with thread compound C-5A (Felt Products), and install plug RD273-6003-0004 and K-seal 12100AA4 in combustor drain boss. Torque plug to 200-240 in-lb. Record actual torque value of plug. Safetywire plug with Inconel lockwire MS20995N.

d. Reinstall thermal insulation, if required. Torque screws to 22-28 in-lb. Safetywire screws with Inconel lockwire MS20995N40.

3.5.13 THRUST CHAMBER FUEL JACKET DRAIN.

a. Connect thrust chamber fuel jacket purge system, meeting requirements of section II, to fuel jacket purge quick-disconnect of each fuel valve. If thermal insulation is installed, gain access to fuel jacket purge quick-disconnect on No. 1 fuel valve by loosening insulator 145510 as outlined in paragraph 3.5.16.

b. Verify that hydraulic control system is pressurized to 415-1,850 psig.

c. Remove pressure caps and connect drain hoses on the following quick-disconnects:

(1) Ignition monitor valve CONTROL port

(2) Hypergol manifold drain

CAUTION

In the following procedure, during removal of the No. 1 or No. 2 thrust chamber fuel inlet manifold quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn, since damage to the quick-disconnect body can result.

(3) No. 1 and No. 2 thrust chamber fuel inlet manifold drain

d. Install Fuel Drainage Kit G2037 as follows:

(1) Remove safetywire from thrust chamber drain plugs (4 places).

(2) Install drain tools at each thrust chamber drain port using gasket PD263-3001-0010 between tool and drain plug adapter. Extend drain tool extension hex wrench outward and position drain port of tool aft. Torque tools to 36-60 in-lb.

(3) Install drain hoses on drain tool ports.

(4) Open drain plugs by inserting drain tool extension hex wrench into head of drain plug and rotating wrench counterclockwise.

e. Turn on operational low-level LOX dome and gas generator LOX injector purge system.

f. Pressurize thrust chamber fuel jacket purge system and flow purge until all fluids and vapors are expelled from thrust chamber exit, overboard drain lines, and drain hoses that were connected in steps c and d.

g. Depressurize thrust chamber fuel jacket purge system.

h. Turn off operational low-level LOX dome and gas generator LOX injector purge system.

i. Disconnect thrust chamber fuel jacket purge system from quick-disconnects on each fuel valve. Remove pressure caps from packaging, and install pressure caps. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

iA. If thermal insulation is installed, secure insulator 145510 as outlined in paragraph 3.5.16.

CAUTION

In the following procedure, during installation of the No. 1 or No. 2 thrust chamber fuel inlet manifold drain quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn, since damage to the quick-disconnect body can result.

j. Disconnect drain hoses installed in step c. Remove pressure caps from packaging, install pressure caps on quick-disconnects. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

k. Depressurize hydraulic control system if required.

l. Remove Fuel Drainage Kit G2037 as follows:

(1) Remove drain hoses from drain tools.

(2) Remove drain plugs, and reinstall plugs using new K-seals 12100AA3. Torque plugs to 8-12 ft-lb. Safetywire plugs with Inconel lockwire MS20995N.

3.5.14 THRUST CHAMBER FUEL INLET MANIFOLD DRAIN.

NOTE

Omit step a unless fuel valve leakage has occurred without the hydraulic control system pressurized.

a. Verify that operational low-level LOX dome and gas generator LOX injector purge is on and that engine hydraulic control system is pressurized to 415-1,850 psig.

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

CAUTION

In the following procedure, during removal and installation of No. 1 or No. 2 thrust chamber fuel inlet manifold drain quick-disconnect pressure cap, the quick-disconnect body must not be allowed to turn, since damage to the quick-disconnect body can result.

b. Connect a drain hose to each quick-disconnect on thrust chamber fuel inlet manifold, and drain all fluid from fuel inlet manifold into clean sampling containers.

c. Remove drain hoses from thrust chamber fuel inlet manifold quick-disconnects. Remove pressure caps from packaging, and install pressure caps. Torque pressure caps to 30-40 ft-lb. Safetywire pressure caps with Inconel lockwire MS20995N.

d. Verify that no visible amount of fuel exists after prefill fluid settles in sampling container.

3.5.15 TURBOPUMP PRESERVATION.

3.5.15.1 Turbopump Preservation (Engines Not Incorporating MD145 Change).

a. Verify that closures are removed from all overboard drain lines.

aA. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

b. Provide a container (6 gallons minimum volume) to catch fluid draining from overboard drain lines.

c. Provide instrumentation for monitoring oxidizer pump bearing jet pressure at tap LB1b as follows:

(1) Disconnect static-firing instrumentation tube from, or remove plug from tap LB1b, as applicable.

(2) Connect a pressure gage (0-400 psig) to tap LB1b.

d. Remove pressure cap from, and connect turbopump preservation servicing purge system, meeting requirements of section II, to bearing coolant control valve PRESERVATIVE IN port quick-disconnect.

e. Turn on turbopump LOX seal purge system. Verify purge operation and that pressure is 80 ±20 psig.

f. Pressurize turbopump preservation servicing purge system to 25-45 psig, and purge turbopump for 5 minutes. Monitor pressure at LOX pump bearing pressure tap LB1b.

g. Disconnect turbopump preservation servicing purge system from bearing coolant control valve PRESERVATIVE IN port quick-disconnect.

h. Make sure preservation fluid has been thoroughly mixed and is at proper temperature; then connect the preservation system, meeting requirements of section II, to bearing coolant control valve PRESERVATIVE IN port quick-disconnect.

i. Prepare to rotate turbopump shaft as follows:

(1) Remove cap from torque-gear housing.

(2) Using a 1-1/6-inch-deep socket and a 2-foot extension, attach a 0-30 ft-lb torque wrench to torque-pinion-gear shaft.

CAUTION

In the following procedure, excessive torque applied to the pinion-gear shaft can damage the turbopump.

(3) To rotate turbopump shaft, depress torque-gear-housing lockpin; then fully depress torque-pinion-gear shaft by applying pressure to torque wrench adapter, and slowly rotate turbopump shaft in one direction. Do not torque pinion-gear shaft in excess of 20 ft-lb.

NOTE

One revolution of the turbopump shaft requires 5 revolutions of the pinion-gear shaft.

j. Turn on preservation fluid system, and preserve turbopump with 5 gallons minimum of preservation fluid at 200 ±25 psig. Monitor pressure at LOX pump bearing pressure tap LB1b, and visually check bearing coolant delivery lines for leakage. No leakage is allowable.

NOTE

A pressure differential of more than 300 psig between the pressure entering the bearing coolant control valve and the pressure on the gage installed at tap LB1b is an indication of a clogged bearing coolant control valve preservative filter. A clogged filter must be replaced as outlined in R-3896-3.

k. Rotate turbopump shaft continuously during preservation for a minimum of one complete revolution.

l. Discontinue turbopump shaft rotation, and allow preservation fluid to flow for 10 seconds; then turn off preservation system.

m. Disconnect preservation system from bearing coolant control valve, and reconnect preservation servicing purge system to quick-disconnect.

n. Remove torque wrench, extension, and adapter from torque-gear housing.

o. Verify that lockpin on torque-gear housing is fully extended and that torque-pinion-gear shaft is in lockout position.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

p. Lubricate (Method J) packing with lubricant grease RB0140-012 (Rocketdyne); then install packing on torque-gear-housing cap.

q. Lubricate (Method A) threads of torque-gear-housing cap with lubricant grease RB0140-012 (Rocketdyne); then install cap fingertight on torque-gear housing. Safetywire cap with Inconel lockwire MS20995N.

r. Allow turbopump to drain for 15 minutes minimum.

s. (Deleted)

t. Pressurize turbopump preservation servicing purge system to 25-45 psig, and purge turbopump for 5 minutes. Re-preserve turbopump if, at anytime, purge pressure exceeds 50 psig.

u. Disconnect purge system from bearing coolant control valve PRESERVATIVE IN port quick-disconnect. Remove pressure cap from packaging, and install pressure cap. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

v. Turn off turbopump LOX seal purge system.

w. Install closures on overboard drain lines.

wA. Disconnect pressure gage from tap LB1b. Remove plugs from tube or plug and seal from packaging, as applicable. On engines not incorporating MD103 and MD166 changes, lubricate (Method A) fitting and (Method G) static-firing instrumentation tube with lubricant grease RB0140-012 (Rocketdyne), and install tube. Torque tube coupling nut to 160 ±10 in-lb. Safetywire coupling nut with Inconel lockwire MS20995N. On engines incorporating MD103 and MD166 changes, lubricate (Method A) plug, and install plug and seal in tap LB1b. Torque plug to 40-65 in-lb. Safetywire plug with Inconel lockwire MS20995N.

x. After each preservation, clean preservation system between 40-micron filter and bearing coolant control valve connection as outlined in R-3896-3, or flush with propellant kerosene (MIL-P-25576) or RJ-1 (MIL-F-25558) fuel through a 40-micron filter, and purge with gaseous nitrogen (MIL-P-27401) through a 40-micron filter.

3.5.15.2 Turbopump Preservation (Engines Incorporating MD145 Change.

a. Verify that closures are removed from all overboard drain lines.

b. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

c. Provide a container (6 gallons minimum volume) to catch fluid drainage during preservation.

d. Provide instrumentation for monitoring oxidizer pump bearing jet pressure at tap LB1b as follows:

(1) Disconnect static-firing instrumentation tube, or remove plug from tap LB1b, as applicable.

(2) Connect a pressure gage (0-200 psig) to tap LB1b.

e. Remove pressure cap from, and connect turbopump preservation servicing purge system (meeting requirements of section II) to, bearing coolant control valve PRESERVATIVE IN port quick-disconnect.

f. Prepare Scavenge Pump G2039 for operation, and connect pump to engine (see figure 3-11A) as follows:

(1) Position pump by No. 2 side of engine.

(2) Connect pump electrical plug to facility 115-vac, 60-cps outlet; then press pump RESET switch.

(3) Position tubing from pump outlet port and pump valve DRAIN port into container provided in step c. Make sure tubing is routed so as to preclude restriction in tubing, and make sure exit ends of tubing are positioned in container so they will not be immersed in fluid. Secure tubing to prevent whipping of tubing.

NOTE

If tubing is kinked so that flow is restricted, resulting pressure buildup during preservation may unseal the turbine bearing seal and allow preservative fluid to enter the exhaust system.

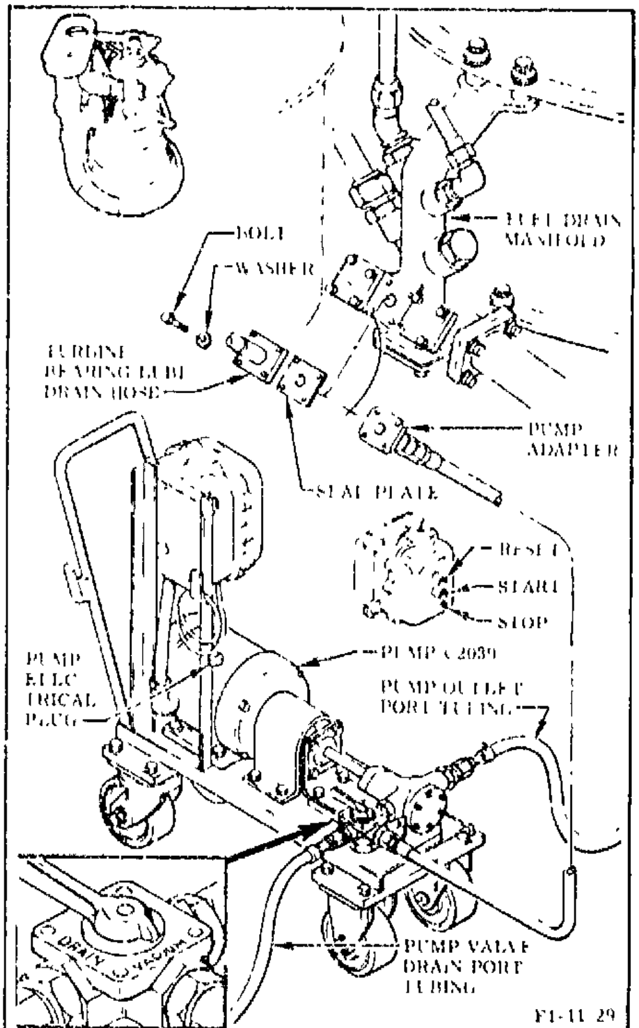


Figure 3-11A. Connecting Scavenge Pump G2039 to Engine

(4) Remove fasteners that secure turbine bearing lube drain hose to fuel drain manifold, and remove seal plate.

(5) Cover opening on fuel drain manifold with polyethylene, or equivalent, to prevent entry of contaminant into fuel drain manifold.

(6) Remove plate RX20660-65 from pump adapter, and connect turbine bearing lube drain hose to pump adapter using seal plate and fasteners removed in substep 4. Torque fasteners to 45 ±2 in-lb.

g. Turn on turbopump LOX seal purge system. Verify purge operation and that pressure is 80 ±20 psig.

h. Turn pump valve to VACUUM position; then press pump START switch, and vacuum fluid from turbine bearing until all liquid flow through turbine bearing lube drain hose ceases.

i. Press pump STOP switch, and turn pump valve to DRAIN position.

NOTE

In the following procedure, pressure in excess of 10 psig may unseat the turbine bearing seal and allow preservative fluid to enter the exhaust system.

j. Slowly pressurize turbopump preservation servicing purge system to 5-10 psig. Maintain purge for 2 minutes; then turn purge off.

k. Disconnect turbopump preservation servicing purge system from bearing coolant control valve PRESERVATIVE IN port quick-disconnect.

l. Make sure preservation fluid has been thoroughly mixed and is at proper temperature; then connect preservation system, meeting requirements of section II, to bearing coolant control valve PRESERVATIVE IN port quick-disconnect.

m. Prepare to rotate turbopump shaft as follows:

(1) Remove cap from torque-gear housing.

(2) Using a 1-1/16-inch-deep socket and a 2-foot extension, attach a 0-30 ft-lb torque wrench to torque-pinion-gear shaft.

CAUTION

In the following procedure, excessive torque applied to the pinion-gear shaft can damage the turbopump.

(3) To rotate turbopump shaft, depress torque-gear housing lockpin; then fully depress torque-pinion-gear shaft by applying pressure to torque wrench adapter, and slowly rotate turbopump shaft in one direction. Do not torque pinion-gear shaft in excess of 20 ft-lb.

NOTE

One revolution of the turbopump shaft requires 5 revolutions of the pinion-gear shaft.

n. Turn pump valve to VACUUM position; then press pump START switch to vacuum fluid from turbine bearing area.

o. Turn on preservation fluid system, and preserve turbopump at 80 ±10 psig while continuously rotating turbopump shaft a minimum of one complete revolution; then turn off preservation system. Monitor pressure at LOX pump bearing pressure tap LB1b, and visually check bearing coolant control lines for leakage. No leakage is allowable.

NOTE

A pressure differential of more than 100 psig between the pressure entering the bearing coolant control valve and the pressure on the gage installed at tap LB1b is an indication of a clogged bearing coolant control valve preservative filter. A clogged filter must be replaced as outlined in R-3896-3.

p. When all fluid flow through turbine bearing lube drain hose ceases, press pump STOP switch and disconnect pump adapter from turbine bearing lube drain hose. Install plate RX20660-65 on pump adapter. Torque fasteners fingertight plus 1/4 turn.

q. Remove polyethylene, and install turbine bearing lube drain hose on fuel drain manifold. Torque fasteners to 45 ±2 in-lb.

r. Disconnect preservation system from bearing coolant control valve PRESERVATIVE IN port quick-disconnect, and connect turbopump preservation servicing purge system.

NOTE

In the following procedure, pressure in excess of 10 psig may unseat the turbine bearing seal and allow preservative fluid to enter the exhaust system.

s. Slowly pressurize turbopump preservation servicing purge system connected to bearing coolant control valve PRESERVATIVE IN port quick-disconnect to 5-10 psig. Maintain purge for 5 minutes; then depressurize purge. Represerve turbopump if, at anytime, purge pressure exceeds 50 psig.

t. Disconnect purge system from bearing coolant control valve PRESERVATIVE IN port quick-disconnect. Remove from packaging and install pressure cap. Torque pressure cap to 30-40 ft-lb. Safetywire pressure cap with Inconel lockwire MS20995N.

u. Turn off turbopump LOX seal purge system.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

v. Disconnect pressure gage from tap LB1b. Remove plugs from tube, or plug and seal from packaging, as applicable. On engines not incorporating MD103 and MD166 changes, lubricate (Method A) fitting and (Method G) static-firing instrumentation tube with lubricant grease RB0140-012 (Rocketdyne), and install tube. Torque tube coupling nut to 160 ±10 in-lb. Safetywire coupling nut with Inconel lockwire MS20995N. On engines incorporating MD103 and MD166 changes, lubricate (Method A) plug, and install plug and seal in tap LB1b. Torque plug to 40-65 in-lb. Safetywire plug with Inconel lockwire MS20995N.

w. Install covers on overboard drain lines.

x. Remove torque wrench, extension, and adapter from torque-gear housing.

y. Verify that lockpin on torque-gear housing is fully extended and that torque-pinion-gear shaft is in lockout position.

z. Lubricate (Method J) packing with lubricant grease RB0140-012 (Rocketdyne); then install packing on torque-gear-housing cap.

aa. Lubricate (Method A) threads of torque-gear-housing cap with lubricant grease RB0140-012 (Rocketdyne); then install cap fingertight on torque-gear housing. Safetywire cap with Inconel lockwire MS20995N.

3.5.16 LOOSENING AND SECURING INSULATOR 145510. This procedure contains instructions for loosening insulator 145510 to provide access to fuel jacket purge quick-disconnect on No. 1 fuel valve and for securing the insulator at the completion of procedures wherein access is required.

a. See figure 3-11B and loosen insulator by removing the following fasteners:

(1) Four bolts and clips (1).

(2) Ten bolts and clips (2).

(3) One bolt and washer (3).

(4) If required to gain additional clearance, one bolt, 2 washers, and a nut (4).

b. At completion of procedures requiring access to fuel jacket purge quick-disconnect on No. 1 fuel valve, see figure 3-11B and secure insulator by installing the following fasteners:

NOTE

All fasteners should be installed prior to tightening and torquing fasteners.

(1) Four bolts and clips (1). Torque bolts to 27 ±3 in-lb.

(2) Ten bolts and clips (2). Torque bolts to 27 ±3 in-lb.

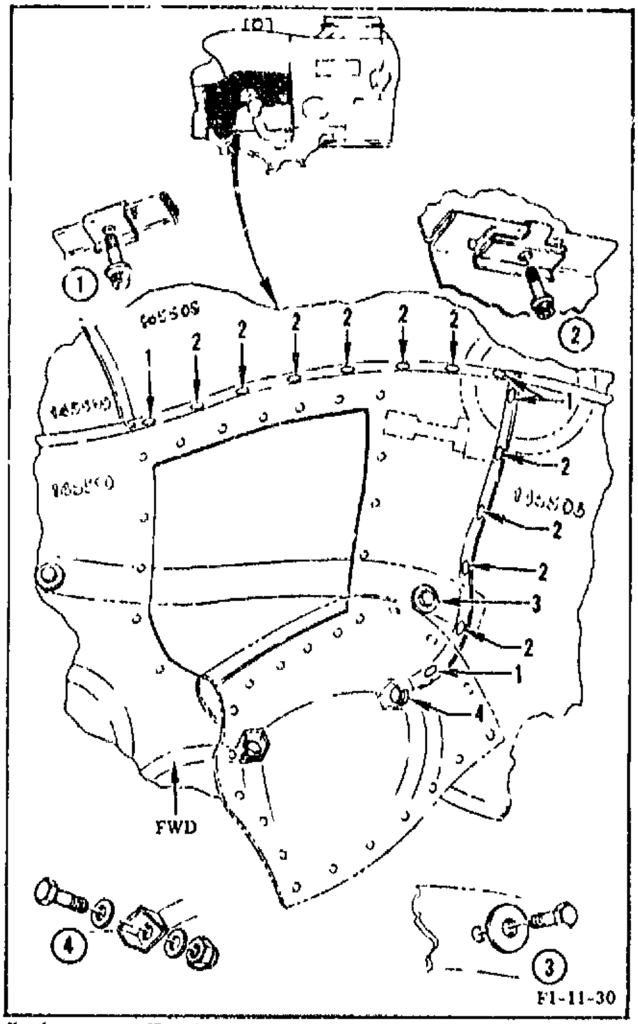
(3) One bolt and washer (3). Torque bolt to 8 ±3 in-lb above running torque.

(4) If removed, one bolt, 2 washers, and a nut (4). Torque nut to 27 ±3 in-lb.

3.6 HANDLING.

3.6.1 ENGINE INSTALLATION. This procedure may be used for horizontal engine installation and for vertical engine installation.

a. Verify that gas generator fuel and LOX ducts do not have surface rust or corrosion.



Index Number	Part Name	Part Number	Quantity
1	Bolt	MS21279-08	4
	Clip	RD114-5002-0002	4
2	Bolt	MS21279-08	10
	Clip	RD114-5001-0002	10
3	Bolt	NAS1004-6A	1
	Washer	RD153-5005-0006	1
4	Bolt	NAS1004-2A	1
	Washer	LD153-0013-0002	1
	Washer	RD153-1002-0004	1
	Nut	NAS679C4W	1

Figure 3-11B. Loosening and Securing Insulator 145510

b. Remove LOX and fuel inlet covers, and inspect inlets for foreign matter. Remove desiccant from covers, and store desiccant as specified in section II.

c. After inspection of LOX and fuel inlets, cover inlets with Aclar No. 33C film (0.002-inch minimum thickness) (Allied Chemical Corp). Secure film with pressure-sensitive tape RB0195-002 (Rocketdyne), or equivalent.

d. Remove engine gimbal boot cover.

e. If installing an outboard engine, verify that electrical cable support post is installed as outlined in R-3896-3.

f. If installing engine into stage vertically, remove 4 Gimbal Bearing Locks G4059. (See figure 3-12.)

g. If installing engine into stage horizontally, verify that engine gimbal wrap-around lines are installed and adequately supported as outlined in R-3896-3.

h. Using Stage-Contractor-supplied horizontal installer or Engine Vertical Installer G4049, as applicable, position engine in stage and attach gimbal bearing to stage attach point.

NOTE

During horizontal installation, gimbal bearing locks may require readjustment or complete removal to facilitate engine stage mating.

i. If installing engine into stage horizontally, remove 4 Gimbal Bearing Locks G4059. (See figure 3-12.)

j. Install gimbal bearing bolts.

k. On vertical engine installation, remove tiedown cables that secure engine to installer.

l. Install No. 1 or No. 2 gimbal actuators, with Stage-Contractor-supplied gimbal actuator locks, on outboard engines or stiff arms on inboard engine, as applicable, and immobilize engine.

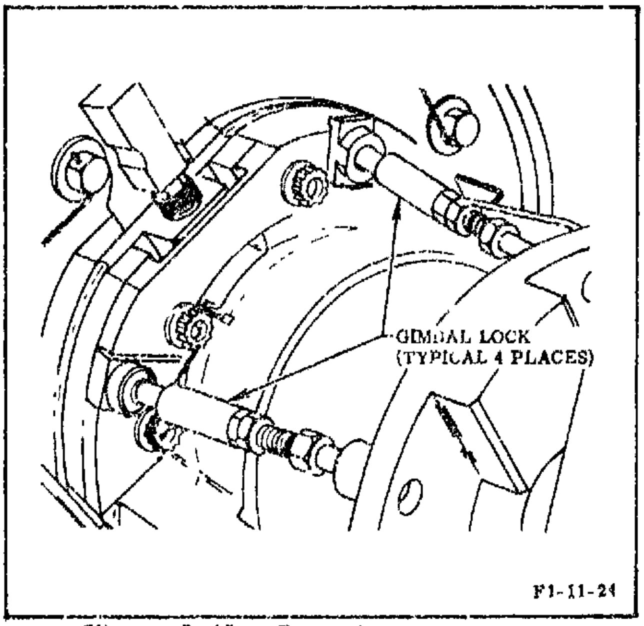


Figure 3-12. Gimbal Bearing Lock Installation

CAUTION

In the following procedure, care must be exercised to prevent contaminants from entering inlets during the connection procedure.

- In the following procedure, foreign matter must not be allowed to enter the oxidizer and fuel inlets, since foreign matter will contaminate the turbopump resulting in extensive turbopump repair.

m. Remove Aclar film from LOX and fuel pump inlets, and connect stage ducting to inlets.

n. Connect interface electrical connectors.

o. Connect stage pressure switch supply line to fitting on interface panel.

p. For vertical engine installation, install wrap-around ducts as outlined in R-3896-3.

q. Connect wrap-around ducts and hoses to stage using Stage-Contractor-supplied hardware and installation criteria.

3. 6. 2 THRUST CHAMBER NOZZLE EXTENSION INSTALLATION. (See figure 3-13.)

a. Install nozzle extension (serial number must be same as listed in Engine Log Book) on Engine Vertical Installer G4049, or equivalent, as outlined in R-3896-3; then position installer and nozzle extension beneath engine.

b. On engines incorporating MD135 change, inspect tadpole asbestos seal lap-joint overlap. Seals with square-cut lap-joint ends having approximately one inch overlap must be compressed as follows:

(1) Remove seal from package.

(2) Place seal lap joint in a clean, smooth-jawed (4-1/2-inch-minimum jaw width) vise. Locate lap joint at approximate center of vise jaws, but do not put large-diameter bead of seal between vise jaws.

(3) Compress seal lap joint to a free-state thickness of 0. 060 to 0. 090 inch.

NOTE

The compression will result in a greater seal width at the joint than adjacent to it.

(4) Check that seal is free from dirt, grease, and metal chips; then replace seal in package until ready to install.

WARNING

The following procedure uses dry-cleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

c. Visually verify that thrust chamber exit flange and flange boltholes and nozzle extension flange and flange boltholes are clean. Clean, if necessary, with a cloth saturated with drycleaning solvent (Federal Specification P-D-680), or equivalent.

d. Install seal on nozzle extension flange.

e. Elevate installer to within approximately 1/4 inch from bottom of thrust chamber.

NOTE

The nozzle extension must not be permitted to contact the thrust chamber during elevation.

f. Aline index mark on nozzle extension flange (located above igniter boss) with index mark on thrust chamber exhaust manifold flange (located under hot-gas manifold inlet).

g. Install 6-8 bolts on flange at index mark (point A, figure 3-13), and tighten nuts until snug. Do not torque nuts at this time.

h. Insert girth strap through loop end of support strap; then install girth strap around thrust chamber above manifold tension tie rods.

i. Verify that both lateral adjustment screws on alinement tool are fully backed off. Using horizontal and vertical adjustment screws, engage jaw pins to boltholes in thrust chamber and nozzle extension flanges, 180-degrees from index mark (point B, figure 3-13). Tighten support strap until alinement tool is in horizontal position. Maintain tool in horizontal position during all procedures.

j. Aline holes in thrust chamber and nozzle extension by adjusting horizontal, vertical, and lateral adjustment screws, as necessary.

k. Install 3-4 bolts on each side of alinement tool, and tighten nuts until snug. Do not torque nuts at this time.

l. Move alinement tool 90-degrees on flange (point C, figure 3-13) and perform steps h through k; then 180-degrees on flange (point D, figure 3-13) and perform steps h through k.

NOTE

One bolt in each exhaust manifold stiffener channel may be installed in the opposite direction if interference prevents normal installation.

m. Continue engaging alinement tool diametrically until all bolts are installed.

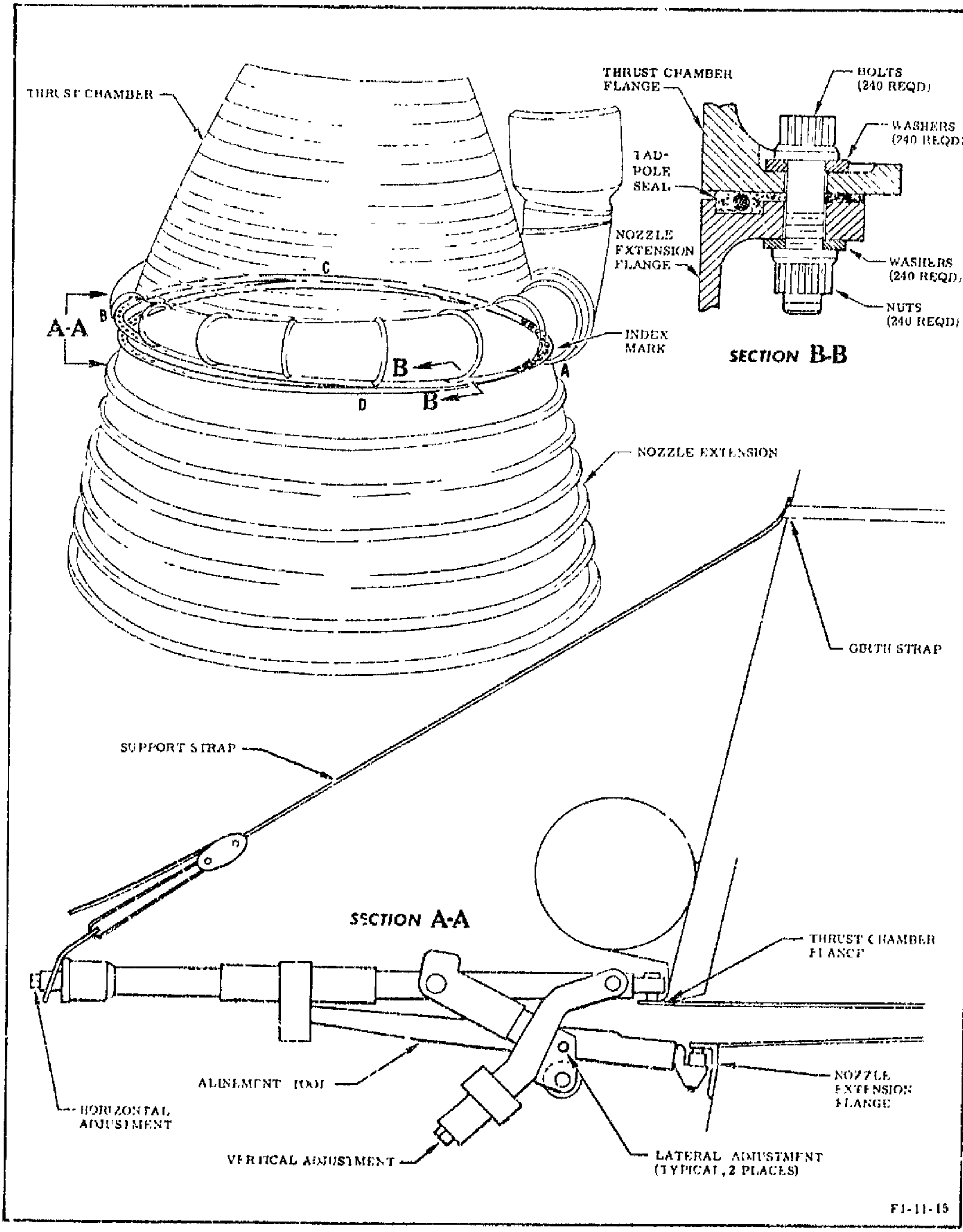


Figure 3-13. Nozzle Extension Installation

n. Visually check that seal is properly seated in nozzle extension before torquing nuts. Cross-torque nuts until each nut is torqued to 115-125 in-lb; then remove installer. On engines incorporating MD135 change, retorque nuts after one hour; then wait another hour and retorque all nuts again.

o. Install overboard drain lines (paragraphs 3.6.2.1 and 3.6.2.2).

3.6.2.1 Oxidizer Overboard Drain Line and Nitrogen Overboard Drain Line Installation.

a. Remove seal plates from packaging, install seal plate, and connect oxidizer overboard drain line. Torque nuts to 34-38 in-lb.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

b. Remove union from packaging. Lubricate (Method A) threads of union with lubricant grease RB0140-012 (Rocketdyne) and install in existing engine drain line. Torque coupling nut to 450-525 in-lb.

c. Connect nitrogen overboard drain line to union. Torque coupling nut to 450-525 in-lb.

d. Install cushion clamps around lines (figure 3-14, view A-A). Secure lines to nozzle extension brackets. Torque bolts to 18-22 in-lb above bolt running torque.

e. Secure clamps and lines to nozzle extension brackets. Torque bolts to 18-22 in-lb above bolt running torque.

3.6.2.2 Fuel Overboard Drain Line Installation.

a. Remove seal plate from packaging, and install seal plate and fuel overboard drain line. Torque nuts to 32-38 in-lb above bolt running torque.

b. Install cushion clamps around lines (figure 3-14, view C-C).

c. Secure clamps and lines to nozzle extension brackets. Torque bolts to 18-22 in-lb above bolt running torque.

3.6.3 IGNITER HARNESS INSTALLATION. (See figure 3-15.)

a. Prior to connecting electrical harness plug to igniters, verify that each igniter has been tested after installation.

b. Connect electrical plug P47 to engine electrical receptacle J47 at turbopump No. 1 fuel pump inlet elbow to turbopump flange. Refer to R-3896-3 for electrical connectors installation and removal.

c. Connect gas generator igniter harness plugs P43 and P44 to igniters. Refer to R-3896-3 for electrical connectors installation and removal.

d. Connect nozzle extension igniter harness plugs P45 and P46 to igniters. Refer to R-3896-3 for electrical connectors installation and removal.

e. Electrically verify and monitor igniter installation.

3.6.4 IGNITER HARNESS REMOVAL. (See figure 3-15.)

a. Disconnect electrical plug P47 from electrical receptacle J47 at turbopump No. 1 fuel pump inlet elbow to turbopump flange. Refer to R-3896-3 for electrical connectors installation and removal.

b. Remove igniter harness.

NOTE

Igniter harnesses are considered reusable for engine static test if they are visually inspected, tested, and determined acceptable as specified in R-3896-3.

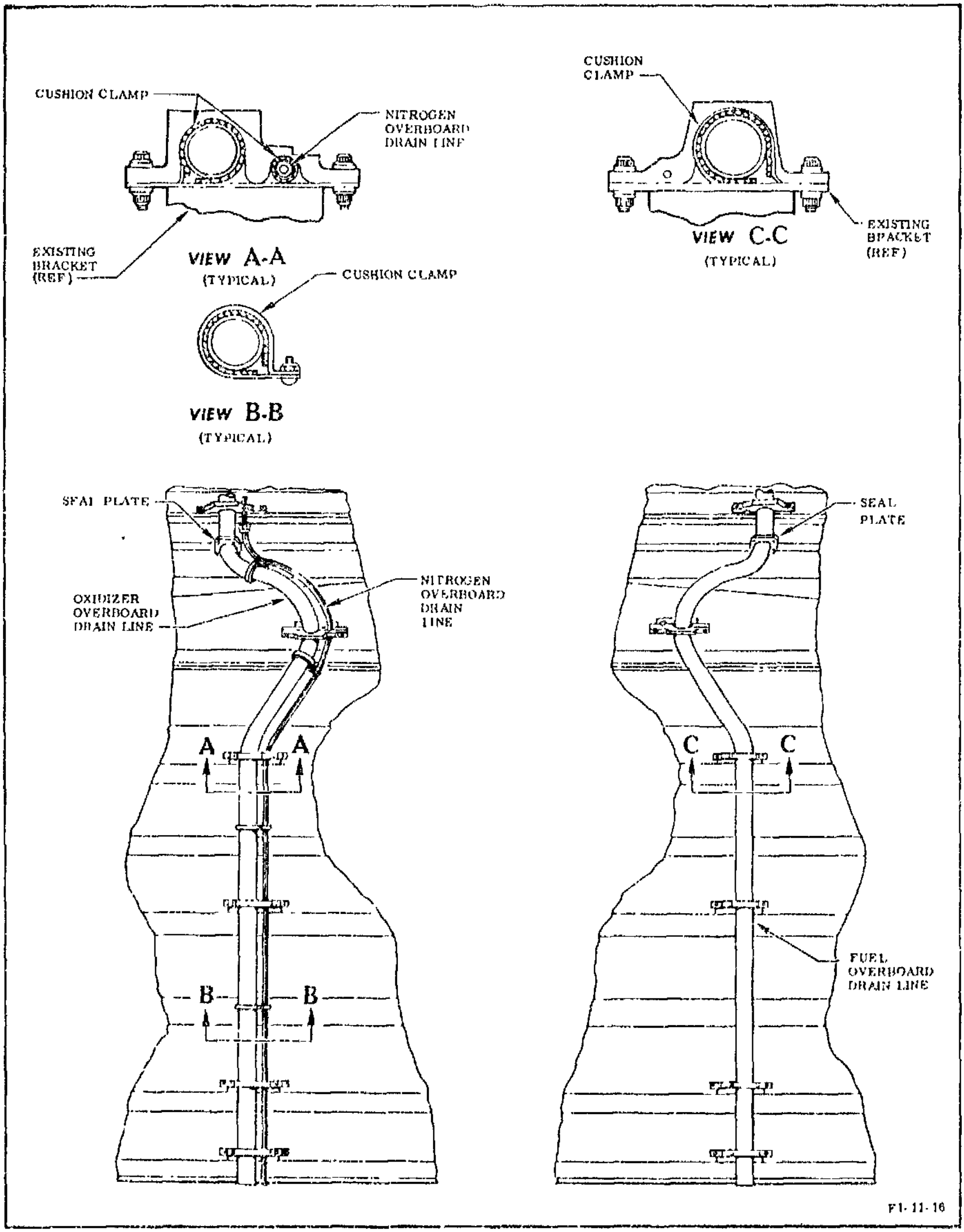


Figure 3-14. Overboard Drain Line Installation

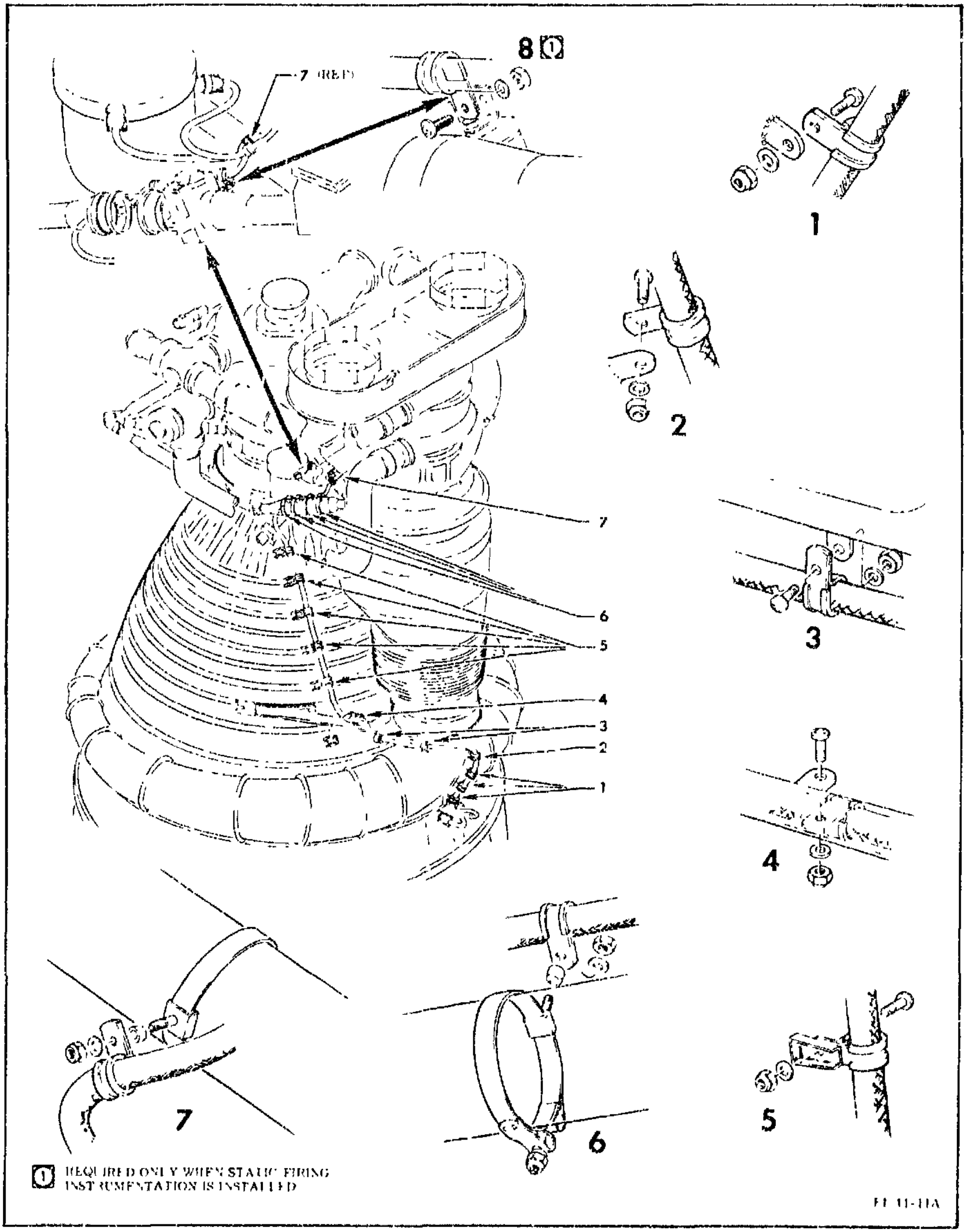


Figure 3-15. Igniter Harness Installation

3.6.5 ENGINE ENVIRONMENTAL COVER INSTALLATION. (See figure 3-16.)

a. Unfold cover in an area immediately adjacent to each engine thrust chamber throat.

NOTE

The silver-colored side of the cover is the inner cover surface.

b. Wrap cover around thrust chamber and nozzle extension, placing cover so that overboard drain lines are exposed through holes provided in cover.

c. Tighten cover around thrust chamber and nozzle extension until edges of cover overlap and can be laced together.

d. Temporarily support cover around thrust chamber throat by attaching lengths of rope to cover grommets and to any suitable vehicle structure that will adequately support weight of cover (approximately 60 pounds).

CAUTION

Support ropes must not be tied to any part of the engine.

e. Gather up excess cover material around throat of thrust chamber. Thread a length of rope through cover grommets, and make a fold in material approximately 5 feet in length. Tie fold together with rope.

f. Continue to fold cover around throat as outlined in step e. taking care not to fold cover in area of flap until cover is as tight as possible. Tighten edges of cover, and lace inside rows of cover grommets with rope; then fold flap over, and lace outside rows of cover grommets.

NOTE

Once the pleating has been completed around the thrust chamber throat for the first cover, the cover may be temporarily removed and used as a pattern for other covers, if desired.

g. Release ropes that were used to support cover, and allow cover to hang free on chamber.

h. Thread rope through cover grommets at exit end of nozzle extension.

i. Pull threaded rope tight, drawing cover around and under exit end of nozzle extension, and tie.

3.6.6 ENGINE ENVIRONMENTAL COVER REMOVAL. (See figure 3-16.)

a. Untie rope at exit end of nozzle extension.

b. Unlace rope at cover flap.

c. Untie ropes that secure cover at thrust chamber throat, and slowly lower cover using appropriate supports to prevent cover from being damaged during lowering.

d. Fold and store cover for future use.

3.6.7 THERMAL INSULATION INSTALLATION AND REMOVAL. Thermal installation and removal is performed using criteria specified in R-3896-6. Observe safety precautions outlined in section II when handling thermal insulation.

3.6.8 IGNITER INSTALLATION. The procedure for installing live igniters or inert igniters is as follows:

a. Using cleaning brush 9512-984347, or equivalent, clean igniter ports.

b. Remove any remaining loose particles or moisture from igniter port at gas generator by turning on operational low-level LOX dome and gas generator LOX injector purge system. Turn purge off before proceeding to step c.

c. Verify that igniters have been inspected and tested using applicable procedures outlined in paragraph 3.3.1.7 for live igniters or paragraph 3.3.1.8 for inert igniters.

d. Verify the gasket is installed on igniter, and install igniter fingertight.

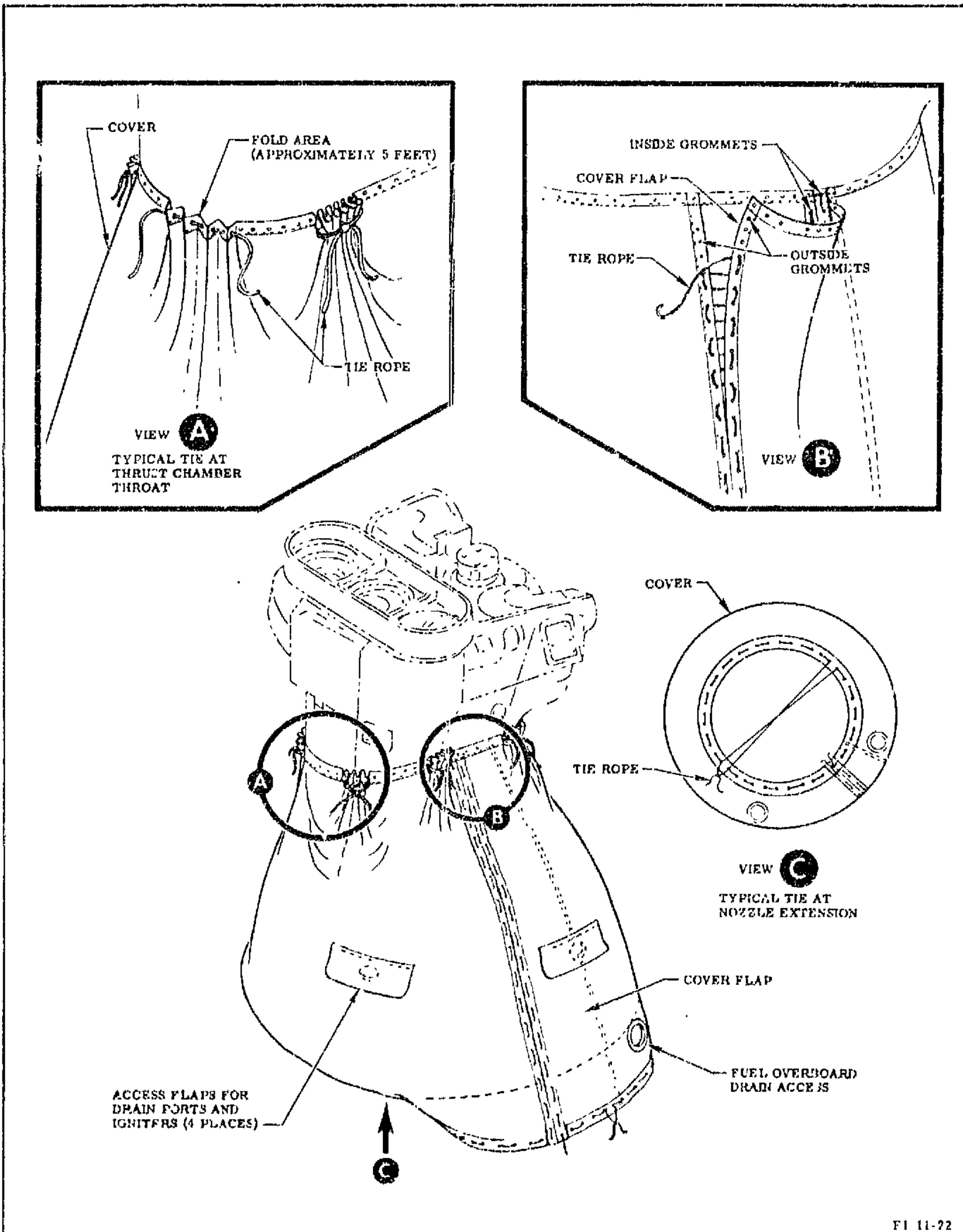


Figure 3-16. Engine Environmental Cover Installation

CAUTION

In the following procedure, if a 12-point, 1-inch deep-well socket is used to torque the igniters, the socket must fit loosely over the igniter shorting or shielding cap, to prevent damage to the shorting or shielding cap.

NOTE

A shielding cap must be used on igniters at KSC during igniter installation and until igniter is connected.

e. Check that gasket seats in recessed groove of igniter boss; then torque each igniter to 625 ±25-in-lb.

f. Safetywire igniters with Inconel lockwire MS20995N.

g. (Deleted)

h. Remove shorting or shielding caps and connect nozzle extension igniter harness plugs P45 and P46 and gas generator igniter harness plugs P43 and P44 to igniters. Refer to R-3896-3 for electrical connectors installation and removal.

CAUTION

Inert igniters must be removed and replaced with live igniters prior to launch.

3.6.9 LIVE IGNITER REMOVAL.

a. Observe igniter handling safety requirements of section II.

b. Disconnect electrical connectors P43 and P44 from gas generator igniters. Refer to R-3896-3 for electrical connectors installation and removal.

c. Disconnect electrical connectors P45 and P46 from nozzle extension igniters. Refer to R-3896-3 for electrical connectors installation and removal.

d. Install shorting or shielding caps on igniters.

NOTE

A shielding cap must be used on igniters at KSC after igniter harness is disconnected and until igniter is removed.

e. Remove gas generator and nozzle extension igniters.

f. Package and store igniters as outlined in section II.

g. Remove plug and washer or gasket, as applicable, from packaging. Clean and inspect threads of plug ST3950122RKL001 for adequate silver plating. Replace plug if silver plating is not adequate. Install washer 651912-3 on plug. Do not lubricate plug. Install plug in gas generator igniter boss and torque to 600-650 in-lb. Safetywire 2 igniter plugs together with Inconel lockwire MS20995N. As an alternate, plug MS9015-08 with washer 651912-3 or gasket AN901-8C may be used. If washer 651912-3 is used, install plug MS9015-08 in igniter boss and torque to 150-200 in-lb. If gasket AN901-8C is used, screw plug MS9015-08 fingertight into igniter boss. Check that gasket seats in recessed groove on igniter boss. Torque plug to 150-200 in-lb. Safetywire plug with Inconel lockwire MS20995N.

h. Install protective closures in nozzle extension igniter bosses.

3.6.10 EXPENDED IGNITER REMOVAL.

a. Disconnect electrical connectors P43 and P44 from gas generator igniters. Refer to R-3896-3 for electrical connectors installation and removal.

b. Disconnect electrical connectors P45 and P46 from nozzle extension igniters. Refer to R-3896-3 for electrical connectors installation and removal.

c. Remove gas generator and nozzle extension igniters.

d. Remove plug and washer or gasket, as applicable, from packaging. Clean and inspect threads of plug ST3950122RKL001 for adequate silver plating. Replace plug if silver plating is not adequate. Install washer 651912-3 on plug. Do not lubricate plug. Install plug in gas generator igniter boss and torque to 600-650 in-lb. Safetywire 2 igniter plugs together with Inconel lockwire MS20995N. As an alternate, plug MS9015-08 with washer 651912-3 or gasket AN901-8C may be used. If washer 651912-3 is used, install plug MS9015-08 in igniter boss and torque to 150-200 in-lb. If gasket AN901-8C is used, screw plug MS9015-08 fingertight into igniter boss. Check that gasket seats in recessed groove on igniter boss. Torque plug to 150-200 in-lb. Safetywire plug with Inconel lockwire MS20995N.

dA. Install protective closures in nozzle extension igniter bosses.

e. Visually inspect each expended igniter to verify that igniter tube is not separated from igniter body. If tube is separated from body, notify Rocketdyne representative.

f. Store and dispose of expended igniter as outlined in section II.

3.6.10A HYPERGOL CARTRIDGE SERVICING.

3.6.10A.1 Hypergol Cartridge Removal From Container. (See figure 3-16-1.)

a. Observe all safety precautions at using organization, and wear protective clothing specified in section II.

b. Remove locking ring, cover, and gasket from each end of hypergol cartridge shipping container.

c. Remove -3 cushions from each end of shipping container.

d. Using 2 people, remove hypergol cartridge from shipping container as follows:

(1) First person hold shipping container securely.

(2) Second person reach into shipping container from end opposite hypergol cartridge cap and push -2 cushion and hypergol cartridge, as a unit, from shipping container sufficiently to permit grasping of -2 cushion and hypergol cartridge at cap end.

(3) Pull hypergol cartridge and -2 cushion, as a unit, from shipping container.

e. Unroll -2 cushion from around hypergol cartridge and remove hypergol cartridge in its polyethylene bag or bags if double-packaged.

WARNING

The following procedures use cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

f. If double-packaged, use a lint-free cloth moistened with cleaning compound (MIL-C-81302) and wipe outer polyethylene bag free of all visible contaminants; inspect bag for tears then carefully open outer polyethylene bag at hypergol cartridge cap end and remove hypergol cartridge still sealed in inner polyethylene bag.

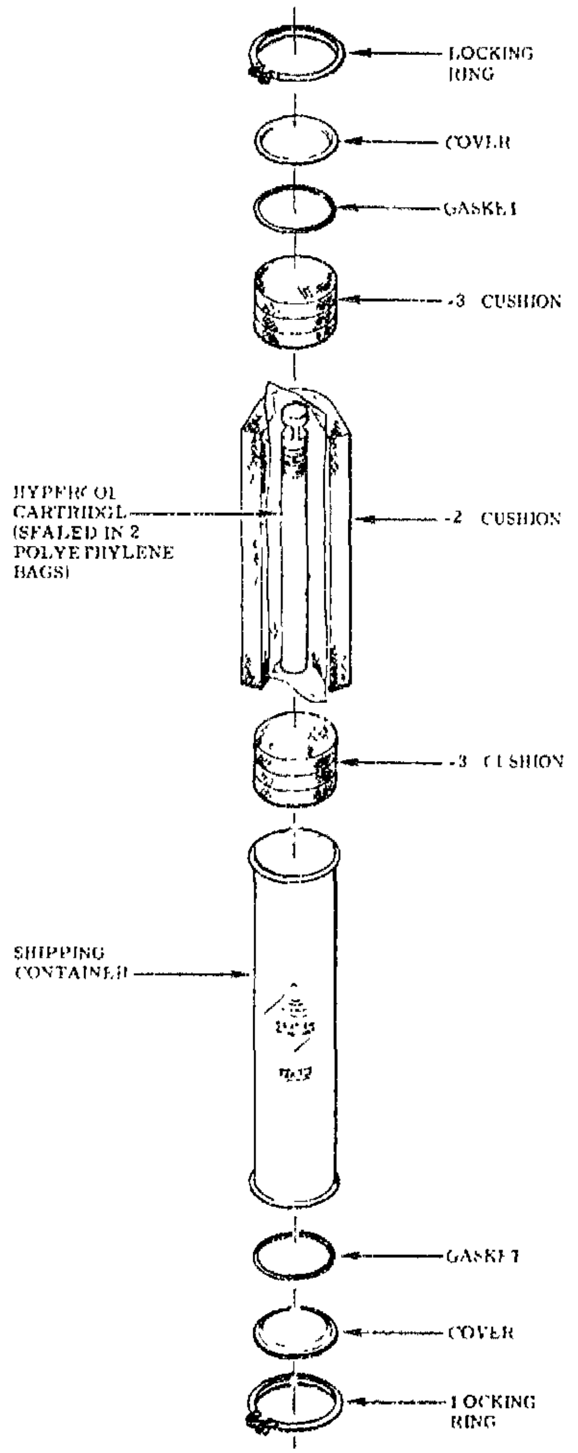


Figure 3-16-1. Hypergol Cartridge Packaging

g. Inspect polyethylene bag containing hypergol cartridge for rips. If inner bag is torn and outer bag was torn, remove bag and restore hypergol cartridge to a serviceable condition as outlined in paragraph 3.6.10A.3.

h. Before unsealing polyethylene bag, use a lint-free cloth moistened with cleaning compound (MIL-C-81302) and wipe polyethylene bag free of visible contaminants.

i. Cut off sealed end of polyethylene bag, and carefully remove hypergol cartridge from bag.

3.6.10A.2 Hypergol Cartridge Inspection.

a. Observe all safety precautions applicable at using organization, and wear protective clothing specified in section II.

b. Verify (by hand torquing in tightening direction) that hypergol cartridge is tight to its plug.

c. Inspect hypergol cartridge packings for chipping, cracking, or improper fit. If packings are damaged, restore hypergol cartridge to a serviceable condition as outlined in paragraph 3.6.10A.3.

d. Verify that downstream packing ring (located between packing and cap in packing groove) is not tucked under packing.

3.6.10A.3 Hypergol Cartridge Restoration. (See figure 3-16-2.)

a. Observe all safety precautions applicable at using organization, and wear protective clothing specified in section II, when applicable.

b. Remove and discard packings and ring from hypergol cartridge.

WARNING

The following procedures use cleaning compound, which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

c. Using a lint-free cloth moistened with cleaning compound (MIL-C-81302), wipe hypergol cartridge exterior, packing grooves, and outside of plug free of all visible contaminants.

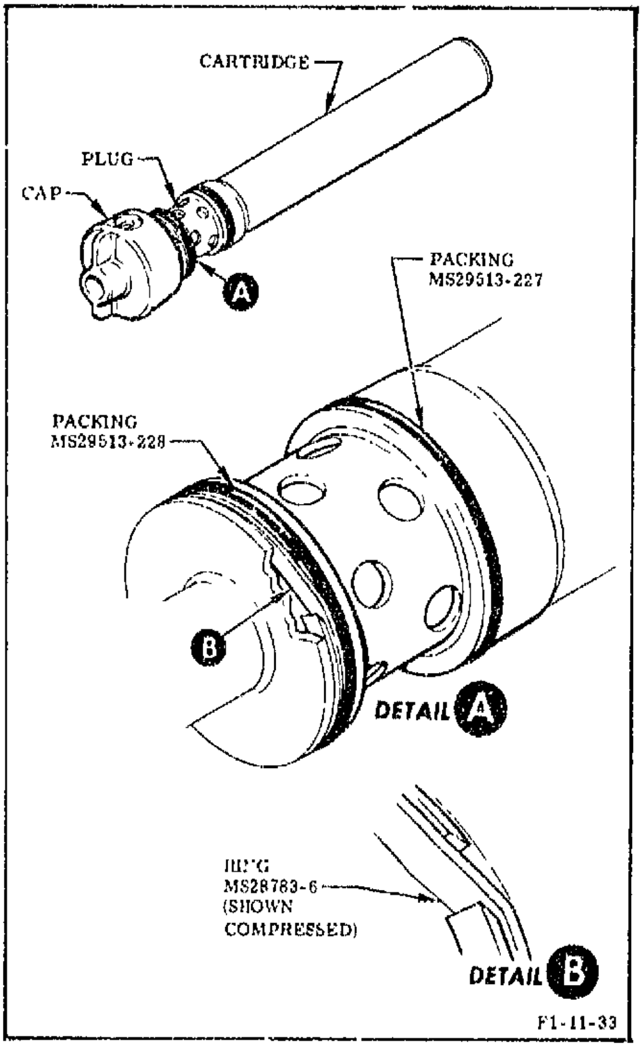


Figure 3-16-2. Hypergol Cartridge Restoration

d. Using a lint-free swab moistened with cleaning compound (MIL-C-81302), remove all visible contamination from interior of plug.

e. Inspect threaded area of cap for contaminants or lubricant.

CAUTION

In the following procedure, cleaning compound must not be permitted to contact the lubricated bearing surface between the cap and plug since the cleaning compound will remove the lubricant.

f. If contamination or lubricant is detected during inspection of cap threads, use a brush or a lint-free cloth moistened with cleaning compound (MIL-C-81302) and remove all visible contamination or lubricant from threads.

g. Install a new ring MS28783-6 in packing groove closest to cap.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

h. Lubricate (Method L) packing MS29513-228 and packing groove closest to cap with FS1281 grease (Dow Corning Corp) and install packing with ring positioned in groove between packing and cap.

i. Lubricate (Method L) packing MS29513-227 and packing groove farthest from cap with FS1281 grease (Dow Corning Corp) and install packing.

NOTE

There is no ring to be installed in the groove with packing MS29513-227.

3.6.10A.4 Hypergol Cartridge Weight Check.

a. Observe all safety precautions applicable at using organization, and wear protective clothing specified in section II.

b. Remove protective packaging from hypergol as outlined in paragraph 3.6.10A.1.

c. Weigh hypergol cartridge, and record weight.

d. Compare weight recorded in step c with weight recorded on hypergol cartridge. Recorded weight must be within 15 grams of hypergol cartridge gross weight.

e. Repackage hypergol cartridge as outlined in paragraph 3.6.10A.5.

3.6.10A.5 Hypergol Cartridge Repackaging. (See figure 3-16-1.)

a. Observe all safety precautions applicable at using organization, and wear protective clothing specified in section II.

b. Verify that hypergol cartridge is free from contaminants and damage.

c. Package hypergol cartridge in a clean bag made from plastic sheet and strip (Federal Specification L-P-378, Type II). Fold top of bag closed and seal bag with pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60).

NOTE

A clean polyethylene bag (Federal Stock No. 8105-LCO-6811) or polyethylene tubing (Federal Stock No. 8135-782-7460) heat sealed at one end, may be used instead of plastic sheet and strip. All polyethylene material used must be 0.004-inch minimum thickness.

d. Package the single-packaged hypergol cartridge in a second clean bag made from plastic sheet and strip (Federal Specification L-P-378, Type II). Fold top of bag closed and seal bag with pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60).

NOTE

A clean polyethylene bag (Federal Stock No. 8105-LCO-6811) or polyethylene tubing (Federal Stock No. 8135-782-7460) heat sealed at one end, may be used instead of plastic sheet and strip. All polyethylene material used must be 0.004-inch minimum thickness.

e. Verify that hypergol shipping container and cushions are free from moisture.

f. Verify that shipping container is the original container for that particular hypergol cartridge.

g. Wrap double-packaged hypergol cartridge in -2 cushion and insert as a unit into shipping container with cap end of cartridge up when caution decal on container is right side up.

h. Install -3 cushions in shipping container at each end of hypergol cartridge.

i. Install gasket, cover, and locking ring on each end of shipping container. Torque locking ring clamp screw sufficiently to seat cover on gasket.

3.6.11 HYPERGOL CARTRIDGE INSTALLATION.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

NOTE

The hypergol-cartridge-installed indication must be monitored throughout this procedure.

aA. Remove pin that secures closure in hypergol manifold cartridge container inlet port; then remove closure.

b. Observe all safety precautions applicable at using organization, and wear protective clothing specified in section II.

bA. Remove hypergol cartridge from shipping container as outlined in paragraph 3.6.10A.1.

c. Verify that hypergol cartridge weight check has been performed as outlined in paragraph 3.6.10A.4.

d. Perform hypergol cartridge inspection as outlined in paragraph 3.6.10A.2.

e. (Deleted)

f. Verify that hypergol-cartridge-installed switch is deactuated.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

g. Lubricate bore of hypergol manifold cartridge container with FS1281 grease (Dow Corning Corp). (See figure 3-9.)

h. Lubricate (Method A) threads of hypergol manifold cartridge container inlet port with FS1281 grease (Dow Corning Corp).

i. Carefully insert cartridge into hypergol manifold cartridge container inlet without binding, scuffing, or any irregular resistance that indicates an incorrect size packing or a damaged hypergol container.

j. Screw hypergol cartridge cap clockwise onto container until hole in cap alines with hole in container. Verify that hypergol cartridge switch actuates.

WARNING

In the following procedure fluid leakage from a damaged hypergol can result in serious injury to personnel and damage to equipment.

k. If electrical verification that hypergol cartridge is installed cannot be obtained, clear immediate area. Disarm an installed hypergol cartridge as outlined in paragraph 3.6.12.1.

CAUTION

In the following procedure, using force to install the hypergol cartridge cap on the container can result in damage to the container and cartridge.

l. Do not use a tool to install hypergol cartridge cap on container. If hole in cartridge gap cannot be alined with hole in container, remove cartridge and take corrective action.

m. Insert pin through alined holes, securing cap on container, until pin locks in place.

3.6.12 HYPERGOL CARTRIDGE REMOVAL.

WARNING

No attempt must be made to remove a live hypergol cartridge if damage to the cartridge diaphragm is suspected since a fire can occur, resulting in serious injury to personnel and damage to equipment.

3.6.12.1 Live Hypergol Cartridge Removal When Damage is Suspected.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

aA. Observe all safety precautions applicable at using organization, and wear protective clothing specified in section II.

b. Remove pressure cap from, and connect hypergol malfunction purge system, meeting requirements of section II, to, hypergol purge quick-disconnect.

c. Remove pressure cap from, and connect thrust chamber fuel jacket purge system, meeting requirements of section II, to, fuel jacket purge quick-disconnect on each fuel valve.

d. Disconnect igniter fuel valve drain tube from, and connect a source of gaseous nitrogen, meeting igniter fuel valve lockup requirements of section II, to, igniter fuel valve vent port.

e. Turn on operational high-level LOX dome and gas generator LOX injector purge system, and audibly verify operation of purge.

f. Pressurize thrust chamber fuel jacket purge system to 350 ±50 psig.

WARNING

In the following procedures, the test area must be cleared until the hypergol cartridge diaphragms have burst and hypergol fluid has been purged from the container since an explosion and fire can occur, resulting in serious injury to personnel and damage to equipment.

g. Pressurize igniter fuel valve lockup purge to 750 ±25 psig.

h. Slowly pressurize hypergol malfunction purge system until hypergol cartridge diaphragms burst.

i. Allow purges to continue until all vapor ceases to be emitted from thrust chamber.

j. Depressurize hypergol malfunction purge system.

k. Depressurize igniter fuel valve lockup purge system, and bleed pressure from igniter fuel valve cap.

l. Depressurize thrust chamber fuel jacket purge system.

m. Turn off operational high-level LOX dome and gas generator LOX injector purge.

n. Disconnect igniter fuel valve lockup purge system from igniter fuel valve vent port, and reinstall igniter fuel valve drain tube as follows:

(1) Remove plug from igniter fuel valve drain tube.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

(2) Lubricate (Method A) fitting and (Method G) igniter fuel valve drain tube with lubricant grease RB0140-012 (Rocketdyne).

(3) Install igniter fuel valve drain tube and torque tube coupling nut to 270-345 in-lb.

o. Disconnect thrust chamber fuel jacket purge system from fuel jacket purge quick-disconnect on each fuel valve. Remove pressure cap from packaging and install pressure cap on quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire cap with Inconel lockwire MS20995N.

p. Disconnect hypergol malfunction purge system from hypergol purge quick-disconnect. Remove pressure cap from packaging and install pressure cap on quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire cap with Inconel lockwire MS20995N.

q. Remove expended cartridge as outlined in paragraph 3.6.12.3.

3.6.12.2 Live Hypergol Cartridge Removal When No Damage is Suspected.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

aA. Observe all safety precautions applicable at using organization, and wear protective clothing specified in section II.

aB. If white smoke is evident at hypergol manifold, assume that hypergol cartridge is damaged and perform paragraph 3.6.12.1.

b. Remove pin that secures hypergol cartridge in cartridge container inlet port.

WARNING

In the following procedure, if there is any evidence of white smoke during removal of cartridge, the area must be evacuated immediately since a fire could result, causing serious injury to personnel and damage to equipment.

c. Unscrew hypergol cartridge cap from container; then carefully remove cartridge from container.

d. Wipe excess lubricant from hypergol cartridge packings and from exterior of cartridge.

e. Repackage hypergol cartridge as outlined in paragraph 3.6.10A.5.

WARNING

The following procedures use drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

f. Clean bore of hypergol manifold cartridge container with drycleaning solvent (Federal Specification P-D-680). Wipe bore dry with a clean, dry, lint-free cloth.

g. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680).

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

gA. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp).

h. Install hypergol cartridge inlet port closure and secure with attaching pin.

3.6.12.3 Expended Hypergol Cartridge Removal.

a. Perform, as applicable, contamination and damage prevention procedures outlined in paragraph 3.1A when performing this procedure.

WARNING

No attempt must be made to remove a live hypergol cartridge if damage to cartridge diaphragms is suspected since a fire can occur, resulting in serious injury to personnel and damage to equipment.

aA. Observe all safety precautions applicable at using organization, and wear protective clothing specified in section II.

NOTE

The procedure for disarming an installed live hypergol cartridge is outlined in paragraph 3.6.12.1.

b. Remove pressure cap from, and connect a drain hose to, hypergol manifold drain quick-disconnect.

c. When all fuel ceases to drain from hypergol cartridge, disconnect drain hose, remove pressure cap from packaging, and install pressure cap on hypergol cartridge drain quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire cap with Inconel lockwire MS20995N.

d. Remove pressure cap from, and connect hypergol servicing purge system, meeting requirements of section II, to, hypergol purge quick-disconnect.

e. Turn on operational high-level LOX dome and gas generator LOX injector purge system, and audibly verify operation of purge.

f. Pressurize hypergol purge system to 150 ±50 psig, and audibly verify operation of purge. After purging 3 minutes minimum, depressurize purge system.

g. Turn off operational high-level LOX dome and gas generator LOX injector purge system.

h. Remove pin that secures cartridge in hypergol manifold cartridge container inlet port.

i. Unscrew hypergol cartridge cap from container; then remove and place cartridge in its shipping container.

WARNING

The following procedure uses drycleaning solvent, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

j. Clean threads of hypergol manifold cartridge container inlet port with drycleaning solvent (Federal Specification P-D-680).

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

jA. Lubricate (Method L) closure packing with FS1281 grease (Dow Corning Corp).

k. Install hypergol cartridge inlet port closure and secure with attaching pin.

l. Disconnect hypergol servicing purge system, remove pressure cap from packaging, and install pressure cap on hypergol cartridge container purge quick-disconnect. Torque pressure cap to 30-40 ft-lb. Safetywire cap with Inconel lockwire MS20995N.

3.6.13 THRUST CHAMBER THROAT SECURITY CLOSURE INSTALLATION.

a. If installed, remove thrust chamber exit closure and thrust chamber throat closure.

b. Obtain shaft from Thrust Chamber Throat Security Closure G4089; then retract pin and secure in detent position.

c. Install shaft in center hole of thrust chamber injector until shaft bottoms, aline pin between extensions on injector face, and then release pin from detent position.

NOTE

In the following procedure, desiccant must not be removed from its airtight container until just prior to installation.

d. Install 48 units of desiccant as outlined in section II in cover of closure, and make sure humidity indicator is in safe range.

e. Install closure on shaft. Aline hole in closure extension with hole in shaft, and install combination padlock 9026900 through closure and shaft.

f. Inflate closure tube to 5-7 psig pressure with gaseous nitrogen (MIL-P-27401).

g. Reinstall thrust chamber exit closure, if applicable.

3.6.14 THRUST CHAMBER THROAT SECURITY CLOSURE REMOVAL.

a. Remove thrust chamber exit closure, if applicable.

b. Remove padlock, deflate closure, and remove thrust chamber throat security closure.

c. Place pin in detent position, and remove shaft.

d. Remove desiccant from closure, and store desiccant as outlined in section II.

e. Package thrust chamber security closure for storage by enclosing it in a clean plastic bag, then cushioning it with polyurethane material in a suitable box.

3.6.15 THRUST CHAMBER THROAT PLUG INSTALLATION.

a. Clean threaded hole in center of thrust chamber injector prior to installing throat plug.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

b. Lubricate (Method A) threads of throat plug shaft with lubricant grease RB0140-012 (Rocketdyne).

CAUTION

In the following procedure, the spacer must not be allowed to bottom against the shaft collar, since damage to the injector may result.

c. Install spacer on shaft. Holding spacer against thrust chamber injector, screw shaft into thrust chamber injector while monitoring that clearance is maintained between spacer and shaft collar.

d. Measure axial spacing between spacer and shaft collar. Allowable spacing is 0.020 to 0.115 inch.

NOTE

If spacing is less than 0.020 inch, perform steps e and f. If spacing is greater than 0.020 inch, proceed to step g.

e. When spacing is less than 0.020 inch, unscrew shaft from injector and insert washer T-5046431 over shaft threads; then holding spacer against thrust chamber injector, screw shaft into thrust chamber injector. Monitor that clearance is maintained between spacer and shaft collar.

f. Measure axial spacing between spacer and shaft collar. Allowable spacing with washer T-5046431 installed is 0.020 t 0.274 inch.

g. Torque shaft to 500 ±50 in-lb.

h. Apply petrolatum (Federal Specification VV-P-236) to tubes in thrust chamber throat.

i. Install support on shaft, alining support keyhole slot with shaft pin; rotate support clockwise to lock.

CAUTION

In the following step, care must be taken when installing the seal, to prevent damaging the seal stem.

j. Make sure that seal is clean, and install seal on support with valve stem facing outboard and ridges of seal periphery alined with tube contours.

k. Install retainer on shaft, alining retainer keyhole slots with studs on support, and rotate retainer clockwise to secure.

l. Install washer and nut on shaft and tighten firmly. Make sure washer contacts retainer.

m. Install quick-disconnect and burst diaphragm in support.

CAUTION

In the following step, the gaseous nitrogen supply hose must be supported to prevent the weight on the seal valve stem from damaging the seal.

mA. Connect a source of gaseous nitrogen to throat plug seal. Using a suitable material, support the gaseous nitrogen supply hose to relieve all weight of hose from seal valve stem.

Procedure	Result
n. Pressurize throat plug seal to 50 (+5, -10) psig. Maintain pressure during remainder of test.	Thrust chamber throat plug seal is pressurized.

3.6.16 THRUST CHAMBER THROAT PLUG REMOVAL.

a. Verify that pressure is vented from thrust chamber.

b. Verify that thrust chamber throat plug seal is depressurized.

c. Remove quick-disconnect and burst diaphragm from retainer.

d. Remove nut and washer from shaft.

e. Rotate retainer counterclockwise on shaft to aline retainer keyhole slots with studs on support, and remove retainer.

f. Rotate support counterclockwise, alining support keyhole slot with shaft pin, and remove support.

CAUTION

In the following step, care must be taken when removing the seal, to prevent damaging the seal stem.

fA. Carefully remove seal from support.

g. Unscrew shaft from injector, and remove spacer from shaft.

WARNING

The following procedure uses trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause injury or death.

h. Wipe thrust chamber throat and throat plug seal free of petrolatum with a clean, lint-free cloth moistened in trichloroethylene (MIL-T-27602).

i. Install thrust chamber throat security closure (paragraph 3.6.13).

3.6.17 TURBINE EXHAUST EXIT PRESSURE TEST FIXTURE INSTALLATION.

a. Apply a thin coat of petrolatum (Federal Specification VV-P-236) to ends of all segment seals where they overlap.

b. Remove knurled thumbnuts from internal wrenching screws on each clamp.

c. Attach one clamp, with quick-release pin, to any lug on inner wall of thrust chamber exit. Omit 3 lugs and attach a second clamp, with quick-release pin, to fourth lug in either direction from first clamp.

d. Place segment on thrust chamber, and aline holes in segment with 2 clamps.

e. Insert internal wrenching screws through holes in thrust chamber exit ring, segment, and clamp. Attach knurled thumbnuts to internal wrenching screws. Do not tighten.

f. Aline outer curvature of segment with curvature of thrust chamber exit ring. Hand-tighten the 4 thumbnuts.

g. To install segments No. 2 through 7, repeat steps b through f, proceeding clockwise.

h. To install segment No. 8, loosen thumbnuts on first segment installed and repeat steps b through f.

NOTE

The tapered seal on the end of segment No. 8 must be placed under segment No. 1.

i. Adjust alinement of all segments, as necessary.

j. Install previously omitted clamps. Hand-tighten all knurled thumbnuts.

k. Inflate each seal using gaseous nitrogen (MIL-P-27401) to 35 ±2 psig, proceeding clockwise.

NOTE

To determine if individual seals have inflated, a visual check must be made that rubber of seal has expanded to meet overlapping backup plate of the junction of each segment.

3.6.18 TURBINE EXHAUST EXIT PRESSURE TEST FIXTURE REMOVAL.

a. Depressurize each segment seal at thrust chamber exhaust exit.

b. Remove knurled thumbnuts that secure clamps, and remove seal segments from thrust chamber exit.

WARNING

The following procedure uses dry-cleaning solvent which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

c. Clean thrust chamber exit flange and flange boltholes of residual lubricant with dry-cleaning solvent (Federal Specification P-D-680).

3.6.19 INTERFACE PANEL ACCESS DOOR REMOVAL. Remove 60 screws that secure each interface panel access door, and remove access doors.

3.6.20 INTERFACE PANEL ACCESS DOOR INSTALLATION. Install access doors on interface panel using 60 screws for each door. Torque screws to 30-40 in-lb.

3.6.20A FUEL INLET ELBOW INSULATION BOOT INSTALLATION. (See figure 3-16A.)

NOTE

The installation of insulation boots is identical for the No. 1 and No. 2 sides of the engine.

a. Position each half of insulation boot around fuel inlet duct between interface panel and fuel inlet elbow.

b. Align boot halves, and secure halves together with snap fasteners provided.

c. Secure insulation boot to interface panel flange and to fuel inlet elbow flange with boot clamps provided. Torque clamp screws to 20 ±2 in-lb.

3.6.21 THRUST CHAMBER NOZZLE EXTENSION REMOVAL.

a. Verify that overboard drain lines are removed (paragraphs 3.6.21.1 and 3.6.21.2).

b. Verify that igniter harness is removed (paragraph 3.6.4).

c. Position Engine Vertical Installer G4049 under nozzle extension, and raise installer until extension is seated in installer 16:1 ring.

d. Disconnect extension from thrust chamber.

e. Lower extension, and position installer clear of engine.

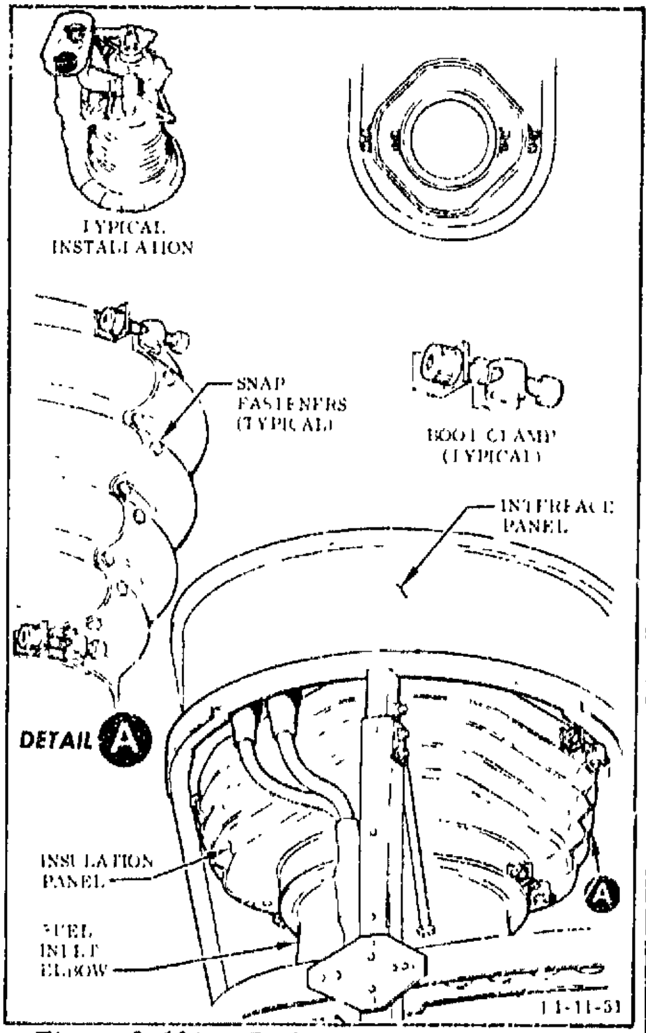


Figure 3-16A. Fuel Inlet Elbow Insulation Boot Installation

3.6.21.1 Fuel Overboard Drain Line Removal.

a. Remove attaching hardware that secures cushion clamps to nozzle extension (figure 3-14, view C-C). Retain attaching hardware for reinstallation, if acceptable for reuse in accordance with requirements of section II.

b. Remove attaching hardware that secures fuel overboard drain line, and remove seal plate. Retain attaching hardware for reinstallation, if acceptable for reuse in accordance with requirements of section II.

c. Install cover on overboard drain.

3.6.21.2 Oxidizer Overboard Drain Line and Nitrogen Overboard Drain Line Removal.

a. Remove attaching hardware that secures cushion clamps to nozzle extension (figure 3-14, view A-A). Retain attaching hardware for reinstallation, if acceptable for reuse in accordance with requirements of section II.

b. Disconnect and remove nitrogen purge overboard drain line from union.

c. Remove attaching hardware that secures oxidizer overboard drain line, and remove seal plate. Retain attaching hardware for reinstallation, if acceptable for reuse in accordance with requirements of section II.

d. Install cover on oxidizer overboard drain line and at thrust chamber exit.

3.6.22 ENGINE REMOVAL.

3.6.22.1 Horizontal Engine Removal.

a. Provide support for wrap-around ducts and hoses.

aA. Perform, as applicable, contamination and damage prevention procedures outlined paragraph 3.1A when performing this test.

b. Disconnect wrap-around ducts and hoses from stage.

CAUTION

Care must be taken to prevent fluid spillage on engine when hydraulic supply and return lines are disconnected.

c. Disconnect pressure switch checkout line from interface panel fitting.

d. Disconnect electrical interface connections.

e. Disconnect ducting from oxidizer and fuel inlets as follows:

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

(1) Using low-pressure (less than 30 psig) gaseous nitrogen (MIL-P-27401) or clean, dry air conforming to cleanness and humidity requirements of MIL-P-27401, blow oxidizer and fuel inlet flanges free of accumulated loose contaminants (water, sand, etc).

WARNING

The following procedure uses trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

(2) Using a clean, lint-free cloth moistened in trichloroethylene (MIL-T-27602), wipe flanges free of all visible contaminants (carbon, etc).

(3) Disconnect ducting from oxidizer and fuel inlets, and remove moisture from inlet flange fastener holes.

f. Using Stage-Contractor-supplied horizontal engine installer, support weight of engine.

g. Disconnect gimbal actuators (outboard engines) or stiff-arms (inboard engine), as applicable.

h. Remove gimbal bearing cover.

i. Remove fasteners from gimbal bearing to stage interface.

j. Install Gimbal Bearing Locks G4049 (figure 3-12) and gimbal bearing cover.

k. Carefully remove engine from stage area and install on Engine Handler G4069. Refer to R-3896-3 for installation information.

l. Install closures on turbopump oxidizer and fuel inlets as follows:

(1) On engines not incorporating MD161 change, install oxidizer inlet closure. On engines incorporating MD161 change, install oxidizer pump inlet test plate 9020163 incorporating captive fasteners and dust cover. Torque plate fasteners to 330-430 in-lb.

(2) On engines not incorporating MD161 change, install fuel inlet closures on No. 1 and No. 2 fuel inlets. On engines incorporating MD161 change, install outboard fuel inlet test plates 9020162 incorporating captive fasteners and dust covers. Torque plate fasteners to 120-155 in-lb.

m. Remove wrap-around ducts and hoses. Verify that hydraulic supply and return ducts are full of liquid when cover plates are installed on ducts. Fill ducts with fluid that meets requirements of section II, if necessary.

n. When Stage-Contractor-supplied horizontal installer is removed from engine, install thrust chamber throat security closure (paragraph 3.6.13).

3.6.22.2 Vertical Engine Removal.

a. Remove thrust chamber nozzle extension (paragraph 3.6.21).

aA. Install protective covers and closures on all engine systems as disconnects and removals are made.

b. Remove wrap-around ducts and hoses. Verify that engine hydraulic supply and return ducts are full of fluid when cover plates are installed on ducts. Fill ducts, if necessary.

c. Disconnect pressure switch checkout line from interface panel fitting.

d. Disconnect electrical interface connections.

e. Disconnect ducting from turbopump oxidizer and fuel inlets as follows:

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

(1) Using low-pressure (less than 30 psig) gaseous nitrogen (MIL-P-27401) or clean, dry air conforming to cleanness and humidity requirements of MIL-P-27401, blow ducting to turbopump oxidizer and fuel inlet flanges free of accumulated loose contaminants (water, sand, etc).

WARNING

The following procedure uses trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

(2) Using a clean, lint-free cloth moistened in trichloroethylene, wipe flanges free of all visible contaminants (carbon, etc).

(3) Disconnect ducting from turbopump oxidizer and fuel inlets, and remove moisture from inlet flange fastener holes.

(4) Separate ducting from oxidizer and fuel inlets, and cover inlets with Aclar No. 33C film (0.002-inch minimum thickness) (Allied Chemical Corp). Secure film with pressure-sensitive tape RB0195-002 (Rocketdyne).

f. Position Engine Vertical Installer G4049 beneath engine, and raise table until 10:1 ring of installer just seats against thrust chamber ring.

g. Install tiedown cables to turbopump mounts.

h. Disconnect gimbal actuators (outboard engines) or stiff-arms (inboard engine), and connect tiedown cables to gimbal actuator struts.

i. Remove fasteners from gimbal bearing to stage interface.

j. Carefully lower installer table.

jA. Remove film from, and install closures on, turbopump oxidizer and fuel inlets as follows:

(1) On engines not incorporating MD161 change, install oxidizer inlet closure. On engines incorporating MD161 change, install oxidizer pump inlet test plate 9020163 incorporating captive fasteners and duct cover. Torque plate fasteners to 330-430 in-lb.

(2) On engines not incorporating MD161 change, install fuel inlet closures on No. 1 and No. 2 fuel inlets. On engines incorporating MD161 change, install outboard fuel inlet test plates 9020162 incorporating captive fasteners and duct covers. Torque plate fasteners to 120-155 in-lb.

k. Install gimbal bearing cover.

l. Connect a turbopump LOX seal purge system to engine and pressurize to 80 +20 psig.

m. Remove engine from stage.

n. Install 4 Gimbal Bearing Locks G4059. (See figure 3-12.)

o. Do not rotate level of fuel pump above level of oxidizer pump until steps p and q have been performed.

CAUTION

Rotating level of fuel pump above level of oxidizer pump at this time can cause contamination.

p. During engine rotation from vertical to horizontal position, supply gaseous nitrogen (MIL-P-27401) at 80 +20 psig to engine turbopump LOX seal purge interface.

q. Allow purge to flow for 30 minutes minimum after engine rotation from vertical to horizontal position.

r. Depressurize turbopump LOX seal purge system.

s. Install engine on air transport engine handler as outlined in R-3896-3.

3.6.23 FUEL OVERBOARD DRAIN SYSTEM ISOLATION.

3.6.23.1 *Preparing Drain System for Isolation.*

a. Provide containers (one gallon minimum volume) for catching residual fluid when performing the following procedures.

b. Disconnect cross-to-lateral drain tube from Y-fitting on fuel overboard drain line. Drain residual fluid into a container. Measure and record volume of fluid collected.

c. Loosen cross-to-lateral drain tube connection at cross. Rotate tube to clear Y-fitting on fuel overboard drain line, and retorque tube-to-cross to 300-500 in-lb.

d. Install clean bags made from plastic sheet and strip (Federal Specification L-P-378, Type II) (one gallon minimum volume) on open cross-to-lateral drain tube and on open Y-fitting on fuel overboard drain line as follows: (See figure 3-16B.)

NOTE

Clean polyethylene bags (Federal Stock No. 8105-LCO-6811) 12 by 18 inches, or clean polyethylene tubing (Federal Stock No. 8135-782-7460) 7-1/2 inches wide, cut to one-gallon minimum volume and heat sealed at one end, may be used instead of plastic sheet and strip. All polyethylene material used must be 0.004 inch thick.

(1) Insert open end of bag over tube or fitting. Pleat bag around tube or fitting, and secure bag to tube or fitting with Airtex 217 tying tape, Type II (Eon Corp), or equivalent. Leave enough collar on bag to permit folding collar over tying tape.

(2) Place a minimum of 2 wraps of pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60) either over tying tape or downstream adjacent to tying tape.

(3) Fold bag collar over tying tape and pressure-sensitive tape; then, using pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60), tape bag collar securely, overlapping pressure-sensitive tape onto tube or fitting.

(4) Vent each bag by puncturing a 1/8-inch hole in top of bag in a location that will prevent entry of contaminants into bag.

(5) A second bag may be installed over first bag, as outlined in substeps 1 through 4, if the vent hole in outer bag is diametrically opposite of vent hole in inner bag.

e. On engines to be installed or on engines installed in S-IC stage in positions 103 and 104, perform the following:

(1) Remove attaching hardware that secures No. 1 fuel valve position transducer vent drain tube to fuel valve. Retain attaching hardware for reinstallation if acceptable for reuse in accordance with requirements of section II.

(2) Remove No. 1 fuel valve position transducer vent drain tube from between fuel valve and tee, and drain residual fluid into a container. Measure and record volume of fluid collected.

(3) Plug each end of No. 1 fuel valve position transducer vent drain tube; package tube as required to prevent contamination, tag tube package with part name, part number and serial number of engine from which tube was removed; and retain tube in storage for reinstallation.

(4) Install clean bags made from plastic sheet and strip (Federal Specification L-P-378, Type II) (one gallon minimum volume) on open fitting on fuel valve and on tee as follows: (See figure 3-16B.)

NOTE

Clean polyethylene bags (Federal Stock No. 8105-LCO-6811) 12 by 18 inches, or clean polyethylene tubing (Federal Stock No. 8135-782-7460) 7-1/2 inches wide, cut to one-gallon minimum volume and heat sealed at one end, may be used instead of plastic sheet and strip. All polyethylene material used must be 0.004 inch thick.

(a) Insert open end of bag over fitting or tee. Pleat bag around fitting or tee, and secure bag to fitting or tee with Airtex 217 tying tape, Type II (Eon Corp) or equivalent. Leave enough collar on bag to permit folding collar over tying tape.

(b) Place a minimum of 2 wraps of pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60) either over tying tape or downstream adjacent to tying tape.

(c) Fold bag collar over tying tape and pressure-sensitive tape; then, using pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60), tape bag collar securely overlapping pressure-sensitive tape onto fitting or tee.

(d) Vent each bag by puncturing a 1/8-inch hole in top of bag in a location that will prevent entry of contaminants into bag.

(e) A second bag may be installed over first bag, as outlined in substeps a through d, if the vent hole in outer bag is diametrically opposite of vent hole in inner bag.

f. On engines to be installed or on engines installed in S-IC stage in positions 101, 102, and 105, perform the following:

(1) Remove attaching hardware that secures No. 2 fuel valve position transducer vent drain tube to fuel valve and to No. 2 fuel valve open tube. Retain attaching hardware for reinstallation if acceptable for reuse in accordance with requirements of section II.

(2) Remove No. 2 fuel valve position transducer vent drain tube from between fuel valve and tee, and drain residual fluid into a container. Measure and record volume of fluid collected.

(3) Plug each end of No. 2 fuel valve position transducer vent drain tube; package tube as required to prevent contamination; tag tube package with part name, part number, and serial number of engine from which tube was removed; and retain tube in storage for reinstallation.

(4) Install clean bags made from plastic sheet and strip (Federal Specification L-P-378, Type II) (one gallon minimum volume) on open fitting on fuel valve and on tee as follows: (See figure 3-16B.)

NOTE

Clean polyethylene bags (Federal Stock No. 8105-LCO-6811) 12 by 18 inches, or clean polyethylene tubing (Federal Stock No. 8135-782-7460) 7-1/2 inches wide, cut to one-gallon minimum volume and heat sealed at one end, may be used instead of plastic sheet and strip. All polyethylene material used must be 0.004 inch thick.

(a) Insert open end of bag over fitting or tee. Pleat bag around fitting or tee, and secure bag to fitting or tee with Airtex 217 tying tape, Type II (Eon Corp or equivalent. Leave enough collar on bag to permit folding collar over tying tape.

(b) Place a minimum of 2 wraps of pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60) either over tying tape or downstream adjacent to tying tape.

(c) Fold bag collar over tying tape and pressure-sensitive tape; then, using pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60), tape bag collar securely overlapping pressure-sensitive tape onto fitting or tee.

(d) Vent each bag by puncturing a 1/8-inch hole in top of bag in a location that will prevent entry of contaminants into bag.

(e) A second bag may be installed over first bag, as outlined in substeps a through d, if the vent hole in outer bag is diametrically opposite of vent hole in inner bag.

g. Install cover on fuel overboard drain line at thrust chamber exit. Tighten fasteners fingertight plus 1/4 turn.

3.6.23.2 Determining Inspection Intervals of Drain System Isolation Bags.

a. Twenty-four hours after preparing system for isolation (paragraph 3.6.23.1), inspect bags for fluid collection. If fluid is evident, remove bags and measure total volume of fluid collected. Record fluid volume as Day 1 volume for a future calculation. If fluid is not evident, omit steps b through d.

b. Install a clean bag made from plastic sheet and strip (Federal Specification L-P-378, Type II) (one gallon minimum volume) wherever a bag was removed as follows: (See figure 3-16B.)

NOTE

Clean polyethylene bags (Federal Stock No. 8105-LCO-6811) 12 by 18 inches, or clean polyethylene tubing (Federal Stock No. 8135-782-7460) 7-1/2 inches wide, cut to one-gallon minimum volume and heat sealed at one end, may be used instead of plastic sheet and strip. All polyethylene material used must be 0.004 inch thick.

(1) Insert open end of bag over tube or fitting. Pleat bag around tube or fitting, and secure bag to tube or fitting with Airtex 217 tying tape, Type II (Eon Corp), or equivalent. Leave enough collar on bag to permit folding collar over tying tape.

(2) Place a minimum of 2 wraps of pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60) either over tying tape or downstream adjacent to tying tape.

(3) Fold bag collar over tying tape and pressure-sensitive t... then, using pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60) tape bag collar securely, overlapping pressure-sensitive tape onto tube or fitting.

(4) Vent bag by puncturing a 1/8-inch hole in top of bag in a location that will prevent entry of contaminants into bag.

(5) A second bag may be installed over first bag, as outlined in substeps 1 through 4, if the vent hole in outer bag is diametrically opposite of vent hole in inner bag.

c. Twenty-four hours after reinstalling bags, again inspect bags for fluid collection. If fluid is evident, remove bags and measure total volume of fluid collected. Record fluid volume as Day 2 volume.

d. Determine subsequent inspection intervals (maximum intervals, 30 days) using the following formula:

$$\frac{\text{Day 1 vol (cc)} + \text{Day 2 vol (cc)}}{2}(\text{x days}) = 3,764 \text{ cc}$$

e. If fluid is not evident in bags or if inspection intervals (when using formula) exceed 30 days, subsequent inspection must be performed at 30-day intervals and bags emptied as required.

3.6.23.3 Securing Drain System From Isolation.

a. Remove cover from fuel overboard drain line at thrust chamber exit.

b. Install a clean bag made from plastic sheet and strip (Federal Specification L-P-378, Type II) (one gallon minimum volume) on fuel overboard drain line at thrust chamber exit as follows: (See figure 3-16B.)

NOTE

Clean polyethylene bags (Federal Stock No. 8105-LCO-6811) 12 by 18 inches, or clean polyethylene tubing (Federal Stock No. 8135-782-7460) 7-1/2 inches wide, cut to one-gallon minimum volume and heat sealed at one end, may be used instead of plastic sheet and strip. All polyethylene material used must be 0.004 inch thick.

(1) Insert open end of bag over tube. Pleat bag around tube, and secure bag to tube with Airtex 217 tying tape, Type II (Eon Corp), or equivalent. Leave enough collar on bag to permit folding collar over tying tape.

(2) Place a minimum of 2 wraps of pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60) either over tying tape or downstream adjacent to tying tape.

(3) Fold bag collar over tying tape and pressure-sensitive tape; then, using pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60), tape bag collar securely, overlapping pressure-sensitive tape onto tube.

(4) Vent bag by puncturing a 1/8-inch hole in top of bag in a location that will prevent entry of contaminants into bag.

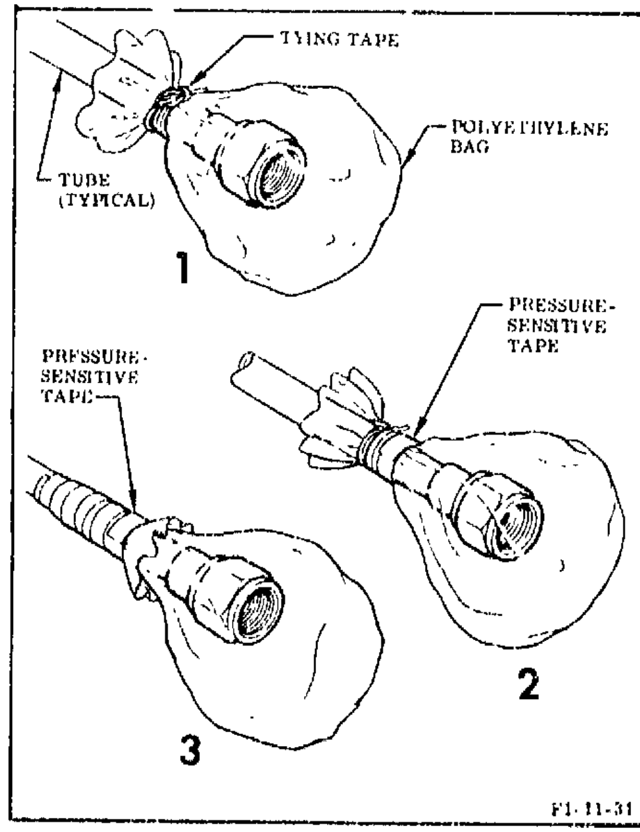


Figure 3-16B. Drain System Isolation Bag Installation (Typical)

(5) A second bag may be installed over first bag, as outlined in substeps 1 through 4, if the vent hole in outer bag is diametrically opposite of vent hole in inner bag.

c. Remove bags from cross-to-lateral drain tube and from Y-fitting on fuel overboard drain line.

d. Loosen cross-to-lateral drain tube at cross. Rotate tube to aline with Y-fitting on fuel overboard drain line.

NOTE

The method for applying lubricant in the following procedure is outlined in R-3896-3.

e. Lubricate (Method A) fittings and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne) and install cross-to-lateral drain tube. Torque tube coupling nuts to 1,200-1,400 in-lb.

f. On engines installed in S-IC stage in positions 103 and 104, remove bags from fitting in fuel valve and from tee; then install No. 1 fuel valve position transducer vent drain tube as follows:

(1) Lubricate (Method A) fittings and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne).

(2) Install tube. Torque tube coupling nuts to 135-185 in-lb.

(3) Install clamp between tube and fuel valve. Torque attaching hardware for clamp to 8-10 in-lb.

g. On engines installed in S-IC stage in positions 101, 102, and 105, remove bags from fitting in fuel valve and from tee; then install No. 2 fuel valve position transducer vent drain tube as follows:

(1) Lubricate (Method A) fittings and (Method G) tube with lubricant grease RB0140-012 (Rocketdyne).

(2) Install tube. Torque tube coupling nuts to 135-185 in-lb.

(3) Install clamp between tube and fuel valve and clamps between tube and No. 2 fuel valve open tube. Torque attaching hardware for clamps to 8-10 in-lb.

3.6.24 PREPARING AND SECURING OXIDIZER AND NITROGEN OVERBOARD DRAIN LINES FOR ROTATING STAGE TO HORIZONTAL POSITION.

3.6.24.1 Preparing Oxidizer and Nitrogen Overboard Drain Lines for Rotating Stage to Horizontal Position.

a. Remove plate RX20636, if installed, from exit end of oxidizer overboard drain line.

b. Remove plug RD265-2001-0008, if installed, from exit end of nitrogen overboard drain line.

c. Install clean bags made from plastic sheet and strip (Federal Specification L-P-378, Type II) (one-gallon minimum volume) on exit ends of oxidizer and nitrogen overboard drain lines as follows:

NOTE

Clean polyethylene bags (Federal Stock No. 8105-LC0-6811) 12 by 18 inches, or clean polyethylene tubing (Federal Stock No. 8135-782-7460) 7-1/2 inches wide, cut to one gallon minimum volume and heat sealed at one end, may be used instead of plastic sheet and strip. All polyethylene material used must be 0.004-inch minimum thickness.

(1) Insert open end of bag over line. Pleat bag around line, and secure bag to line with Airtex 217 tying tape, Type II (Eon Corp), or equivalent. Leave enough collar on bag to permit folding collar over tying tape.

(2) Place a minimum of 2 wraps of pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60) over tying tape or downstream adjacent to tying tape.

(3) Fold bag collar over tying tape and pressure-sensitive tape; then, using pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60), tape bag collar securely, overlapping pressure-sensitive tape onto line.

(4) Vent each bag by puncturing a 1/4-inch hole in top of bag in a location on the low side of the line when the stage is rotated to the horizontal position.

d. Turn on turbopump LOX seal purge and verify bag installation before installing stage engine covers.

3.6.24.2 Securing Oxidizer and Nitrogen Overboard Drain Lines.

a. Remove bags from oxidizer overboard drain line and install plate RX20636 on line. Tighten fasteners fingertight plus 1/4 turn.

b. Remove bags from nitrogen overboard drain line and install plug RD265-2001-0008 on line. Tighten plug fingertight.

3.7 MAINTAINING ENGINE LOG BOOK.

3.7.1 PURPOSE. The following paragraphs contain the general requirements and instructions necessary to produce entries of standard accuracy and completeness with log book delivered with the engine. The Engine Log Book is the official document for recording the operational status and configuration of the engine from production to launch.

3.7.2 SOURCE DOCUMENTATION. In order to assist in the maintenance of the Engine Log Books, the entries required for a task are specified in engine Modification Instructions, Engine Field Inspection Requests (EFIRs), and Field Task and Verification Plans (FTVPs) that support technical manual instructions. Modification Instructions and EFIRs incorporate necessary instructional steps and an attachment for log book data transmittal to organizations having log book maintenance responsibility. FTVPs specify log book entry FTVPs to be used for log book data transmittal to organizations having log book maintenance responsibility.

3.7.3 WHEN TO UPDATE LOG BOOK. Log books must reflect open as well as completed tasks or events, and initial entries should be made as soon as requirements are identified or approval documents received. The log book must be updated at least each time any of the following tasks or events are completed: (Rocketdyne Configuration Report R-5857 may be used to verify open log book entries for modification and Engine Field Inspection Request (EFIR) tasks.)

a. Engine Contractor receiving inspection

b. Stage Contractor receiving inspection

c. Engine post-modification checkout

d. Storage

e. Preparation for shipment

f. Pre-static firing modification and checkout

g. Prelaunch

3.7.4 HOW TO UPDATE LOG BOOK. Log book entries should be typewritten. Entries handprinted in ink are acceptable when typewritten entries are impractical. (Additional general rules are outlined in paragraphs 3.7.4.1 and 3.7.4.10.)

3.7.4.1 Abbreviations. Abbreviations to be used in the preparation and maintenance of the Engine Log Book are listed in the introductory data of the individual log books or are defined in this manual. The abbreviations UNK or DNA must be inserted in blank spaces for which information is unknown or does not apply.

3.7.4.2 Definition of Terms. The terms to be used in preparation and maintenance of the Engine Log Book are listed in the introductory data of the individual log books or are defined in the detailed instructions in this manual.

3.7.4.3 Identifying Vehicle, Organization, and Location. The symbols used in preparation and maintenance of the Engine Log Book, to identify the vehicle, sites (locations), and organizations must be consistent with the following:

a. Vehicle: Saturn V, first stage, S-IC-X

b. Organization locations:

(1) Rocketdyne, Michoud Assembly Facility, RD-MAF

(2) Rocketdyne, Kennedy Space Center, RD-KSC

(3) Rocketdyne, Marshall Space Flight Center, RD-MSFC

(4) Rocketdyne, Mississippi Test Facility, RD-MTF

3.7.4.4 Entering Dates. All dates entered in the log book must be recorded by the day, month (abbreviated), and year (for example 10 Mar 68).

3.7.4.5 Rounding-Off Parameter Values. All recorded parameter values must be rounded off to the desired number of significant figures by rounding up whenever the digit next to the last desired significant figure is 5 or greater and rounding down whenever the digit next to the last desired significant figure is less than 5.

3.7.4.6 Verifying Log Book Entries (Log Book Audit). Engine Log Books must be reviewed at least concurrent with each receiving inspection and prior to shipping and launch, to assure that the books are complete and accurate. Log book audits will be documented on the Transfer Record of the log book. Government inspection signoff is required for these entries. (Rocketdyne Configuration Report R-5857, may be used to verify open log book entries for modification and Engine Field Inspection Request (EFIR) tasks.)

3.7.4.7 Deleting Log Book Entries Made in Error. Erasures are not permitted. If an error is made, the incorrect entry must be voided and the abbreviation EIE (entered in error) entered adjacent to the line. The initials or stamp of the individual who made the entry must be entered adjacent to the entry.

3.7.4.8 Indicating Obsolete Log Book Entries. Erasures are not permitted. With a single inked line, line out the obsolete entry, thus indicating that the entry no longer reflects the current engine configuration. Do not obliterate the entry. The initials or stamp of the individual voiding the entry must be entered adjacent to the line.

3.7.4.9 Inserting Additional or New Log Book Forms. Additional copies of the same form must be utilized in the event a single form does not provide sufficient space for recording all of the required information. These forms must be added to the log book immediately behind the form affected. All new or additional forms must have the engine model and serial number entered on the form prior to insertion in the log book. All new or additional log book forms must be dated and numbered consecutively in accordance with the existing page numbering system.

3.7.4.10 Entering Inspection Signatures or Stamps. The individual making a data entry in the Engine Log Book must also enter his signature or stamp in the inspection signoff column of the log book form. Unless otherwise specified in the detailed instructions, the signature or stamp is a verification of the accuracy and completeness of the entry as transcribed from the source data and does not indicate verification of the completion or observance of a specific task.

NOTE

Government inspection signoff of entries on specified forms is not required except when a log book audit is performed.

3.7.5 TRANSFERRING LOG BOOK. The Engine Log Book must accompany the engine whenever custody is transferred or the engine is shipped. The organization having custody of the engine is responsible for transferring the log book.

3.7.6 LOG BOOK FORMS THAT REQUIRE POST-DELIVERY MAINTENANCE. The Engine Log Book consists of 11 major sections containing engine records and forms. Instructions for completing log book form entries, corrections, and transfers are presented for those forms that may require post-delivery maintenance; these forms are:

Component Data section

Primary Flight Instrumentation System Road Map

Component Records section

Component Test Record

Engine Data section

Post-Delivery Performance Uncertainty Record[a]

Engine Weight Record

Engine Records section

Engine Test Record

Configuration Record section

Configuration Record

(a) This form is not in all log books as delivered but must be inserted subsequent to engine delivery.

Serialized Component Record section

Delivered Serialized Component Record

Rigid-Duct Spacer Dimensions[b]

Post-Delivery Serialized Component Replacement Record

Post-Delivery Flight Instrumentation Pressure Transducer Replacement Record[a]

Orifice Record section

Delivered Orifice Record

Post-Delivery Orifice Replacement Record

Operational Data Log section

Post-Delivery Component Cycle Record[a]

Operational Data (Heat Exchanger Performance Summary)

Maintenance Record section

Discrepany Record

Inspection Record

Turbopump Preservation Record

Age Control Log For Component Synthetic Rubber Items

Loose Equipment Flight Installation Record[a]

Transfer Record Section

Transfer Record

(a) This form is not in all log books as delivered but must be inserted subsequent to engine delivery.
(b) This form may be found in either of two configurations in the log book. Instructions are provided for the maintenance of both forms.

3.7.7 HOW TO DETERMINE LOG BOOK ENTRY REQUIREMENTS. The Minimum Log Book Entry Requirements chart (figure 3-17) identifies which log book forms must be updated when specific tasks are performed or events occur. Figure 3-17 reflects minimum requirements; additional log book forms (not listed in figure 3-17) may be affected depending on the nature or results of the task or event. Figures 3-18 through 3-37 specify when or under what conditions the additional forms will be affected. To determine the necessary log book entries for a specific task or event, proceed as follows: (See figure 3-17.)

a. Select the title that best describes the task or event. Example: An engine modification is to be performed in accordance with an approved Rocketdyne Engineering Change Proposal (ECP); the task title in figure 3-17 is Modification.

b. Search across the page to locate the figure number of the applicable instructions. This figure 3-23 provides general and detailed instructions for completing the log book form and makes reference to other log book forms that are (or may be) affected, depending on the nature and results of the task or event. The X's indicate the other forms that must be updated for that specific task or event.

Task or Event \ Log Book Form	Engine Test Record	Configuration Record	Post-Delivery Component Cycle Record	Discrepancy Record	Inspection Record	Turbopump Preservation Record	Loose-Equipment Flight Installation Record	Transfer Record
Shipping		X						3-37
Receiving								3-37
Inspections					3-33			
Log book audit								3-37
Turbopump preservation						3-34		
Static firing	3-22							
Modification		3-23						
Discrepancy disposition (UCR)				3-32				
Component cycling			3-31					
Loose-equipment flight installation							3-36	
Launch		X						3-37

NOTE

The figure numbers and X's represent the minimum log book forms affected by a specific task or event.

Figure 3-17. Minimum Log Book Entry Requirements

F-1 PRIMARY INSTRUMENTATION SYSTEM ROAD MAP

ENGINE SERIAL NO [illegible]

DATE [illegible]

TAP NO.	MSFC NO.	PARAMETER	RANGE	NAS SPECIFICATION	MANUFACTURER'S IDENTIFICATION NAME	PART NO.	SERIAL NO.	REDUCED CALIBRATION DATA A_0 (PSIA)	A_1 (VOLTS/PSIA)	20% XN(PSIA)	80% XN(PSIA)	INSP STAMP
XPF6a-1	D4	FUEL TURBOPUMP INLET NO 1 PR	0 TO 300 PSIA	NAS-2744OT2	STATHAM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 01	1.58727078E 02	
TG5a	D10	TURBINE OUTLET PR	0 TO 100 PSIA	NAS-2744OT1P	STATHAM	[illegible]	[illegible]	[illegible]	[illegible]	2.0357300# 01	8.1268494E 01	
NN8a	D12B	COMMON HYDRAULIC RETURN PR	0 TO 500 PSIA	NAS-2744OT8	STATHAM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 02	5.0380027F 02	
LB1a	D15	OXIDIZER TURBOPUMP BEARING JET PR	0 TO 1000 PSIA	NAS-2744OT10	STATHAM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 02	8.0851196F 02	
CB1a	D8	COMBUSTION CHAMBER PR	0 TO 1500 PSIA	NAS-2744OT15P	STATHAM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 02	1.2185564E 03	
GG1a	D9	GAS GENERATOR CHAMBER PR	0 TO 1500 PSIA	NAS-2744OT15P	STATHAM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 02	1.2099504F 03	
PO2a-2	D3	OXIDIZER TURBOPUMP DISCHARGE NO 2 PR	0 TO 2000 PSIA	NAS-2744OT20	STATHAM	[illegible]	1037	[illegible]	[illegible]	[illegible] 02	1.61300A5F 03	
PF2a-2	D7	FUEL TURBOPUMP DISCHARGE NO. 2 PR	0 TO 2500 PSIA	NAS-2744OT25	STATHAM	[illegible]	1106	[illegible]	[illegible]	[illegible] 02	1.99278/7E 03	

TAP NO	MSFC NO	PARAMETER	RANGE	NAS SPECIFICATION	MANUFACTURER'S IDENTIFICATION NAME	PART NO	SERIAL NO.	REDUCED CALIBRATION DATA A_0	A_1	A_2	A_3	A_4	A_5	A_6	INSP STAMP
LS1	C6	OTP BEARING NO TEMP	0 TO 400 F	NAS-2733577	[illegible]	[illegible]	949	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~0 TO 400 F~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	3
[illegible]	[illegible]	[illegible] ENVIRONMENTAL [illegible]	0 TO 1000 F	NAS-2721776	ROSEMOUNT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4
TG4a	C3	TURBINE INLET TEMP	0 TO 2000 F	NAS-2744472	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

	MSFC NO	PARAMETER	VALVE STROKE	NAS SPECIFICATION	MANUFACTURER'S IDENTIFICATION NAME	PART NO	SERIAL NO
	K7	MFV NO 1 POSITION POTENTIOMETER	2.097 ± 0.064 IN	NAS-27409	TELEDYNE	[illegible]	[illegible]
	K8	MFV NO 2 POSITION POTENTIOMETER	2.097 ± 0.064 IN	NAS-27409	[illegible]	[illegible]	[illegible]
	K9	MOV NO 1 POSITION POTENTIOMETER	2.346 ± 0.050 IN	NAS-27338	[illegible]	[illegible]	[illegible]
	K10	MOV NO 2 POSITION POTENTIOMETER	2.346 ± 0.050 IN	NAS-27338	TELEDYNE	[illegible]	[illegible]
	K6	GAS GENERATOR VALVE SWITCHES		NAS-27443	[illegible]	[illegible]	[illegible]

TURBOPUMP P/N [illegible] S/N [illegible]

T1	TURBOPUMP SPEED NO 1	RANGE 0-7000 RPM	SPEC NO NAS-27330	MFG NAME [illegible]	PART NO [illegible]	SERIAL NO [illegible]	CONSTANT 2 CYCLES PER REV
T	TURBOPUMP SPEED NO 2	RANGE 0-7000 RPM	SPEC NO NAS-27330	MFG NAME [illegible]	PART NO [illegible]	SERIAL NO [illegible]	CONSTANT 36 CYCLES PER REV

	MSFC NO	PARAMETER	RANGE	NAS SPECIFICATION	MANUFACTURER'S IDENTIFICATION NAME	PART NO.	SERIAL NO.	REDUCED CALIBRATION DATA A (CYCLES PER GALLON)	B (SECONDS PER GALLON)	INSP STAMP
	F44	HEAT EXCHANGER LOX INLET FLOWRATE	20 TO 100 GPM	NAS-2729872	[illegible]	[illegible]	[illegible]	[illegible]	0.001538	

I. GENERAL INSTRUCTIONS.

Entries must be made in the Primary Instrumentation System Road Maps whenever a transducer is replaced, installed, or removed. Existing entries for replaced or deleted transducers are lined out.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1 If a transducer is replaced or added to the engine, enter all data for transducer being installed. Obtain data from Individual Transducer Data Sheet shipped with new or replacement transducer.

NOTE

Individual Transducer Data Sheets, manufacturer's test and calibration sheets, IBM printouts, and IBM cards are not included in the log book but are retained as part of the log book backup date.

2 Line out when applicable, all data for transducer being removed. (Refer to paragraph 3.7.4.8.) Individual Transducer Data Sheet, manufacturer's test and calibration sheets, IBM printouts, and IBM cards for the removed transducer must be removed from log book backup data and routed with the removed transducer.

3 Enter stamp or signature of individual who lined out entries.

4 Enter stamp or signature of individual making entries from Individual Transducer Data Sheet.

Figure 3-18. Primary Instrumentation System Road Map

I. GENERAL INSTRUCTIONS.

The Component Test Record (CTR) of each of the components listed in paragraph II, containing the results of the required functional tests, must be included in the log book. No entries are required on the CTR as a function of log book maintenance. The forms are removed from or inserted in the log book whenever their respective component is removed from or installed on an engine.

II. DETAILED INSTRUCTIONS.

Whenever one of the following components is replaced, remove CTR of removed component from log book and insert CTR for installed component in its place:

NOTE

Some components that do not appear on this list will be accompanied by CTRs. When these components are replaced, the CTR for the installed component should be retained with the engine maintenance records.

- The removed CTR must accompany the removed component.

a. Turbopump assembly

b. Turbopump heater thermostat

c. Turbopump tachometer

d. Turbopump bearing coolant valve assembly

e. Gas generator ball valve assembly

f. Gas generator ball valve switch

g. Hydraulic manifold assembly

h. Hydraulic control 4-way valve assembly

i. Hydraulic control valve stop solenoid valve assembly

j. Hydraulic control valve start solenoid valve assembly

k. Hypergol manifold assembly

l. Ignition monitor valve assembly

m. Hypergol installed switch

n. Main LOX valve assembly

o. Main LOX valve indicator assembly

p. Main fuel valve assembly

q. Main fuel valve indicator assembly

r. Checkout valve assembly

s. Checkout valve assembly rotary actuator

t. Thrust chamber inert prefill check valve

u. Heat exchanger LOX supply assembly check valve

v. Heat exchanger LOX supply check valve

w. LOX dome purge check valve

x. Gas generator LOX purge check valve

y. Pressure-actuated calibratable-type switch

Figure 3-19. Component Test Record

MODEL F-1	POST DELIVERY PERFORMANCE UNCERTAINTY RECORD			ENGINE S/N F-20XX	
1 ENTRY DATE	2 SOURCE OF PERFORMANCE UNCERTAINTY	3 MAXIMUM EXPECTED PERFORMANCE UNCERTAINTIES		4 CUMULATIVE MAXIMUM EXPECTED PERFORMANCE UNCERTAINTY	
		SEA LEVEL THRUST (KIPS)	SEA LEVEL MIXTURE RATIO	SEA LEVEL THRUST (KIPS)	SEA LEVEL MIXTURE RATIO
	DELIVERED PERFORMANCE UNCERTAINTY	8.0	0.011	8.0	0.011
11 Sep 1968	Replaced gas generator injector. New P/N 309149-11, S/N 6759727	31.6	0.005	32.6	0.011
18 Sep 1968	Replaced downstream gas generator LOX orifice. New P/N RD251-4130-0986	1.9	0.0	32.7	0.012
3 Oct 1968	Recalibration to 1523 KIP thrust, differences in gas generator injector pressure drop means, and resulting orifice pressure drop excursion.	12.5	0.002	35.0	0.012

IV A.6 DATE 5 APR 1967

I. GENERAL INSTRUCTIONS.

Entries must be made in the Post-Delivery Performance Uncertainty Record whenever performance uncertainty is increased as a result of specified components being replaced, or reevaluated as a result of subsequent testing or data analysis. Refer to section II for a complete list of components that require entries if replaced.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1 ENTRY DATE - Enter date entry is made.

2 SOURCE OF PERFORMANCE UNCERTAINTY - If performance uncertainty is to be increased as a result of component replacement, enter name, part number, and serial number of component being replaced. For reevaluated uncertainty, enter reason for reevaluation, such as identification of subsequent testing, or name, date, and number of document that provided new values for maximum expected performance uncertainty.

3 MAXIMUM EXPECTED PERFORMANCE UNCERTAINTIES - Enter numerical values of maximum expected performance uncertainty for listed source of performance uncertainty. Refer to section II for numerical values resulting from replacement of specified components. Numerical values resulting from subsequent testing must be extracted from documentation approved by Rocketdyne Engineering.

4 CUMULATIVE MAXIMUM EXPECTED PERFORMANCE UNCERTAINTY - For increased performance uncertainty due to component replacement, enter root sum square of previous cumulative maximum expected performance uncertainty and uncertainties resulting from component replacement. For reevaluated uncertainty, enter same numerical values that were entered in Maximum Expected Performance Uncertainties column. Refer to section II for calculation procedures and methods of handling second and subsequent replacements of a particular component.

Figure 3-20. Post-Delivery Performance Uncertainty Record

MODEL F-1 | **ENGINE WEIGHT RECORD** | ENGINE S/N F-20XX

DATE OF ORIGINAL WEIGHING 14 APR 67 | WEIGHED PER SPEC RA0220-639 | SPEC WEIGHT, DRY 17,700 POUNDS

DESIGN CHANGE NO (ECP) (1)	MD CONFIGURATION NO (2)	MD WEIGHT CHANGE (POUNDS) (3)	MD ARM* (INCHES) (4)	MD MOMENT CHANGE (POUNDS-INCHES) (5)	NET WEIGHT, DRY (POUNDS) (6)	NET ARM* (INCHES) (8)	NET MOMENT (POUNDS-INCHES) (7)	INSPECTION (9) CONTRACTOR	INSPECTION GOVERNMENT
ENGINE AND ACCESSORIES AS DELIVERED					17,416	54.6	950,914		
F1-475	DNA	+212	+51.2	+6614	17,628	54.3	957,528		DNA
F1-428	87	+2	-2.8	-6	17,630	54.3	957,522		DNA
F1-482	134	+18.0	+38.0	+684.0	17,648	54.29	958,206		DNA
F1-476	135	+1.5	+150.6	+226	17,649.5	54.30	958,432		DNA
F1-530	163	+15.0	+11.2	+168	17,664.5	54.26	958,600		DNA

*HORIZONTAL ARM IS REFERENCED FROM THE CENTER LINE OF THE GIMBAL BEARING, PLUS (+) BEING IN THE AFT DIRECTION.

DATE 14 APR 67

I. GENERAL INSTRUCTIONS.

Entries must be made in the Engine Weight Record whenever engine weight is affected by an engine modification resulting from an approved Engineering Change Proposal (ECP).

II. DETAILED INSTRUCTIONS.

Complete form as follows:

NOTE

Obtain entry information for columns 1 through 5 from Modification Instruction R-5266-XXX.

1. DESIGN CHANGE NO. (ECP) - Enter design change number (ECP) number.
2. MD CONFIGURATION NO. - Enter modification designation (MD) number, if applicable.
3. MD WEIGHT CHANGE (POUNDS) - Enter weight change resulting from modification. Indicate if weight is added (+) or subtracted (-).
4. MD ARM (INCHES) - Enter horizontal arm length of modification. Indicate if arm length is measured in aft (+) direction from gimbal bearing centerline or in forward (-) direction from gimbal bearing centerline.
5. MD MOMENT CHANGE (POUNDS-INCHES) - Enter moment change resulting from modification. Indicate if moment change is plus (+) or minus (-).
6. NET WEIGHT, DRY (POUNDS) - Add or subtract, as applicable, value entered in MD Weight Change (Pounds) column for this modification to last listed value in this column.
7. NET MOMENT (POUNDS-INCHES) - Add or subtract, as applicable, value entered in MD Moment Change (Pounds-Inches) column for modification to last listed value in this column.
8. NET ARM (INCHES) - Divide value entered in Net Moment (Pounds-Inches) column by value entered in Net Weight, Dry (Pounds) column and enter result here.
9. INSPECTION - Enter stamp or signature of Contractor representative making entries. Enter DNA in Government column.

Figure 3-21. Engine Weight Record

ENGINE TEST RECORD

MODEL F-1 ENGINE S/N F-20XX

1 TEST NUMBER	2 TEST DATE	3 TEST DURATION	4 TOTALED DURATION	5 TOTALED STARTS	6 TEST COMMENTS
S-IC-8-7	18 Dec 68	126.7	410.62	5	Objectives: S-IC-8 stage firing to verify engine performance. Results: Satisfactory.

X.C 2 DATE 14 APR 67

I. GENERAL INSTRUCTIONS.

Entries must be made in the Engine Test Record to record information concerning engine tests conducted after delivery.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1 TEST NUMBER - Enter letters and/or numerals that designate testing facility and/or vehicle identification, and enter test sequence number.

2 TEST DATE - Enter date test is conducted.

3 TEST DURATION - Enter effective duration (Thrust OK Pickup to Stop Solenoid Signal) of test to nearest 0.1 second.

4 TOTALED DURATION - Enter accumulated effective duration of all tests of engine to nearest 0.1 second.

5 TOTALED STARTS - Enter accumulated starts of engine.

6 TEST COMMENTS - Enter pertinent comments concerning engine performance, malfunctions or part failures, and effect on (or of) facility or vehicle systems significant for evaluation of overall engine performance.

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. POST-DELIVERY PERFORMANCE UNCERTAINTY RECORD. Reevaluate engine performance uncertainty and make necessary Post-Delivery Performance Uncertainty Record changes resulting from post-delivery engine testing. (See figure 3-20 for instructions.)

Figure 3-22. Engine Test Record

CONFIGURATION RECORD

MODEL F-1 ENGINE S/N F-20XX

(1) DESIGN CHANGE NO	(2) DESCRIPTION OF CHANGE	(3) MD NO	(4) COMPLETION DATE	(5) ORGANIZATION
F1-506	Replacement of engine environmental temp transducer, R-5266-506, 17 Jan 68	159	18 Jul 68	RD-MAF
F1-521	Replacement of heat exchanger system orifices, R-5266-521, 2 Feb 68	155	15 Sep 68	RD-MAF
F1-550	Incorporation of improved support brackets for hydraulic control lines, R-5266-550, 2 Feb 68	165	15 Sep 68	RD-MAF
F1-557	Inspection and reidentification of thrust OK pressure switches, R-5266-557, 11 Apr 68	169	25 Sep 68	RD-MAF
F1-572	Replacement of thrust chamber drain plugs, R-5266-572, 11 May 68	170	11 Sep 68	RD-MAF
F1-584	Replacement of gas generator ball valve bushing, R-5266-584, 22 May 68	168	18 Jul 68	RD-MAF
	Prior to Shipment: 1x7 11x13 15x16x18x20 22x25x26x29x31 33x35x37 39x42 45x46 47x49 51x55 55x57 59x61x65 75x75 79x86 90x92x95x96x99 101x105 107x109 110x112 113x115x117 132x135 139x151 152x155x150 150x152 155x157x159x165x168 170			

XI.B 2 DATE 8 NOV 1967

I. GENERAL INSTRUCTIONS.

The Configuration Record is used to record all design changes incorporated on the engine subsequent to engine delivery. Entries are initially made on this form upon receipt of an approved modification and again at completion of the installation. The entries pertinent to completion of the installation are not dependent upon completion of post-installation checkout. The record also reflects the current composite MD number at the time of shipment or launch.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

A. Upon receipt of an approved Modification Instruction, complete columns 1, 2, and 3 as follows:

1. DESIGN CHANGE NO. - Enter design change (ECP) number including revisions (R1, R2, etc), if applicable.

2. DESCRIPTION OF CHANGE - Enter Modification Instruction title, number, and date as obtained from Modification Instruction.

3. MD NO. - Enter modification designation (MD) number as obtained from Modification Instruction.

NOTE

If the modification requirement is canceled prior to completion of the installation, the initial entries (columns 1, 2, and 3 must be lined out). (Refer to paragraph 3.7.4.8.

B. Upon completion of modification installation, complete columns 4 and 5 as follows:

4. COMPLETION DATE - Enter date modification installation is completed.

5. ORGANIZATION - Enter organization identification and location where modification installation is completed. Enter stamp or signature of individual making entry.

C. Prior to engine shipment or launch, complete form as follows:

2. DESCRIPTION OF CHANGE - Enter words "Prior to Shipment" or "Prior to Launch," as applicable, and current composite MD number. The MD number must reflect all completed ECPs.

Figure 3-23. Configuration Record (Sheet 1 of 2)

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. COMPONENT TEST RECORD. If modification required addition, deletion, or replacement of a component that has a Component Test Record (CTR), make necessary changes to forms involved. (See figure 3-19 for instructions.)

B. POST-DELIVERY PERFORMANCE UNCERTAINTY RECORD. If engine performance uncertainty is affected by modification, make necessary Post-Delivery Performance Uncertainty Record changes. (See figure 3-20 for instructions.)

C. ENGINE WEIGHT RECORD. If modification creates an engine weight change, make proper entries in Engine Weight Record. (See figure 3-21 for instructions.)

D. RIGID-DUCT SPACER DIMENSIONS. If modification involved removal of components that require accomplishment of fit-check procedures, make changes on appropriate Rigid-Duct Spacer Dimensions form. (See figure 3-25 or 3-26 for instructions.)

E. POST-DELIVERY SERIALIZED COMPONENT REPLACEMENT RECORD. If modification required a serialized component addition, replacement, or part number change, make proper entries in Post-Delivery Serialized Component Replacement Record. (See figure 3-27 for instructions.)

F. POST-DELIVERY ORIFICE REPLACEMENT RECORD. If modification required an orifice replacement, make proper entries in Post-Delivery Orifice Replacement Record. (See figure 3-30 for instructions.)

Figure 3-23. Configuration Record (Sheet 2 of 2)

I. GENERAL INSTRUCTIONS.

The Delivered Serialized Component Record lists, by item number, certain engine serialized components that are installed on the engine at the time of delivery. The only post-delivery alteration required on this form is the lining out of entries when post-delivery replacement or reidentification of a listed serialized component is performed.

II. DETAILED INSTRUCTIONS.

Identify component that was replaced or reidentified, and correctly line out all obsolete entries for this component. (Refer to paragraph 3.7.4.8.)

NOTE

Loose equipment items listed on this form are installed on the engine subsequent to delivery. Installation of this equipment is entered in the Loose-Equipment Flight Installation Record. (See figure 3-36.) The Inspection column of the Delivered Serialized Component Record form should be completed with the stamp or signature of the individual making entries, in the Loose-Equipment Flight Installation Record, when loose equipment is installed.

Figure 3-24. Delivered Serialized Component Record

RIGID DUCT SPACER DIMENSIONS

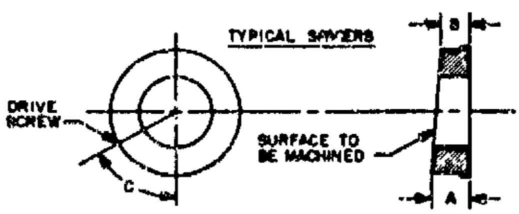
MODEL F-1 ENGINE S/N F-20XX

RIGID DUCT SPACER LOCATION	(1) IDENTIFICATION OF SPACER TO APPEAR ON OUTSIDE DIAMETER AS SHOWN BELOW	(2) SPACER HIGH POINT "A" ± 0.002 IN.	(3) SPACER LOW POINT "B" ± 0.002 IN.	(4) ANGLE "C" DEGREES (SEE NOTE 3)	(5) ANGLE "D" DEGREES (SEE NOTE 2)
NO. 1 LOX VALVE	P/N 408805 (1LV) S/N				DNA
NO. 1 LOX TP VOLUTE	P/N 408805 (1LP) S/N				DNA
NO. 2 LOX VALVE	P/N 408805 (2LV) S/N				DNA
NO. 2 LOX TP VOLUTE	P/N 408805 (2LP) S/N				DNA
NO. 1 FUEL VALVE	P/N 408806 (1FV) S/N 0266964	0.878	0.863	041° 10'	DNA
NO. 1 FUEL TP VOLUTE	P/N 408825 (1FP) S/N 0266966	2.571	2.570	126° 00'	009° 00'
NO 2 FUEL VALVE	P/N 408806 (2FV) S/N				DNA
NO. 2 FUEL TP VOLUTE	P/N 408825 (2FP) S/N				

NOTE 1 SPACER IDENTIFICATION SHALL BE ABBREVIATED AS SHOWN WHERE L, F, V AND P STAND FOR LOX, FUEL, VALVE AND PUMP RESPECTIVELY.

2 WHEN INSTALLING THE FUEL SPACERS AT THE TP FUEL VOLUTES THE DRIVE SCREWS SHALL BE POSITIONED 0 DEGREES COUNTER-CLOCKWISE FROM THE FORWARD MOST POSITION OF THE TP FUEL VOLUTE WHEN FACING THE VOLUTE TO ALLOW FOR THE SPACER ECCENTRICITY.

3 ANGLE "C" SHALL BE GIVEN IN DEGREES COUNTER-CLOCKWISE FROM THE DRIVE SCREW TO SPACER HIGH POINT WHEN FACING TP VOLUTE OR VALVE FLANGE



(6) EXPANDO TOOL INSTALLATION RECORD

LOX DOME SER NO. ____

INJECTOR SER NO. ____

THRUST CHAMBER SER NO. ____

*LOX DOME BOLT HOLE LOCATION NO. ____

*LOX DOME BOLT HOLE LOCATION NO. ____

* NOTE: THE EXPANDO TOOL SHALL BE LOCATED APPROX 90° APART IN OR NEAR LOX DOME BOLT HOLES NO. 6 & 91

REL. C DATE 14 APR 67

I. GENERAL INSTRUCTIONS.

Entries must be made on the Rigid-Duct Spacer Dimensions (engines not incorporating MD137 change) form when the engine components that require the accomplishment of fit-check procedures are removed and reinstalled or removed and replaced. If no space is available for entries on the form included in the log book as delivered, a new (blank) Rigid-Duct Spacer Dimensions form must be inserted when it is necessary to make entries subsequent to engine delivery. The original form must be retained in the log book.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

(1) IDENTIFICATION OF SPACER TO APPEAR ON OUTSIDE DIAMETER AS SHOWN BELOW - Enter serial number of spacer on appropriate line (as indicated in Rigid-Duct Spacer Location column).

(2) SPACER HIGH POINT "A" ±0.002 IN. - Enter spacer high-point dimension recorded during fit-check procedure.

(3) SPACER LOW POINT "B" ±0.002 IN. - Enter spacer low-point dimension recorded during fit-check procedure.

(4) ANGLE "C" DEGREES - Enter angle "C" degrees recorded during fit-check procedure.

(5) ANGLE "D" DEGREES - For applicable spacers, enter angle "D" degrees recorded during fit-check procedure.

(6) EXPANDO TOOL INSTALLATION RECORD - Information entered in this block is for reference purposes when the oxidizer dome and/or injector are removed from the thrust chamber. Entries are not applicable to rigid-duct spacer dimension requirements.

NOTE

Entries on the existing log book Rigid-Duct Spacer Dimensions form must be changed by identifying the applicable line for the affected spacer and correctly voiding obsolete entries. (Refer to paragraph 3.7.4.8.)

Figure 3-25. Rigid-Duct Spacer Dimensions (Engines Not Incorporating MD137 Change)

RIGID DUCT SPACER DIMENSIONS

MODEL F-1 ENGINE S/N F-20XX

RIGID DUCT SPACER LOCATION	SELECTIVE SPACER P/N	1 (*) SPACER SELECTED	2 ANGLE "D" DEGREES (SEE NOTE 1)	3 ANGLE "E" DEGREES (SEE NOTES 2 & 3)
NO 1 MOV	410837 - (*)		DNA	
NO. 1 OTP VOLUTE	410837 - (*)		DNA	
NO 2 MOV	410837 - (*)		DNA	
NO 2 OTP VOLUTE	410837 - (*)		DNA	
NO 1 MFV	410836 - (*)	-3	DNA	180°
NO 1 FUEL TP VOLUTE	410835 - (*)	-11	009°	DNA
NO 2 MFV	410836 - (*)		DNA	
NO. 2 FUEL TP VOLUTE	410835 - (*)			DNA

4 EXPANDO TOOL INSTALLATION RECORD

OXID DOME SERIAL NUMBER______

INJECTOR SERIAL NUMBER______

THRUST CHAMBER SERIAL NUMBER______

*OXID DOME BOLT HOLE LOCATION NO.______

*OXID DOME BOLT HOLE LOCATION NO.______

*NOTE: THE EXPANDO TOOL SHALL BE LOCATED APPROXIMATELY 90 DEGREES APART IN OR NEAR OXID DOME BOLT HOLES NO. 6 AND 61

NOTES: 1. WHEN INSTALLING THE FUEL SPACERS AT THE TP FUEL VOLUTES, THE NOTCH SHALL BE POSITIONED "D" DEGREES COUNTER-CLOCKWISE FROM THE FORWARD MOST POSITION OF THE TP FUEL VOLUTE WHEN FACING THE VOLUTE.

2. WHEN INSTALLING THE OXID SPACERS AT THE TP VOLUTES OR VALVES, THE NOTCH ON THE SPACERS SHALL BE POSITIONED "E" DEGREES COUNTER-CLOCKWISE FROM THE FORWARD MOST POSITION OF THE TP VOLUTE OR VALVE WHEN FACING THE VOLUTE OR VALVE FLANGES.

3. WHEN INSTALLING THE FUEL SPACER AT THE VALVE FLANGE, THE NOTCH SHALL BE POSITIONED "E" DEGREES COUNTER-CLOCKWISE FROM THE INBOARD MOST POSITION OF THE VALVE FLANGE WHEN FACING THE VALVE FLANGE.

VII. C

DATE 30 AUG 68

I. GENERAL INSTRUCTIONS.

Entries must be made on the Rigid-Duct Spacer Dimensions (Engines Incorporating MD137 Change) form when the engine components that require the accomplishment of fit-check procedures are removed and reinstalled or removed and replaced. If no space is available for entries on the form included in the log book as delivered, a new (blank) Rigid-Duct Spacer Dimensions form must be inserted when it is necessary to make entries subsequent to engine delivery. The original form must be retained in the log book. Log books delivered with engines incorporating MD137 change may contain a Rigid-Duct Spacer Dimensions form that differs from that shown. The form shown should be used when additional forms are needed.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1. SPACER SELECTED - Enter dash number of spacer part number selected during fit-check procedure.

2. ANGLE "D" DEGREES - For applicable spacers, enter angle "D" degrees recorded during fit-check procedure.

3. ANGLE "E" DEGREES - For applicable spacers, enter angle "E" degrees recorded during fit-check procedure.

4. EXPANDO TOOL INSTALLATION RECORD - Information entered in this block is for reference purposes when the oxidizer dome and/or injector are removed from the thrust chamber. Entries are not applicable to rigid-duct spacer dimension requirements.

NOTE

Entries on the existing log book Rigid-Duct Spacer Dimensions form must be changed by identifying the applicable line for the affected spacer and correctly voiding obsolete entries. (Refer to paragraph 3.7.4.8.)

Figure 3-26. Rigid-Duct Spacer Dimensions (Engines Incorporating MD137 Change)

POST DELIVERY SERIALIZED COMPONENT REPLACEMENT RECORD

MODEL F-1 ENGINE S N F-20XX

① ITEM NO.	② PART NAME	③ PART NO.	④ ORIGINAL SERIAL NO.	⑤ NEW SERIAL NO.	⑥ COMMENTS	⑦ DATE INSTALLED	⑧ INSP
202	Gas generator injector	308574 309159-11	6702277	6749727	Installed per ECP F1-506	11 Sep 68	
301	Pressure switch No. 1	NA5-28183-1 308391	25281	No change	P N change only per ECP F1-547	11 Sep 68	
302	Pressure switch No. 2	NA5-28183-1 308391	25274	No change	P N change only per ECP F1-547	11 Sep 68	
303	Pressure switch No. 3	NA5-28183-1 308391	25289	No change	P N change only per ECP F1-547	11 Sep 68	
621	Engine environmental temp transducer	NA5-27558-1 NA5-272176-1	AB01760666	14757	Installed per ECP F1-506	17 Sep 68	
115	Main oxidizer valve No. 2	409565 409565-21	4000925	No change	P N change only per ECP F1-550	17 Sep 68	

XII D 2 DATE 13 OCT 67

I. GENERAL INSTRUCTIONS.

Entries must be made in the Post-Delivery Serialized Component Record whenever the part number or serial number of selected serialized components changes as a result of component replacement or reidentification. Entries must be made for all replaced or reidentified components listed in Field Task and Verification Plan R-7241. Entries for replaced (or reidentified) serialized subassemblies, or details contained within an assembly that are not listed in this document, are not necessary when the higher assembly is replaced (or reidentified).

II. DETAILED INSTRUCTIONS.

Complete form as follows:

NOTE

If a component listed on this form is subsequently replaced or reidentified, line out the obsolete entries as outlined in paragraph 3.7.4.8.

① ITEM NO. - Enter card identification number from Field Task and Verification Plan that corresponds to component being replaced or reidentified.

② PART NAME - Enter name of component being replaced or reidentified.

③ PART NO. - Enter part number of component being replaced or reidentified. If NA5 component, make sure dash number suffix is included, if applicable. If part number of new component differs from part number of original component, enter new part number; then enter original part number, and enter reason for part number difference in Comments column.

④ ORIGINAL SERIAL NO. - Enter serial number of component being replaced; if this column is not on form, use Comments column and indicate "ORIG S/N."

⑤ NEW SERIAL NO. (or SERIAL NO.) - Enter serial number of component being installed.

⑥ COMMENTS - Enter a brief description of condition that caused component to be replaced.

⑦ DATE INSTALLED - Enter date new component is installed.

⑧ INSP - Enter stamp or signature of individual making the entry.

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. PRIMARY INSTRUMENTATION SYSTEM ROAD MAP. If primary instrumentation system

Figure 3-27. Post-Delivery Serialized Component Replacement Record (Sheet 1 of 2) transducers are replaced or deleted, make necessary changes in Primary Instrumentation System Road Map. (See figure 3-18 for instructions.)

NOTE

> If flight instrumentation pressure transducers are replaced or deleted, changes must also be made in the Post-Delivery Flight Instrumentation Pressure Transducer Replacement Record. (See figure 3-28 for instructions.)

B. DELIVERED SERIALIZED COMPONENT RECORD. If a listed component is removed and replaced, removed and deleted, or re-identified, make proper changes in Delivered Serialized Component Record. (See figure 3-24 for instructions.)

C. POST-DELIVERY COMPONENT CYCLE RECORD. If a component that requires a Post-Delivery Component Cycle Record is replaced, make necessary Post-Delivery Component Cycle Record changes. (See figure 3-31 for instructions.)

D. AGE CONTROL LOG FOR COMPONENT SYNTHETIC RUBBER ITEMS. If listed components containing rubber items are replaced, make necessary entries in Age Control Log for Component Synthetic Rubber Items. (See figure 3-35 for instructions.)

Figure 3-27. Post-Delivery Serialized Component Replacement Record (Sheet 2 of 2)

POST-DELIVERY FLIGHT INSTRUMENTATION PRESSURE TRANSDUCER REPLACEMENT RECORD

MODEL F-1 ENGINE S/N F-20XX

ITEM NO. 1	PART NO. 2	SERIAL NO. 3	TAP NO. 4	5 PARAMETER (PRESSURES)		CALIB. 6 VOLTAGE	7 COMMENTS	8 INSP.
					INITIAL			
					LOW CALIB.			
					HIGH CALIB.			
					INITIAL			
					LOW CALIB.			
					HIGH CALIB.			

VII.E.2. Date 30 SEP 68

I. GENERAL INSTRUCTIONS.

NOTE

This form will not appear in all log books; this instruction applies only to log books having this form.

Entries must be made in the Post-Delivery Flight Instrumentation Pressure Transducer Replacement Record whenever a flight instrumentation pressure transducer is replaced.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1. ITEM NO. - Enter item number listed in log book Delivered Serialized Component Record that corresponds to transducer being replaced. If transducer is not listed in log book Delivered Serialized Component Record, leave this column blank.
2. PART NO. - Enter part number of transducer being installed.
3. SERIAL NO. - Enter serial number of transducer being installed.
4. TAP NO. - Enter tap identification number applicable to transducer being installed.
5. PARAMETER (PRESSURES) - Enter parameter name applicable to tap number in which transducer is being installed.
6. CALIB. VOLTAGE - Enter initial, low-calibration, and high-calibration voltage output reading as obtained from flight instrumentation checkout console printer, or equivalent.
7. COMMENTS - Enter reason for transducer replacement.
8. INSP. - Enter stamp or signature of individual making the entry.

Figure 3-28. Post-Delivery Flight Instrumentation Pressure Transducer Replacement Record

I. GENERAL INSTRUCTIONS.

The delivered Orifice Record lists all variable orifices that are installed in the engine at the time of delivery. The only post-delivery alteration required on this form is the lining out of entries when a post-delivery change of a listed orifice is performed.

II. DETAILED INSTRUCTIONS.

Identify orifice that was replaced, and correctly line out all entries for this orifice. (Refer to paragraph 3.7.4.8.)

Figure 3-29. Delivered Orifice Record

POST-DELIVERY ORIFICE REPLACEMENT RECORD

MODEL F-1 ENGINE S/N F-20XX

ITEM NO. (1)	(2) ORIFICE NAME	(3) ORIGINAL PART NO.	(4) NEW PART NO.	LOCATION IDENTIFICATION CODE (5)	(6) COMMENTS	(7) DATE	(8) INSP
07	No. 1 main LOX valve opening line orifice	RD251-4085-0161	RD251-4085-0179	No. 1 MLV	Replaced per ECP F1-444	13 Oct 67	
08	No. 2 main LOX valve opening line orifice	RD251-4085-0161	RD251-4085-0180	No. 2 MLV	Replaced per ECP F1-444	13 Oct 67	
09	No. 1 main fuel valve opening line orifice	RD251-4083-0089	RD251-4083-0082	No. 1 MLV	Replaced per ECP F1-444	13 Oct 67	
10	No. 2 main fuel valve opening line orifice	RD251-4083-0089	RD251-4083-0082	No. 2 MLV	Replaced per ECP F1-444	13 Oct 67	
11	GG valve opening line orifice	RD251-4098-0079	RD251-4098-0097		Replaced per ECP F1-444	13 Oct 67	
04	Downstream GG LOX orifice	RD251-4130-0986	RD251-4130-1183		Replaced per ECP F1-596	18 Sep 68	

XIII.C.2

DATE 30 SEP 68

I. GENERAL INSTRUCTIONS.

Entries must be made in the Post-Delivery Orifice Replacement Record whenever an orifice listed on the log book Delivered Orifice Record is replaced, including those cases where the replacement does not involve an orifice diameter change.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

NOTE

If an orifice listed on this form is subsequently replaced, line out the obsolete entries as outlined in paragraph 3.7.4.8.

1. ITEM NO. - Enter item number listed in log book Delivered Orifice Record that corresponds to orifice being replaced.

2. ORIFICE NAME - Enter name of orifice being replaced.

3. ORIGINAL PART NO. - Enter part number of original orifice, the last four digits of which indicate original orifice diameter. If Original Part No. column is not on the form, use Comments column and indicate "Orig P/N."

4. NEW PART NO. (or PART NO.) - Enter part number of new orifice, the last four digits of which indicate new orifice nominal diameter.

5. LOCATION IDENTIFICATION CODE - Refer to log book Delivered Orifice Record and determine if orifice being replaced requires a location identification code. Enter location identification code letters that correspond to orifice being replaced.

6. COMMENTS - Enter reason for orifice replacement.

NOTE

Columns 7 and 8 may appear in reverse order on the form.

7. DATE - Enter date new orifice is installed.

8. INSP (or INSPECTION) - Enter stamp or signature of individual making the entry.

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. DELIVERED ORIFICE RECORD. If a listed orifice is removed and replaced, make proper changes in Delivered Orifice Record. (See figure 3-29 for instructions.)

Figure 3-30. Post-Delivery Orifice Replacement Record

OPERATIONAL DATA (HEAT EXCHANGER PERFORMANCE SUMMARY)

MODEL F-1 ENGINE S/N F-2011

HEAT EXCHANGER PART NUMBER 1 308551-11	HEAT EXCHANGER SERIAL NUMBER 2 N295129			
TEST NUMBER		3 MTF 7-		
TEST EFFECTIVE DURATION	SEC	4 120.5		
DATA INTERVAL	SEC TO SEC	5 55-58		
TURBINE EXHAUST GAS FLOWRATE	LBS/SEC	6 174.15		
TURBINE EXHAUST STATIC PRESSURE	PSIA	7 58.17		
TURBINE EXHAUST TEMPERATURE	F	8 1133.5		
HEAT EXCHANGER LOX FLOWRATE	LBS/SEC	9 5.820		
HEAT EXCHANGER LOX INLET STATIC PRESSURE	PSIA	10 Not measured		
HEAT EXCHANGER LOX INLET TEMPERATURE	F	11 Not measured		
HEAT EXCHANGER GOX OUTLET STATIC PRESSURE	PSIA	12 1328.5		
HEAT EXCHANGER GOX OUTLET TEMPERATURE	F	13 298.9		
DIAMETER OF LOX COIL BYPASS ORIFICE	INCHES	14 0.197		
DIAMETER OF LOX COIL INLET ORIFICES	INCHES	15 0.130		
HELIUM COIL OPERATING FLUID		16 Helium		
HELIUM COIL WET OPERATION INTERVAL	SEC TO SEC	17 0.0-120.5		
HEAT EXCHANGER HELIUM COIL FLUID FLOWRATE	LBS/SEC	18 Not measured		
HEAT EXCHANGER HELIUM COIL INLET FLUID STATIC PRESSURE	PSIA	19 Not measured		
HEAT EXCHANGER HELIUM COIL INLET FLUID TEMPERATURE	F	20 -262.9		
HEAT EXCHANGER HELIUM COIL OUTLET FLUID STATIC PRESSURE	PSIA	21 231.8		
HEAT EXCHANGER HELIUM COIL OUTLET FLUID TEMPERATURE	F	22 285.[illegible]		
DIAMETER OF HELIUM COIL BYPASS ORIFICE	INCHES	23 0.58[illegible]		
DIAMETER OF HELIUM COIL INLET ORIFICES	INCHES	24 0.500		

IX.A 3 DATE ______

I. GENERAL INSTRUCTIONS.

Entries must be made on the Operational Data (Heat Exchanger Performance Summary) form to record performance of the heat exchanger during engine tests conducted after delivery.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1 HEAT EXCHANGER PART NUMBER - Enter part number of heat exchanger installed on engine.

2 HEAT EXCHANGER SERIAL NUMBER - Enter serial number of heat exchanger installed on engine.

3 TEST NUMBER - Enter letters and/or numerals that indicate test facility or vehicle identification.

4 TEST EFFECTIVE DURATION - Enter effective duration of test to nearest 0.1 second.

5 DATA INTERVAL - Enter elapsed effective duration of test when data interval was started and terminated to nearest 0.1 second.

6 TURBINE EXHAUST GAS FLOWRATE - Enter total propellant weight flow supplied to gas generator to nearest pound per second.

Figure 3-30A. Operational Data (Heat Exchanger Performance Summary) (Sheet 1 of 2)

7. TURBINE EXHAUST STATIC PRESSURE - Enter absolute value of combustion gas static pressure at heat exchanger entrance to nearest 0.1 psia.

8. TURBINE EXHAUST TEMPERATURE - Enter measured temperature of combustion gas at heat exchanger entrance to nearest degree fahrenheit.

9. HEAT EXCHANGER LOX FLOWRATE - Enter weight flowrate of oxidizer through heat exchanger LOX coils to nearest 0.01 lb/sec.

10. HEAT EXCHANGER LOX INLET STATIC PRESSURE - Enter words "Not measured".

11. HEAT EXCHANGER LOX INLET TEMPERATURE - Enter words "Not measured".

12. HEAT EXCHANGER GOX OUTLET STATIC PRESSURE - Enter absolute value of oxidizer static pressure at exit of LOX coils to nearest pound per square inch absolute.

13. HEAT EXCHANGER GOX OUTLET TEMPERATURE - Enter measured temperature of oxidizer exiting from LOX coils to nearest degree fahrenheit.

14. DIAMETER OF LOX COIL BYPASS ORIFICE - Enter diameter of LOX bypass orifice to nearest 0.001 inch. If no orifice is installed, enter words "No orifice".

15. DIAMETER OF LOX INLET ORIFICES - Enter diameter of orifices installed in inlet of LOX coils to nearest 0.001 inch. If no orifices are installed, enter words "No orifices".

16. HELIUM COIL OPERATING FLUID - Enter type of fluid being passed through heat exchanger helium coils during data interval.

17. HELIUM COIL WET OPERATIONAL INTERVAL - Enter elapsed effective duration of test when helium coil operating fluid started and terminated flow through helium coils to nearest 0.1 second. If coils were flowed throughout test, enter 0.0 and effective duration of test.

18. HEAT EXCHANGER HELIUM COIL FLUID FLOWRATE - Enter words "Not measured".

19. HEAT EXCHANGER HELIUM COIL INLET FLUID STATIC PRESSURE - Enter words "Not measured".

20. HEAT EXCHANGER HELIUM COIL INLET FLUID TEMPERATURE - Enter measured temperature of helium coil operating fluid entering helium coils to nearest degree fahrenheit.

21. HEAT EXCHANGER HELIUM COIL OUTLET FLUID STATIC PRESSURE - Enter absolute value of helium coil operating fluid static pressure at exit of helium coils to nearest pound per square inch absolute.

22. HEAT EXCHANGER HELIUM COIL OUTLET FLUID TEMPERATURE - Enter measured temperature of helium coil operating fluid exiting from the helium coils to nearest degree fahrenheit.

23. DIAMETER OF HELIUM COIL BYPASS ORIFICE - Enter diameter of helium bypass orifice to nearest 0.001 inch. If no orifice is installed, enter words "No orifice".

24. DIAMETER OF HELIUM COIL INLET ORIFICES - Enter diameter of orifices installed in inlet of helium coils to nearest 0.001 inch. If no orifices are installed, enter words "No orifices".

Figure 3-30A. Operational Data (Heat Exchanger Performance Summary) (Sheet 2 of 2)

MODEL F-1 POST-DELIVERY COMPONENT CYCLE RECORD ENGINE S N F-20XX

COMPONENT NAME 6 THREE-WAY SOLENOID VALVE ASSY PART NO 7 558350 SERIAL NO 8 835P995

1 DATE	2 TEST OR PROCEDURE	3 NO. OF CYCLES	4 ACCUMULATED NO. OF CYCLES	5 COMMENTS
9 Oct 68	V-24026	2	2	
10 Oct 68	V-24024	7	9	
22 Oct 68	V-20021	1	10	
25 Oct 68	V-24024	1	11	

IX C 4

DATE 30 SEP 68

I. GENERAL INSTRUCTIONS.

Entries must be made in the appropriate log book Post-Delivery Component Cycle Record whenever the components listed in paragraph II are cycled on an engine, excluding those cycles that occur during engine static firing. Refer to section II for cycle definitions and cycle limits.

II. DETAILED INSTRUCTIONS.

Whenever one of the following components is cycled during performance of a test or procedure, make entries in applicable Post-Delivery Component Cycle Record:

a. No. 1 main fuel valve

b. No. 2 main fuel valve

c. No. 1 main LOX valve

d. No. 2 main LOX valve

e. Gas generator ball valve

f. Engine control valve

g. Ignition monitor valve

h. Igniter fuel valve

i. Bearing coolant control valve

j. Redundant shutdown valve

k. Gimbal bearing

l. No. 1 thrust OK pressure switch

m. No. 2 thrust OK pressure switch

n. No. 3 thrust OK pressure switch

o. Checkout valve

p. Heat exchanger GOX outlet customer connect line

q. Heat exchanger helium supply customer connect line

r. Heat exchanger helium return customer connect line

s. Hydraulic supply customer connect line

t. Hydraulic return customer connect line

Complete form as follows:

1 DATE - Enter date component is cycled.

2 TEST OR PROCEDURE - Enter a brief description of test or procedure being performed during which component was cycled.

3 NO. OF CYCLES - Enter number of times component is cycled during test or procedure. When recording gimbal bearing and customer-connect line cycles, enter magnitude of gimbal angular excursion also.

Figure 3-31. Post-Delivery Component Cycle Record (Sheet 1 of 2)

4 ACCUMULATED NO. OF CYCLES - Enter sum of previous entry in this column and current entry in No. of Cycles column (column 3). When recording gimbal bearing and customer-connect line accumulated cycles, enter sum of current entry in No. of Cycles column and last entry in this column at same gimbal excursion.

5 COMMENTS - Enter reason component is cycled.

NOTE

Entries numbered 6, 7, and 8 are completed to initiate a Post-Delivery Component Cycle Record for replacement components or to add new sheets to the log book.

6 COMPONENT NAME - Enter name of component.

7 PART NO. - Enter component part number.

8 SERIAL NO. - Enter component serial number.

Figure 3-31. Post-Delivery Component Cycle Record (Sheet 2 of 2)

DISCREPANCY RECORD

MODEL F-1 ENGINE S/N F-20XX

❶ DISCREPANCY	❷ ACTION TAKEN	❸ DATE	❹ INSPECTION
8. During post-modification and buildup checkout (heat exchanger LOX coil leak test), leakage noted at H/E GOX out flange static seal monitor port. (Ref UCR F009660, UTR U272591)	8. Seal replaced.	4 Oct 67	
9. During post-modification checkout, inert prefill check valve 407825, S/N 4088305, failed to open. (Ref UCR F009137 and UTR U311032)			
10. During static test S-IC-8-7, thermal insulation system brackets 143233 and 143436 came loose and dislodged. (Ref UER U284237, UCR R011321)	10. Brackets repositioned and retorqued at MTF.	30 Dec 68	
11. Nozzle extension 209210-21, S/N 284265- Post-test S-IC-8-7 inspection reveals a nut plate is missing from No. 6 band at 185°. (Ref UTR U284265, UCR X011319)			

X. A 2 DATE 14 APR 67

I. GENERAL INSTRUCTIONS.

Significant engine discrepancies resulting in Unsatisfactory Condition Reports (UCRs) or material review type action, discovered after engine delivery, are recorded in the Discrepancy Record. Entries must be made on this form to record engine discrepancies as soon as the discrepancy is discovered.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

❶ DISCREPANCY - Enter a brief description of discrepancy, and indicate date and time relative to engine tests conducted when discrepancy occurs. Enter number of UCR written against discrepancy.

❷ ACTION TAKEN - Enter a brief description of action taken to clear discrepancy. Reference all Government or Contractor UCRs written against discrepancy.

❸ DATE - Enter date discrepancy is cleared.

❹ INSPECTION - Enter stamp or signature of individual making the entry.

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. COMPONENT TEST RECORD. If discrepancy disposition required replacement of a component that has a Component Test Record (CTR), make necessary changes to forms involved. (See figure 3-19 for instructions.)

B. POST-DELIVERY PERFORMANCE UNCERTAINTY RECORD. If engine performance uncertainty is affected by discrepancy disposition, make necessary Post-Delivery Performance Uncertainty Record changes. (See figure 3-20 for instructions.)

C. RIGID-DUCT SPACER DIMENSIONS. If discrepancy disposition resulted in removal of components that require accomplishment of fit-check procedures, make changes on appropriate Rigid-Duct Spacer Dimension form. (See figure 3-25 or 3-26 for instructions.)

D. POST-DELIVERY SERIALIZED COMPONENT REPLACEMENT RECORD. If discrepancy disposition resulted in replacement of a serialized component, make entries in Post-Delivery Serialized Component Replacement Record. (See figure 3-27 for instructions.)

E. POST-DELIVERY ORIFICE REPLACEMENT RECORD. If discrepancy disposition resulted in an orifice replacement, make entries in Post-Delivery Orifice Replacement Record, as necessary. (See figure 3-30 for instructions.)

Figure 3-32. Discrepancy Record

INSPECTION RECORD

MODEL F-1 ENGINE S/N F-20XX

1 TYPE OF INSPECTION	2 RESULTS	3 PLACE OF INSPECTION	DATE 4	INSPECTION 5
1. Thermal insulation brackets installation per Rocketdyne drawing 145011	Installed items 195, 196, 532 thru 535, 807, 810, 812 thru 819, and 821 thru 842 as noted on sheet No. 3 of drawing 145011. (TIS S/N 17-5)	NAR Rocketdyne Canoga Park	6 Jun 67	
2. FFIR F1-28A - Replacement of oxidizer pump primary oxidizer seal	Replaced oxidizer pump primary seal	NAR Rocketdyne Canoga Park	28 Jun 67	
3. Receiving inspection (visual)	No significant discrepancies noted.	RD-MAF	27 Jul 67	
4. Post-modification and buildup checkout	See Discrepancy Record, Item 8.	RD-MAF	6 Oct 67	
5. FFIR F1-33 - Inspection of J-box support strut rod ends	Two rod ends RE131-7001-0003 and one rod end RE131-7002-0003 found discrepant and were replaced.	RD-MAF	16 Oct 67	
6. Post-modification checkout	See Discrepancy Record, Item 9.	RD-MAF	23 Oct 67	
7. FFIR F1-45 - Replacement and insp of engine control valve opening, closing, and GSE engine supply filters	Filters replaced.	RD-MAF	9 Sep 68	
8. Main injector Inspection	No discrepancies noted.	RD-MTF	16 Nov 68	
9. Inspection of FIDC return hose per FFIR F1-37B (leak check)	No leakage	RD-MTF	9 Dec 68	
10. Inspection of removed FIDC return hose assy & ascertainment of intactness of MS29513-121 packing per FFIR F1-37B	No discrepancies noted.	RD-MTF	26 Nov 68	

X 9 2 DATE 14 APR 67

I. GENERAL INSTRUCTIONS.

The Inspection Record is used to record engine inspections and inspection results, except engine closure humidity indicator inspections. Humidity indicator inspections are recorded in individual records that are not associated with the log book.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1. TYPE OF INSPECTION - Enter name or description of inspection. If inspection requirements is an Engine Field Inspection Request (EFIR), enter EFIR title and number upon receipt.

2. RESULTS - Enter a brief description of inspection results. Make note of any discrepancies discovered and enter these in Discrepancy Record.

3. PLACE OF INSPECTION - Enter complete designation of facility at which inspection is conducted.

4. DATE - Enter date inspection is completed.

5. INSPECTION - Enter stamp or signature of individual making the entry.

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. DISCREPANCY RECORD. Enter any discrepancies discovered during performance of engine inspections in Discrepancy Record. (See figure 3-32 for instructions.)

Figure 3-33. Inspection Record

MODEL F-1

TURBOPUMP PRESERVATION RECORD

ENGINE S/N F-20XX

1 TURBOPUMP SERIAL NO.	2 APPLICABLE SPECIFICATION	3 SPECIFICATION TITLE	4 TEST NO. OR OPERATION	5 INSPECTION	6 DATE
4089893	RA0220-726A	F-1 Engine Acceptance Test Requirements and Procedures	Post test 436-016		8 Mar 67
4089893	D5-11789-100, 1.29 F	Turbopump Preservation	Post test S-IC-8-7		19 Dec 68

X.C.2

DATE 14 APR 67

I. GENERAL INSTRUCTIONS.

The Turbopump Preservation Record must be updated whenever preservation of the turbopump is accomplished.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1. TURBOPUMP SERIAL NO. - Enter turbopump serial number.
2. APPLICABLE SPECIFICATION - Enter number, including revision or change number if any, of document utilized to accomplish preservation procedure.
3. SPECIFICATION TITLE - Enter title of document utilized to accomplish preservation procedure.
4. TEST NO. OR OPERATION - Enter time preservation procedure is completed (include static test number, if applicable).
5. INSPECTION - Enter stamp or signature of individual making the entry.
6. DATE - Enter date preservation procedure is completed.

Figure 3-34. Turbopump Preservation Record

AGE CONTROL LOG FOR COMPONENT SYNTHETIC RUBBER ITEMS

MODEL F-1 ENGINE S/N F-20XX

1 PART NAME	2 PART NO	3 SERIAL NO.	4 MFG CODE	5 SPEC NO	6 INSTALL DATE	7 REPLACE-MENT DATE	8 INSPEC-TION	9 DATE REPLACED
Three-way solenoid valve assy	558350	8359932	02602	RA0115-122	1967	1973		

X.D.2

30 SEP 68

I. GENERAL INSTRUCTIONS.

Entries must be made on the Age Control Log for Component Synthetic Rubber Items form for all components listed that contain synthetic rubber items, when the life of synthetic rubber items expires or components are overhauled or replaced.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1. PART NAME - Enter name of component.
2. PART NO. - Enter part number of component.
3. SERIAL NO. - Enter serial number of component.
4. MFG CODE - Enter code number of component manufacturer.
5. SPEC NO. - Enter applicable Contractor or Customer document number that specifies age control for component rubber items.
6. INSTALL DATE - Enter date of installation of rubber items into component.
7. REPLACEMENT DATE - Enter date component rubber items must be replaced.
8. INSPECTION - Enter stamp or signature of individual making the entry.
9. DATE REPLACED - On existing entry, enter date component is overhauled or replaced and line-out obsolete entry as outlined in paragraph 3.7.4.8.

III. INSPECTION REQUIREMENTS.

Perform oldest assembly/installation date inspection as outlined in paragraph 3.1.3.

Figure 3-35. Age Control Log for Component Synthetic Rubber Items

LOOSE EQUIPMENT FLIGHT INSTALLATION RECORD

MODEL F-1 ENGINE S/N F-20XX

PART NAME	PART NO.	QUANTITY	CONFIGURATION CODE	(1) INSTALLATION DATE	INSTALLATION INSPECTION	(2) COMMENTS
TC EXTENSION GAS COOLED	209210	1	J			
GOX OUTLET DUCT	406070	1	V			
HYDRAULIC SUPPLY DUCT	406071	1	V			
HYDRAULIC RETURN DUCT	406072	1	V			
HELIUM SUPPLY DUCT	406073	1	V			
HELIUM RETURN DUCT	406075	1	V			
TP LOX SEAL PURGE HOSE ASSY	NA5-26881	1	V			
LOX DOME PURGE HOSE ASSY	NA5-26882	1	V			
TC JACKET PREFILL HOSE ASSY	NA5-26883	1	V			
GG FUEL INJ AND THERM INS PRG HOSE ASSY	NA5-26884	1	V			
WIRING HARNESS ASSY, HIGH VOLTAGE IGNITERS	502932	1	H			
IGNITER ASSY, HIGH VOLTAGE	651990	4	J			
COVER, SUPPORT, PURGE HOSE	651578	1	V			
COVER, BRACKET, HYDRAULIC	652297	2	V			
PAD	K2297-4	4	V			
COVER, BRACKET, RETURN DUCTS	651296	2	V			

X.E.2.1 DATE 25 FEB 69

I. GENERAL INSTRUCTIONS.

Entries must be made in the Loose-Equipment Flight Installation Record whenever a loose-equipment item listed on the form is permanently installed for flight. If an installed item is subsequently replaced, entries are also required.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

NOTE

Codes listed in Configuration Code column indicate the location where the part will normally be installed. Codes V or J indicate MAF or KSC, respectively. Code H indicates post-static test installation at MAF (during refurbishment).

- Listed part names preceded by one asterisk (*) are applicable to outboard engine installation only. Those preceded by two asterisks (**) are applicable to inboard engine installation only.
- This figure does not duplicate the entire loose-equipment list that appears in the log book.

(1) INSTALLATION - Enter date listed item is installed and stamp or signature of individual making the entry.

(2) COMMENTS - If items listed are replaced or deleted subsequent to installation, enter reason item is replaced or deleted referencing any supporting documentation (UCR, UER, etc).

Figure 3-36. Loose-Equipment Flight Installation Record (Sheet 1 of 2)

III. <u>OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.</u>

A. <u>DELIVERED SERIALIZED COMPONENT RECORD.</u> Make entries in Delivered Serialized Component Record when listed items of loose equipment are installed on engine and subsequently replaced. (See figure 3-24 for instructions.)

B. <u>POST-DELIVERY SERIALIZED COMPONENT REPLACEMENT RECORD.</u> Update Post-Delivery Serialized Component Replacement Record when listed items of installed loose equipment are replaced. (See figure 3-27 for instructions.)

Figure 3-36. Loose-Equipment Flight Installation Record (Sheet 2 of 2)

MODEL F-1		TRANSFER RECORD		ENGINE S/N F-20XX
1 ORGANIZATION AND LOCATION	2 INSPECTION	3 DATE	4 TIME SINCE NEW OR OVERHAULED	5 TOTAL TIME
NR Rocketdyne, Canoga Park		10 Dec 65	275.7 seconds	275.7 seconds
The Boeing Company, MAF		3 Jan 66	275.7 seconds	275.7 seconds
Log Book Audit		10 Jan 66		
Log Book Audit		5 Nov 66		
The Boeing Company, MSFC		5 Nov 66	275.7 seconds	275.7 seconds
Log Book Audit		12 Nov 66		
Log Book Audit		28 Nov 67		
The Boeing Company, MAF		28 Nov 67	397.6 seconds	397.6 seconds
Log Book Audit		10 Dec 67		

XI. A.2

DATE 9 DEC 65

I. GENERAL INSTRUCTIONS.

Entries must be made in the Transfer Record whenever engine custody is transferred or the engine is shipped, received, or launched. In addition, entries must be made to record log book audits performed during shipping, receiving, and prelaunch operations.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1 ORGANIZATION AND LOCATION - Enter organization designation and location of organization responsible for shipping or receiving engine. If engine was launched, enter "Launched" as last entry in this column. If a log book audit was performed, enter "Log Book Audit."

2 INSPECTION - Enter stamp or signature of individual making the entry. In the case of a log book audit, enter date and stamp of Contractor representative making the entry and Government representative verifying accuracy and completeness of log book.

3 DATE - Enter date that engine is shipped or received. If engine is launched, enter launch date.

4 TIME SINCE NEW OR OVERHAULED - Enter accumulated effective duration of all tests on engine since new or overhauled, to nearest 0.1 second. Obtain accumulated time from Engine Test Record. (See figure 3-22.)

5 TOTAL TIME - Enter accumulated effective duration of all tests on engine independent of overhaul.

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. CONFIGURATION RECORD. Review the Configuration Record and complete entries, if necessary, to make Configuration Record reflect engine configuration at time of transfer or launch. (See figure 3-23.)

Figure 3-37. Transfer Record

OPERATING INSTRUCTION CHANGE NOTICES

Operating Instruction Change Notices (OICNs) are issued from time to time to communicate important and urgent information concerning the equipment covered in this manual. These OICNs bear an identifying number and should be filed in this Appendix.

OICNs directly affect the data in this manual and will be incorporated into this manual during a future updating effort.

An OICN Record is issued periodically to indicate the status of OICNs issued for this manual. The status of each OICN is indicated in the "OICN Status" column. For active OICNs, no status is entered. For incorporated OICNs, "Incorporated" is entered.

Upon receipt of an OICN, make an appropriate reference to the OICN in the margin next to the data changed, and enter the applicable information in figure 2 of the Introduction.

OPERATING INSTRUCTION CHANGE NOTICE RECORD

This OICN Record indicates the status of OICNs issued for Technical Manual R-3896-11. OICNs which have been incorporated into the manual shall be removed from the Appendix and destroyed.

OICN Number	Dated	Description	OICN Status
1	24 June 1969	Deletes post-manufacturing checkout activities at MAF and integrates them with pre-static checkout activities at MTF.	Incorporated
2	9 October 1969	Adds fuel overboard drain system isolation requirements and fuel feed system drain requirements.	Incorporated
3	1 August 1969	Revises torque requirements for igniter installation.	Incorporated
4	12 December 1969	a. Adds a new activity for leak check of fuel valves and gas generator ball valve after admitting fuel, consolidates activities for admitting fuel, and changes sequence constraints for admitting fuel and prefill. b. Adds reusability requirement for K-seals used on seal monitoring port plugs and pressure-actuated (Naflex) seal used at oxidizer overboard drain line flange (thrust chamber to nozzle extension joint). c. Revises turbopump LOX seal purge sequence requirements.	Incorporated

OICN Number	Dated	Description	OICN Status
4 (cont)		d. Adds a constraint to vent turbine system during uninstalled-engine testing at MAF when LOX dome and gas generator LOX injector purge is pressurized, when fuel or LOX system is pressurized, and when fuel overboard drain system is pressurized. e. Clarifies that pressure specified in turbopump bearing coolant system leak test is supply pressure, not monitor pressure, and clarifies vapor emission from thrust chamber exit during thrust chamber fuel jacket flush. f. Adds MD coding for engine environmental temperature transducer. g. Changes turbopump preservation frequency from 2 years to 3 years. h. Changes method required for leak-testing thrust chamber external tubes when stage is in horizontal position. i. Changes requirements for launch abort recycle, and deletes visual inspection activity subsequent to launch abort. j. Adds special constraints and remarks specifying method for determining fuel valve nose and skirt seal leakage and requiring LOX system pressurization during fuel feed system leak test at MAF subsequent to static test, and at KSC. k. Revises component cycle definitions. l. Changes igniter test voltage requirement. m. Allows reuse of slave engine hardware when static-testing engines at MTF. n. Deletes instrumentation requirement not applicable to engines covered in this manual, specifies use of hypergol system test tool 9021279, clarifies LOX dome flushing requirements, and corrects typographical errors in titles and references.	

OICN Number	Dated	Description	OICN Status
4 (cont)		o. Adds sequence requirements for purge systems, adds a thrust chamber liquid-leak-test constraint, deletes specific solvent requirement for nozzle extension flange and seal groove cleaning, and revises electrical control system sequencing and safety circuit requirements. p. Adds a constraint that requires Engine Contractor concurrence and that specifies minimum allowable clearance, installation, and clamping requirements when hardware, other than engine hardware, is installed on the engine. q. Changes fuel admittance requirements to permit loading of fuel with prevalves open.	
5	24 September 1969	Substitutes lubricant grease RB0140-012 (Rocketdyne) for KEL-F 90 (Minnesota Mining and Mfg) as specified.	Incorporated
6	11 December 1969	Adds requirement to perform an ignition monitor valve poppet position verification test.	Incorporated
8	3 October 1969	Corrects procedures for pressurizing and depressurizing hydraulic system for uninstalled engines and adds closure installation for vertical-engine removal.	Incorporated
10	11 December 1969	Revises test pressures required during heat exchanger LOX system leak test for uninstalled engines, and at MTF, for installed engines.	Incorporated
11	16 October 1969	Adds removal and installation of gas generator seal monitoring vent hoses during exhaust system leak test at KSC.	Incorporated
12	22 October 1969	Adds a procedure for gaining access to fuel jacket purge quick-disconnect on No. 1 fuel valve when thermal insulation is installed.	Incorporated

OICN Number	Dated	Description	OICN Status
13	29 December 1969	Adds requirement to perform checkout valve engine return switch verification, adds control system voltage level for load conditions, and changes igniter harness measurement requirement.	Incorporated
14	12 November 1969	Provides alternate types of polyethylene material which may be used to make plastic bags to be used during fuel overboard drain system isolation procedures.	Incorporated
16	25 March 1970	Revises cocoon purge sequence requirements and engine environmental temperature requirements.	Incorporated
17	5 December 1969	Incorporates validation comments in turbopump preservation procedure for engines not incorporating MD145 change and in live- and expended-igniter removal procedures.	Incorporated
19	14 April 1970	Adds requirement to inspect specified engine joints, to make sure that joint closures are removed before static test or launch, and deletes the security requirement for the thrust chamber throat security closure lock.	Incorporated
20	25 March 1970	Adds requirement to perform ignition monitor valve poppet position verification after static test or launch abort, changes serialized component log book entry requirements, deletes 28 ±4 vdc electrical requirement from section I, and changes hydraulic control system constraints.	Incorporated
22	9 April 1970	Revises engine storage requirements and limits.	Incorporated
23	9 January 1970	Updates preservation procedure for series lube engines to include use of Scavenge Pump G2039.	Incorporated
24	4 February 1970	Adds hypergol cartridge servicing procedures and changes hypergol cartridge installation procedures.	Incorporated
25	22 May 1970	Adds hypergol cartridge restoration requirements and updates hypergol cartridge repackaging requirements.	Incorporated
26	25 June 1970	Updates turbopump preservation requirements for series lube engines to include the use of Scavenge Pump G2039.	Incorporated

OICN Number	Dated	Description	OICN Status
27	29 June 1970	Amends joint leakage acceptability criteria and establishes standard leakage monitoring techniques.	Incorporated
28	29 June 1970	Deletes the requirement for igniter checkout after installation, deletes the resistance requirement when igniter harness continuity is verified, changes the thrust OK pressure switch leak-test pressure level, changes the hydraulic control system leak-test pressure requirement, changes the valve timing-test cycle requirement, and adds the thrust chamber internal tube leak test.	Incorporated
29	13 February 1970	Adds instructions for maintaining the Operational Data (Heat Exchanger Performance Summary)	Incorporated
30	3 March 1970	Deletes equivalent milliseconds from vibration safety cutoff verification test, lowers the torque value of the cross-to-lateral drain tube, and adds a new method for securing bags during fuel overboard drain system isolation.	Incorporated
31	30 September 1970	Deletes the ordnance storage requirement at MAF; corrects an activity requirement during storage at MTF; clarifies hydraulic component leakage into fuel overboard drain line; adds nitrogen purge line requirement for thrust chamber nozzle extension removal and installation; specifies that when using operational low-level LOX dome and gas generator LOX injector purge for LOX dome and gas generator LOX injector flush, purge must be maintained for a minimum of 15 minutes; changes operational low-level and high-level LOX dome and gas generator LOX injector purge sequencing requirements; updates sequencing requirements for thrust chamber fuel jacket purge systems and hypergol servicing purge system to agree with section I requirements; and corrects a typographical error.	Incorporated

OICN Number	Dated	Description	OICN Status
32	30 September 1970	Adds a requirement to inspect igniters before performing the igniter test, adds a requirement for performing an igniter thread inspection, and adds a remark specifying that an igniter must be installed in a protective device that will prevent injury to personnel in event of accidental firing of an igniter during testing.	Incorporated
33	29 April 1970	Requires use of a plastic cap on the pressure switch checkout connection and corrects the part number of the alternate plug used in the gas generator igniter bosses.	Incorporated
34	5 May 1970	Simplifies the procedure for isolating the oxidizer dome purge check valves, clarifies the use of shorting caps on high-voltage igniters, and adds a caution when using a deep-well socket for torquing igniters.	Incorporated
35	30 September 1970	Deletes the requirement for gas generator injector purge check valve reverse-flow leak test and LOX dome purge check valve reverse-flow leak test at KSC, and adds an exhaust system leak test at KSC.	Incorporated
36	18 June 1970	Adds a procedure for inspecting variable orifices to determine that their actual size is within machining tolerance of the variable orifice nominal size recorded in the Engine Log Book, and changes the Engine Log Book instructions to specify that the last four digits of an orifice part number recorded in the Engine Log Book indicate the orifice nominal diameter.	Incorporated
37	30 September 1970	Updates the tube alinement requirements figure to add new tubes, joint locations, and allowable limits. It also updates various data in the figure to make it compatible with other manuals and specifications.	Incorporated

OICN Number	Dated	Description	OICN Status
38	8 July 1970	Adds a procedure for installing plastic bags on oxidizer and nitrogen purge overboard drain lines, to permit venting of drain lines when turbopump LOX seal purge is applied when rotating the stage to the horizontal position.	Incorporated
39	6 November 1970	Adds thermal insulation damage limits.	Incorporated
40	3 February 1971	Standardizes fuel loading requirements at MTF and KSC; deletes 1,000 psig LOX dome and gas generator LOX injector purge as a redline requirement; deletes turbopump LOX seal purge pressure requirement with fuel in engine; and deletes hydraulic pressure requirement with fuel or prefill in engine.	Incorporated
41	23 February 1971	Extends turbopump preservation life to five years, deletes requirement for using only KEL-F-90 on the throat plug shaft threads, adds new limits for flex hose braid damage due to impact, deletes reference to variable or fixed when referring to the gas generator upstream and downstream orifices, and adds closure RX20700 as an alternate to the thrust chamber throat security closure.	Incorporated
42	2 October 1970	Corrects the lubrication material specified for hypergol cartridge container inlet threads.	Incorporated
44	9 October 1970	Adds a method for supporting the pressurizing hose attached to the thrust chamber throat plug seal, and corrects paragraph references to engine environmental cover installation, thrust chamber throat security closure installation and removal, thrust chamber throat plug installation and removal, and turbine exhaust exit pressure test fixture installation and removal.	Incorporated
45	2 November 1970	Provides the option to blank off the ignition monitor valve sense tube during the ignition monitor valve diaphragm leak test for uninstalled and installed engines, specifies that no leakage is allowable at the ATMOS REF port during the ignition monitor valve diaphragm leak test for installed engines, changes MTF to MAF in note in exhaust system leak test for installed engines, and specifies that vent hoses be disconnected at the combustor end instead of the turbine end during the exhaust system leak test for installed engines.	Incorporated

OICN Number	Dated	Description	OICN Status
46	4 November 1970	Adds a 10 ±1 psig leak test of thrust chamber internal tubes between the throat plug and the thrust chamber exit.	Incorporated
47	16 August 1971	Adds a constraint which limits the period of time prefill fluid can be retained in the thrust chamber fuel jacket and replaces damage limits for the nozzle extension external reinforcing bands.	Incorporated
48	15 February 1971	Revises the detail instructions for making entries on the engine test record form in the Engine Log Book.	Incorporated
49	24 May 1971	Revises the test requirements and limits for the heat exchanger flowmeter transducer and the turbopump speed transducer.	Incorporated
50	20 July 1971	Updates applicable specifications to latest amendment number, revision letter, and revision date.	Incorporated
53	25 October 1971	Relaxes turbopump preservation requirements.	Incorporated
54	25 July 1971	Updates torque requirement for plugs in taps KF6d-2, KF7a-1, and IF2 and adds procedures for use of test plate T-5047892 during LOX dome and gas generator LOX injector flushing.	Incorporated
55	16 June 1971	Updates seal monitoring port plug requirements and changes exhaust system leak-test procedures to be compatible with requirements in section I.	Superseded by OICN No. 57
56	15 August 1972	Relaxes gas generator leak test requirements.	Incorporated
57	13 July 1971	Updates seal monitoring port plug requirements and changes exhaust system leak-test procedures to be compatible with requirements in section I.	Incorporated
58	4 August 1971	Permits use of an equivalent simulator when hypergol simulator T-5029716 is specified, adds the use of a hypergol simulator during fuel feed system leak test, and deletes a note and clarifies a plug removal requirement during the exhaust system leak test.	Incorporated
59	15 August 1972	Updates engine storage requirements and adds engine standby requirements to be compatible with existing field operating requirements.	Incorporated

OICN Number	Dated	Description	OICN Status
61	6 March 1972	Adds a requirement to perform a pneumatic leak test on the thrust chamber after LOX dome flushing; changes the DC control system power requirements; updates applicable specifications to include current amendment number, revision letter, and revision date pertaining to leak-test compound and MSFC standard specifications; and adds a requirement to actuate the hypergol manifold switch after performing ignition monitor valve diaphragm leak test.	Incorporated
63	29 November 1972	Adds an inspection to determine compatibility between date entered in Engine Log Book and date stamped on a metal strip for OLDEST ASSEMBLY/INSTALLATION DATE.	Incorporated
64	31 March 1972	Incorporates the requirement to use desiccant RB0295-001 (Rocketdyne) in engine closures instead of desiccant MIL-D-3464, Type II.	Incorporated
65	5 April 1972	Requires drainage of the ignition monitor valve sense line after thrust chamber fuel jacket trichloroethylene flush and changes the hydraulic pressure requirement when admitting fuel to the engine.	Incorporated
66	24 May 1972	Adds engine requirements after a lightning strike.	Incorporated
67	17 October 1972	This change extends turbopump preservation frequency requirement from every 5 years to every 10 years.	Incorporated
68	13 June 1972	Reduces pressure limit for low-pressure gases.	Incorporated

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CODE IDENT NO. 02602
DATE 3 January 1973
PAGE 1 OF 2

OPERATING INSTRUCTIONS CHANGE NOTICE

☐ PROPOSED
☒ APPROVED

NO. 69

1. ECP NO.	2. ENGINE OPERATING INSTRUCTIONS	3. PAGES AFFECTED
F1-938	NO. R-3896-11	As listed

4. EFFECTIVITY	5. CONTRACTUAL AUTHORITY*
Engines F-2029 through F-2098	Supplemental Agreement No. 150 to Contract NAS8-25156, dated 22 December 1972

6. CHANGE

This change updates storage preparation for uninstalled and installed engines to require that gas generator igniter port closures, actuator holding pin attach point closures, and oxidizer dome accelerometer hole screws be left installed during engine storage.

On page 1-71, paragraph 1.4.1, change step 1B as follows:

1B. Verify that gas generator igniter port closures, actuator holding pin attach point closures, and oxidizer dome accelerometer hole screws are installed; then install protective closures on oxidizer overboard drain and nitrogen purge overboard drain line exits, hypergol container, and electrical connectors. All other covers and closures except as noted in this step and in steps j and k are to be removed, including the gimbal bearing boot and the fuel overboard drain line exit.

On page 1-72A/1-72B, paragraph 1.4.2, step mA, change substep 1 as follows:

(1) Verify that gas generator igniter port closures, actuator holding pin attach point closures, and oxidizer dome accelerometer hole screws are installed; then install protective closures on oxidizer overboard drain, fuel overboard drain, and nitrogen purge overboard drain line exits, hypergol container, and igniter harness electrical connectors. All other covers and closures except as noted in this step and in step k are to be removed, including the gimbal bearing boot.

*This document shall be considered as a preliminary OICN until contractual coverage is received and noted in this block.

OPERATING INSTRUCTIONS
CHANGE NOTICE

ECP	ENGINE OPERATING INSTRUCTIONS	OICN
NO. F1-938	NO. R-3896-11	NO. 69

On page 1-72A/1-72B, paragraph 1.4.2, change step mB as follows:

mB. For engines stored in a vertical stage, verify that gas generator igniter port closures, actuator holding pin attach point closures, and oxidizer dome accelerometer hole access hole screws are installed; then install protective closures on oxidizer overboard drain line and nitrogen purge overboard drain line exits, hypergol container, and igniter harness electrical connectors. All other closures except as noted in this step and in step k are to be removed, including the gimbal bearing boot and fuel overboard drain line exit. Install suitable drainage line on fuel overboard drain line exit, and route line exit so that leakage flows externally from engine.

On page 2-10A, paragraph 2.2A.3, step m, change substep 2 as follows:

(2) Verify that drain bags are installed, or remove and replace fuel overboard drain system bags with drain hoses and route hoses so that leakage flows externally from engine.

CODE IDENT NO. 02602
DATE 12 March 1973

OPERATING INSTRUCTIONS CHANGE NOTICE

☐ PROPOSED
☒ APPROVED

NO. 52R1

1. ECP NO.	2. ENGINE OPERATING INSTRUCTIONS	3. PAGES AFFECTED
F1-927R1	NO. R-3896-11	As listed

4. EFFECTIVITY	5. CONTRACTUAL AUTHORITY*
Engines F-2029 through F-2098	Supplemental Agreement No. 160 to Contract NAS8-25156, dated 5 March 1973

6. CHANGE

This change: (1) adds a scheduled authorized field activity to verify that four-way solenoid valve replacement has been accomplished within the 12 months preceding launch; (2) updates detail requirements changing RP-1 fuel to propellant kerosene to be compatible with applicable specifications list as amended by supplemental agreement No. 55 to the contract; (3) adds acceptable shelf life for synthetic rubber soft goods and changes installed life of synthetic rubber soft goods from 32 quarters to 40 quarters; and (4) updates applicable specification to include current amendment number, revision letter, and revision date of propellant oxygen.

On page 1-2, figure 1-1, between Activity Number 6A and "ELECTRICAL TESTS", add activity number 6B, titled Four-way solenoid valve replacement verification, and in column T, add paragraph number 1.1.12C.

*This document shall be considered as a preliminary OICN until contractual coverage is received and noted in this block.

OPERATING INSTRUCTIONS
CHANGE NOTICE

ECP	ENGINE OPERATING INSTRUCTIONS	OICN
NO. F1-927R1	NO. R-3896-11	NO. 52R1

On page 1-24D, add paragraph 1.1.12C as follows:

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.12C	FOUR-WAY SOLENOID VALVE REPLACEMENT VERIFICATION	Verify that four-way solenoid valve is replaced per EFIR F1-62.	Within the 12 months preceding launch.	Replacement valve soft goods must have been replaced and the valve tested with hydraulic fluid MIL-H-5606.

On page 2-4, paragraph 2.1.5 and page 2-6, paragraph 2.1.6, step a, change RP-1 fuel (MIL-R-25576) to propellant kerosene (MIL-P-25576).

On page 2-20, replace the text of paragraph 2.4.7 with the following:

The maximum acceptable shelf life of uninstalled synthetic rubber soft goods is 12 quarters. An age control log for components that contain soft goods is provided in each Engine Log Book. If it becomes necessary to replace a component that contains synthetic rubber soft goods, the Engine Log Book age control log must be updated to reflect the replacement date. The replacement date is defined as the installation date of the synthetic rubber soft goods in the component plus 40 quarters.

On page 2-25, paragraph 2.5.6, step e, Material column, change Fuel (RJ-1 and RP-1) to Fuel (RJ-1 and propellant kerosene).

On page 2-55/2-56, paragraph 2.7.1, change information pertaining to the following specification as follows:

MIL-P-25508E Amendment 1 30 April 1971	Propellant, oxygen

CODE IDENT NO. 02602
DATE 3 May 1973
PAGE 1 OF 3

OPERATING INSTRUCTIONS CHANGE NOTICE

☐ PROPOSED
☒ APPROVED

NO. 70

1. ECP NO.	2. ENGINE OPERATING INSTRUCTIONS	3. PAGES AFFECTED
F1-939	NO. R-3896-11	As listed

4. EFFECTIVITY	5. CONTRACTUAL AUTHORITY*
Engines F-2029 through F-2098	Supplemental Agreement No. 168 to Contract NAS8-25156, dated 26 April 1973

6. CHANGE

This change adds a constraint that must be observed when thermal insulation panels are removed and reinstalled during prelaunch operations; and constraints that must be observed when specified plugs, igniters, and the hypergol cartridge are installed, since they cannot be leak tested after installation.

On pages 1-2, 1-4, 1-5, and 1-7 through 1-9, figure 1-1, replace existing single asterisk footnote with the following:

* Activity requires removal and installation of thermal insulation panels. (Refer to section II for panel location.) Two persons must inspect, and record by separate buyoff, final prelaunch installation of thermal insulation panels to verify that panels are correctly installed, torqued, and safetywired.

On page 1-70, paragraph 1.3.43, Special Constraints and Remarks column, add constraint as follows:

Before installing plug and K-seal in the LOX system port used to pressurize the thrust chamber, visually verify that K-seal, plug, and engine port sealing surfaces are free of foreign particles, nicks, scratches, and other imperfections that could impair sealing and that plug and engine port threads are free of damage. During installation, verify that K-seal is correctly installed on plug and centered in engine port countersink before torquing plug. Two persons must inspect, and record by separate buyoff, that plug and K-seal are correctly installed, torqued, and safetywired. Record plug actual torque value.

*This document shall be considered as a preliminary OICN until contractual coverage is received and noted in this block.

OPERATING INSTRUCTIONS
CHANGE NOTICE

ECP	ENGINE OPERATING INSTRUCTIONS	OICN
NO. F1-939	NO. R-3896-11	NO. 70

On page 1-78, paragraph 1.5.1, Special Constraints and Remarks column, opposite step x, add constraint as follows:

Before installing plug and K-seal in gas generator fuel purge ports GF2a and GF2b, visually verify that K-seal, plug, and engine port sealing surfaces are free of foreign particles, nicks, scratches and other imperfections that could impair sealing and that plug and engine port threads are free of damage. During installation, verify that K-seal is correctly installed on plug and centered in engine port countersink before torquing plug. Two persons must inspect, and record by separate buyoff, that plug and K-seal are correctly installed, torqued, and safetywired. Record plug actual torque value.

On page 1-78E/1-78F, paragraph 1.5.1B, Special Constraints and Remarks column, opposite step r, add constraint as follows:

Before installing plug and K-seal in gas generator fuel purge ports GF2a and GF2b, visually verify that K-seal, plug, and engine port sealing surfaces are free of foreign particles. nicks, scratches, and other imperfections that could impair sealing and that plug and engine port threads are free of damage. During installation, verify that K-seal is correctly installed on plug and centered in engine port countersink before torquing plug. Two persons must inspect, and record by separate buyoff, that plug and K-seal are correctly installed, torqued, and safetywired. Record plug actual torque value.

On page 1-84A/1-84B, paragraph 1.5.9, Special Constraints and Remarks column, between Caution and step r constraint, add constraint as follows:

Before installing plug and K-seal in gas generator combustor drain port, visually verify that K-seal, plug, and engine port sealing surfaces are free of foreign particles, nicks, scratches, and other imperfections that could impair sealing and that plug and engine port threads are free of damage. During installation, verify that K-seal is correctly installed on plug and centered in engine port countersink before torquing plug. Two persons must inspect, and record by separate buyoff, that plug and K-seal are correctly installed, torqued, and safetywired. Record plug actual torque value.

OPERATING INSTRUCTIONS
CHANGE NOTICE

ECP	ENGINE OPERATING INSTRUCTIONS	OICN
NO. F1-939	NO. R-3896-11	NO. 70

On page 1-103, paragraph 1.6.7, Special Constraints and Remarks column, opposite step d, change constraint as follows:

Before installing igniters, visually verify that seal, igniter, and engine port sealing surfaces are free of foreign particles, nicks, scratches, and other imperfections that could impair sealing and that igniter and engine port threads are free of damage. During installation, verify that lubrication is not used on igniter threads and that igniter seal is correctly installed on igniter and that seal seats in recessed groove of igniter port before torquing igniter. Two persons must inspect, and record by separate buyoff, that igniter and seal are correctly installed, torqued, and safety-wired. Record igniter actual torque value.

On page 1-104, paragraph 1.6.10, Special constraints and Remarks column, opposite step g, add constraint as follows:

Before installing hypergol cartridge, visually verify that hypergol container bore sealing surfaces are free of foreign particles, nicks, scratches, and other imperfections that could impair sealing and verify that hypergol cartridge and hypergol container threads are free of damage. Inspect hypergol cartridge exterior surfaces to verify that there are no burs or other imperfections that could damage hypergol container sealing surfaces during hypergol cartridge installation. Two persons must inspect, and record by separate buyoff, that hypergol cartridge is correctly installed.

CODE IDENT NO. 02602
DATE 11 July 1973
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OPERATING INSTRUCTIONS CHANGE NOTICE

☐ PROPOSED
☒ APPROVED

NO. 71

1. ECP NO. F1-940

2. ENGINE OPERATING INSTRUCTIONS NO. R-3896-11

3. PAGES AFFECTED As listed

4. EFFECTIVITY
Engines F-2029 through F-2098

5. CONTRACTUAL AUTHORITY*
Supplemental Agreement No. 176 to Contract NAS8-25156 dated 5 July 1973

6. CHANGE

This change replaces leak-test compound (MIL-L-25567) with leak-test compound (MSFC-SPEC-384).

On page 2-28A/2-28B, paragraph 2.5.11, step n, change (MIL-L-25567) to (MSFC-SPEC-384).

On page 2-55/2-56, paragraph 2.7.1, delete the following specification data:

MIL-L-25567C 9 June 1971	Leak Test Compound, Oxygen Systems

On page 2-55/2-56, paragraph 2.7.1, add the following specification data:

MSFC-SPEC-384A 20 December 1968	Leak-Test Compound, LOX Compatible

*This document shall be considered as a preliminary OICN until contractual coverage is received and noted in this block.