R-3896-3
VOLUME 1

TECHNICAL MANUAL

MAINTENANCE AND REPAIR

F-1 ROCKET ENGINE

(ROCKETDYNE)

CHANGE NOTICE

LATEST CHANGED PAGES SUPERSEDE THE SAME PAGES OF PREVIOUS DATE

Insert changed pages into basic publication. Destroy superseded pages.

PUBLISHED UNDER AUTHORITY OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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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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INTRODUCTION

This manual, consisting of Volumes I and II, is one of seven R-3896-series technical manuals prepared to provide official Rocketdyne field support documentation for the operation and maintenance of the F-1 Rocket Engine, Part Number 104001, Serial Numbers F-2029 through F-2098, and its related ground support equipment, designed and manufactured by Rocketdyne, a division of North American Rockwell Corporation, 6633 Canoga Avenue, Canoga Park, California 91304. The information in these manuals was prepared by Logistics Publications & Training Department of Rocketdyne.

The manuals are used to best advantage when each manual is current and complete (see figure 1) and the purpose and scope of each manual is known. The manuals in this series, and the nature of the data each provides, are found in the contents and support function chart.

1. F-1 MANUALS--THEIR SUPPORT FUNCTIONS.

The manuals' contents and support functions chart lists all F-1 series technical manuals, describes the support function each manual serves, and lists the section titles of each manual. The chart also explains how the technical data in each manual relates to the support of the engine and its ground support equipment throughout a normal engine flow, as well as during unscheduled maintenance tasks. Information appearing in one manual is not duplicated in another. Thus, information on the description, operation, and maintenance of ground support equipment is in R-3896-5. However, the instructions for servicing the engine using ground support equipment are in R-3896-3 and R-3896-11.

Manual	Contents and Support Function	Section and Title
R-3896-1 F-1 Rocket Engine Data	This manual contains a physical description of the various F-1 engine systems and the individual engine system components; a decription of the flow the engine follows from the time it is accepted by the Customer through Apollo/Saturn V launch; data pertaining to engine design characteristics including environmental conditions, attitude, mass properties data, turbopump inlet propellant conditions, and interface connections for mating the engine with the S-IC of the Saturn V vehicle; and nominal engine performance characteristics, methods for predicting engine variable characteristics, and other pertinent information that can be used as an aid for analyzing and/or determining specific engine performance. The manual serves to familiarize the reader with the design and operation of the F-1 engine and serves as a training aid document.	I Description and Operation II Interface Design Criteria III Performance

Manual	Contents and Support Function	Section and Title
R-3896-3, Volume I F-1 Rocket Engine Maintenance and Repair	This manual contains general maintenance practices that are peculiar to the engine covered in this volume and to the component repair procedures contained in Volume II of this manual; the use of engine, thrust chamber, and nozzle extension ground support equipment and the tasks necessary to prepare the equipment for maintenance using the applicable pieces of ground support equipment; detailed procedures for component removal, reinstallation, or replacement, and the post-installation test requirements that will verify the integrity of engine systems affected by the removal of individual engine components and lines. This volume and Volume II provide the necessary maintenance and repair data to perform unscheduled maintenance tasks on an uninstalled engine and the required post-maintenance tests to determine that the engine is in an operable condition.	See detailed table of contents for this manual.
R-3896-3, Volume II F-1 Rocket Engine Maintenance and Repair	This manual contains cleaning, inspecting, repairing, and testing procedures for the individual engine components. This manual provides the data to restore and/or maintain components of the engine in an operable condition for reinstallation on the engine or assignment as a spare.	I Quick-Disconnect II Gas Generator III Gas Generator Ball Valve IV Gas Generator Injector Purge and Pump Seal Purge Check Valve V Deleted VI Heat Exchanger VII Heat Exchanger Check Valve VIII Thrust Chamber (Installed) IX Thrust Chamber (Uninstalled) X Thrust OK Pressure Switch XI Inert Prefill Check Valve XII Oxidizer Dome Purge Check Valve XIII Oxidizer Valve XIV Fuel Valve XV Turbopump XVA Turbine XVI Bearing Coolant Control Valve XVII Deleted XVIII Electrical Harness XIX Hypergol Manifold XX Ignition Monitor Valve XXI Checkout Valve XXII Engine Control Valve

Manual	Contents and Support Function	Section and Title	
R-3896-3, Volume II (cont)		XXIII	Four-Way Solenoid Valve
		XXIV	Thrust Chamber Nozzle Extension
		XXV	Pressure Transducer
		XXVI	Temperature Transducer
		XXVII	Flight Instrumentation Junction Boxes
		XXVIII	Rigid Ducts, Flexible Lines, and Braided Flex Hoses
		XXIX	Redundant Shutdown Valve
		XXX	Volumetric Liquid Oxygen Transducer (Oxidizer Flowmeter)
		XXXI	Gimbal Boot, Insulation Boot, and Insulation Seal
R-3896-4 F-1 Rocket Engine Illustrated Parts Breakdown	This manual contains illustrative and columnar listings of all parts of the engine that can be disassembled, reassembled, repaired, replaced, or overhauled. This manual locates and identifies the interrelationship of parts, aids in the requisition of replacement parts, indicates part usage and interchangeability and recommended repair or replacement for the F-1 engine and its individual components and parts.	I	Introduction
		II	Group Assembly Parts List
		III	Numerical Index
R-3896-5, Volume I F-1 Rocket Engine Ground Support Equipment Maintenance and Operation	This manual contains safety requirements and general maintenance practices peculiar to the equipment covered in this volume and to equipment and T-tools covered in Volume II of this manual; inspection requirements, physical description, operation, intended usage, operating limitations, periodic maintenance, and parts listings with maintenance-level codes for the F-1 engine ground support equipment covered in this volume. This volume provides data to restore and/or maintain the F-1 rocket engine ground support equipment in an operable condition.	I	General Maintenance and Repair
		II	Hydraulic Pumping Unit G2025
		III	Hydraulic Pumping Unit G2026
		IV	Accumulator Unit G2027
		V	Engine Checkout Console G3142
		VI	Pneumatic Flow Monitors G3130 and G3131
		VII	Engine Vertical Installer G4049
		VIII	Engine Rotating Sling G4050
		IX	Flight Combustion Monitor 703227
		X	Components Test Console G3141 and Components Adapter Set G3143
		XI	Cryogenic Supply Unit G3146
		XII	Pneumatic Flow Testers G3104 and G3104MD1
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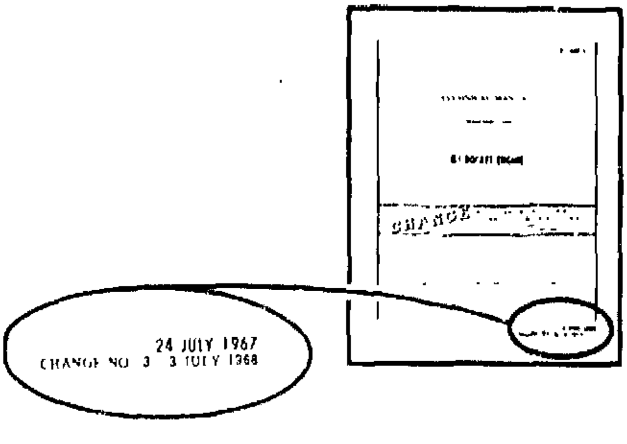
Manual	Contents and Support Function	Section and Title	
R-3896-5, Volume I (cont)		XIV	Impact Recorder Unit G4090 and 99-9014031
		XV	Components Welding Sets 9026560, 9026561, and 9026570
		XVI	Handling and Shipping Equipment
R-3896-5, Volume II F-1 Rocket Engine Ground Support Equipment Maintenance and Operation	This manual contains inspection requirements, physical description, operation, intended usage, operating limitations, periodic maintenance, and parts listing with maintenance-level codes for the F-1 engine ground support equipment end items that are considered tools (ie, test kits, sets, and tools) and T-tools. This volume provides data necessary to determine that those items of ground support equipment covered by this volume and the F-1 field T-tools are in an operable condition.	I	Test Kits, Sets, and Tools
		II	T-Tools
		III	Dummy Weight T-Tools
R-3896-6 F-1 Rocket Engine Thermal Insulation Installation and Repair	This manual contains a description of the thermal insulation panels, special tools and equipment, installation and removal procedures, access provisions, repair data, and applicable packaging, storage, and handling information. This manual provides information pertinent to the maintenance and repair of F-1 engine thermal insulation.	I	Description
		II	Special Tools and Equipment
		III	Installation and Removal (Engines F-2003 Through F-2016)
		IV	Installation and Removal (Engines F-2017 and Subsequent)
		V	Access Provisions
		VI	Repair
		VII	Storage and Handling

Manual	Contents and Support Function	Section and Title
R-3896-9 F-1 Rocket Engine Transportation	This manual contains procedures for preparing the F-1 rocket engine, nozzle extension, thermal insulation, and miscellaneous engine loose equipment for shipment, and procedures for shipping by truck, air, or water. Included are recommended truck-, air-, and water-transport check lists, which may be used to make sure that procedures and in-transit inspection have been performed.	I Preparation for Shipping II Shipping by Truck Transport III Shipping by Air Transport IV Shipping by Water Transport
R-3896-11 F-1 Rocket Engine Operating Instructions	This manual contains complete, authorized field operating requirements that affect F-1 flight engines F-2029 through F-2098 during normal operational flow from engine receipt at MAF through vehicle launch. Specific and general requirements and procedures for normal F-1 engine activities are provided and include acceptability criteria and limits, special constraints, safety precautions, and correct sequences required to satisfactorily accomplish the activities.	I Operating Requirements II General Requirements III Operating Procedures

USE YOUR MANUAL ONLY IF CURRENT AND COMPLETE

Manuals that are not current and complete are not authoritative documents and are not to be used. The following outlines the method for determining whether your manual is current and complete.

A. DETERMINING CURRENCY. To be sure that yours is the latest issue of the manual, refer to Configuration Identification & Status Report , which is revised monthly and lists the technical manual numbers, titles, unincorporated supplements, and latest change or revision dates. Your manual must have a title page with the same or later date than the date shown in the Configuration Identification & Status Report. Your manual must also include the unincorporated supplements listed in the Configuration Identification & Status Report, or if your manual is later than shown in the report, the unincorporated supplements listed in the Manual Data Supplement Record in your manual. If your title page incorporates two dates as illustrated below, compare the change (lower) date. If your manual is not current, obtain a current copy through your technical manual supply system.

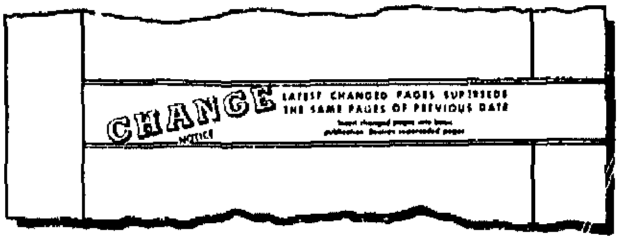


B. DETERMINING COMPLETENESS. To be sure that your manual is complete, make a page-by-page comparison of its pages to those listed in the List of Effective Pages. The List of Effective Pages, which shows the change status since the basic issue or last revision, is found on the alphabetically lettered page(s) immediately following the title page. All pages, except supplements, are listed with their issue dates. Manual pages that are dated must have the same date as that appearing in the List of Effective Pages for that page. Unchanged pages are listed as "original" and are not dated.

HOW TO KEEP YOUR MANUAL UP-TO-DATE

As design changes are made to the rocket engine and ground support equipment and better methods of maintenance are discovered, your manual is periodically changed, revised, or supplemented. The following steps will help you keep your manual up-to-date:

A. CHANGES. Updating by adding to or partially replacing existing pages is defined as a change. Changes can be identified by the change notice on the new title page.



To collate a change, refer to the Filing Instructions sheet issued with the manual and proceed as follows:

1. Remove the pages listed in the "Remove" column of the Filing Instructions sheet from the manual and destroy them. Do not concern yourself with the data on the opposite side of the deleted page since, if this date is not deleted, it is replaced in the change package.

2. Insert all pages listed in the "Insert" column of the Filing Instructions sheet in sequence. Pages with a suffix letter are inserted in alphabetical order following the page with the same basic number; for example, pages 3-14A, 3-14B, etc, follow page 3-14.

GEN-NASA-1A

Figure 1. How to Maintain Your Manual (Sheet 1 of 2)

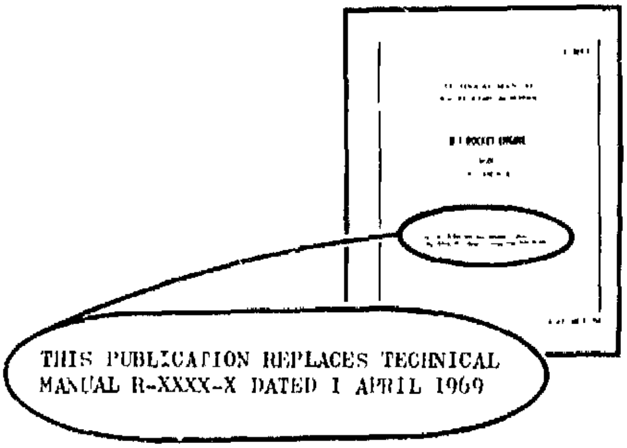
3. If you are unsure of the status of any page or pages, refer to the List of Effective Pages and make sure your manual contains pages (with the corresponding change dates) listed in the List of Effective Pages.

4. Remove manual supplements that have been incorporated.

NOTE

Incorporated supplements can be determined by reviewing the newly issued Manual Data Supplement Record.

B. REVISIONS. Updating by replacing all the existing pages of a manual is defined as a revision. Revisions can be identified by the replacement notice on the new title page.



To collate a revision, proceed as follows:

1. Remove and destroy all existing pages of your manual except Manual Data Supplements that have not been incorporated.

NOTE

Unincorporated supplements can be identified by reviewing the Manual Data Supplement Record supplied in the revision.

2. Insert the new pages in your cover.

C. SUPPLEMENTS. Updating that authorizes the addition to, or alteration of, the existing data in your manual is defined as a Manual Data Supplement. Information on how to insert supplements is found in the supplements.

HOW TO KEEP ABREAST OF THE LATEST CHANGES TO TECHNICAL DATA

Changes and/or additions to technical data are identified by a vertical bar (change bar) in the margin of the page adjacent to the changed data. A direct comparison between the new (identified by the change bar) and the old data will help you in identifying specific changes made.

GEN-NASA-2

Figure 1. How to Maintain Your Manual (Sheet 2 of 2)

2. 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 identification plate.

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) that are 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 2 illustrates how MD changes incorporated in the equipment are represented by the MD identification symbol.

MD identification plates RD171-1052-0001 through -0006 have pre-printed 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 2 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. When an MD reference appears in this manual, examine the MD identification symbol on the equipment to determine which set of information is applicable.

3. CONFIGURATION CHANGES--MANUAL EFFECTIVITY.

All approved ECPs (Engineering Change Proposals) and associated MD numbers applicable to the equipment covered in this manual are listed in figure 3. The date in the last column is the publication date of the manual during which the change made by the ECP was incorporated. When N/A is entered, the ECP does not change the data in the manual.

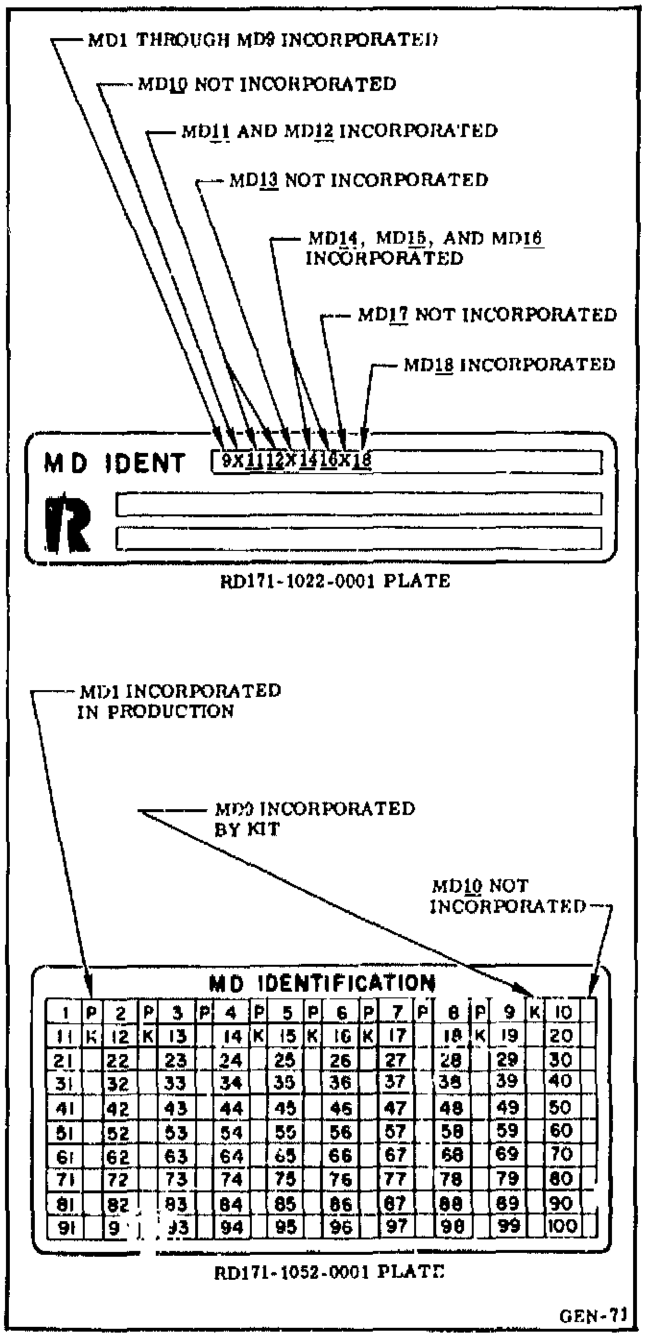


Figure 2. MD System

Engine configuration information is in R-5857, Saturn F-1 Configuration Identification & Status Report. Engine serial numbers within this manual are in accordance with Rocketdyne F-1 engine designation. For F-1 engine serial number allocation, refer to the cross-reference index in R-5857.

Approved ECP Number	MD Number	Incorporated In Manual Dated
F1-38	37	4 June 1965
F1-38R1	--	N/A
F1-39	11	16 June 1964
F1-40	--	N/A (superseded by F1-254)
F1-42	7	16 June 1964
F1-45	7	16 June 1964
F1-56	7	16 June 1964
F1-57	7	16 June 1964
F1-59	7	16 June 1964
F1-60	16	N/A
F1-62	7	16 June 1964
F1-64	7	N/A
F1-65	7	16 June 1964
F1-67	10	16 June 1964
F1-69	7	16 June 1964
F1-71	9	16 June 1964
F1-74	7	16 June 1964
F1-76	24	15 January 1965
F1-76R1	--	N/A
F1-78	--	16 June 1964
F1-80	7	16 June 1964
F1-82	18	16 June 1964
F1-85	7	16 June 1964
F1-86	7	16 June 1964
F1-90	7	16 June 1964
F1-91	7	N/A
F1-95	7	16 June 1964
F1-97	7	16 June 1964
F1-98	20	N/A (superseded by F1-197)
F1-99	14	16 June 1964
F1-100	7	16 June 1964
F1-101	8	16 June 1964
F1-106	7	16 June 1964
F1-108	7	16 June 1964
F1-124	7	16 June 1964
F1-129	8	N/A
F1-129R1	--	N/A
F1-131	7	16 June 1964
F1-132	7	16 June 1964
F1-135	7	16 June 1964

Approved ECP Number	MD Number	Incorporated In Manual Dated
F1-143	11	15 January 1965
F1-143R1	--	N/A
F1-146	1	15 January 1965
F1-147	7	16 June 1964
F1-149	11	15 January 1965
F1-153	7	11 March 1965
F1-154	7	16 June 1964
F1-165	12	16 June 1964
F1-165R1	--	N/A
F1-166	13	16 June 1964
F1-168	8	16 June 1964
F1-169	7	16 June 1964
F1-172	7	16 June 1964
F1-174	21	4 June 1965
F1-174R1	--	N/A
F1-176	22	N/A
F1-180	34	15 January 1965
F1-182	7	N/A
F1-185	32	4 June 1965
F1-185R1	--	N/A
F1-188	7	15 January 1965
F1-188R1	--	N/A
F1-189	7	15 January 1965
F1-191	7	15 January 1965
F1-192	46	N/A
F1-192R1	--	N/A
F1-192R2	--	N/A
F1-193	7	15 January 1965
F1-193R1	--	N/A
F1-194	7	15 January 1965
F1-195	7	15 January 1965
F1-196	29	N/A
F1-197	20	4 June 1965
F1-198	26	N/A
F1-198R1	--	N/A
F1-202	7	15 January 1965
F1-206	22, 62	4 June 1965
F1-206R1	--	N/A
F1-206R2	--	N/A
F1-208	33	15 January 1965
F1-214	31	N/A

Figure 3. Configuration Changes--Manual Effectivity (Sheet 1 of 5)

Approved ECP Number	MD Number	Incorporated In Manual Dated
F1-214R1	--	N/A
F1-215	116	8 August 1966
F1-215R1	--	N/A
F1-215R2	--	N/A
F1-216	31	N/A
F1-216R1	--	N/A
F1-217	7	11 March 1965
F1-226	35	N/A
F1-228	36	15 January 1965
F1-229	8	15 January 1965
F1-229R1	--	N/A
F1-233	38	17 February 1966
F1-235	31	N/A
F1-236	7	15 January 1965
F1-241	7	15 January 1965
F1-242	39	15 January 1965
F1-244	7	15 January 1965
F1-251	7	15 January 1965
F1-253	43	N/A
F1-254	7	15 January 1965
F1-255	42, 45	15 January 1965
F1-258	22	15 January 1965
F1-258R1	--	N/A
F1-258R2	--	N/A
F1-260	54	N/A
F1-260R1	--	N/A
F1-260R2	155	N/A
F1-261	22	N/A
F1-262	50	15 January 1965
F1-263	51	N/A
F1-267	49	15 January 1965
F1-268	59	N/A
F1-268R1	--	N/A
F1-269	55	15 January 1965
F1-270	47	N/A
F1-270R1	--	N/A
F1-270R2	--	N/A
F1-274	53	N/A
F1-276	22	N/A
F1-277	61	N/A
F1-278	64	N/A
F1-279	21	23 November 1965
F1-279R1	--	N/A
F1-282	31	N/A
F1-283	65	N/A
F1-283R1	--	N/A
F1-283R2	--	N/A
F1-285	68	23 November 1965
F1-285R1	--	N/A
F1-287	31	N/A
F1-288	31	N/A
F1-289	63	N/A
F1-289R1	--	N/A
F1-289R2	--	N/A
F1-294	57	4 June 1965
F1-294R1	--	N/A
F1-294R2	--	N/A
F1-303	54	23 November 1965
F1-303R1	--	N/A
F1-304	67	23 November 1965
F1-304R1	--	N/A
F1-305	73	23 November 1965
F1-305R1	--	N/A
F1-306	66	N/A
F1-306R1	--	N/A
F1-306R2	--	N/A
F1-307	74	N/A
F1-307R1	--	N/A
F1-308	31	17 February 1966
F1-309	77, 80, 95	26 May 1966
F1-310	78, 80, 95	N/A
F1-311	31, 108	10 November 1966
F1-311R1	--	N/A
F1-312	96, 97	10 November 1966
F1-312R1	--	N/A
F1-312R2	--	N/A
F1-312R3	--	N/A
F1-312R4	179	N/A
F1-313	69	N/A
F1-313R1	--	N/A
F1-314	31	17 February 1966
F1-315	70, 83	23 November 1965
F1-315R1	--	N/A
F1-315R2	--	N/A
F1-316	31	N/A
F1-317	71	23 November 1965
F1-319	31	N/A
F1-320	75	N/A
F1-320R1	--	N/A
F1-321	31	23 November 1965
F1-323	84, 85, 86	17 February 1966
F1-323R1	--	N/A
F1-323R2	--	N/A
F1-323R3	--	N/A
F1-324	72	23 November 1965
F1-324R1	--	N/A
F1-326	79, 80, 95	N/A
F1-328	76	23 November 1965
F1-328R1	--	N/A
F1-331	31	N/A
F1-332	31	17 February 1966
F1-333	54	23 November 1965
F1-335	31	6 November 1967
F1-342	30	N/A
F1-343	90, 91	N/A

Figure 3. Configuration Changes--Manual Effectivity (Sheet 2 of 5)

Approved ECP Number	MD Number	Incorporated In Manual Dated
F1-347	31	17 February 1966
F1-352	31	N/A
F1-352R1	--	N/A
F1-353	82	N/A
F1-356	88, 93	17 February 1966
F1-357	89	N/A
F1-358	31	N/A
F1-360	99	N/A
F1-361	92	7 March 1968
F1-362	54	N/A
F1-369	94	23 November 1965
F1-370	106	N/A
F1-370R1	--	N/A
F1-370R2	--	N/A
F1-370R3	--	N/A
F1-370R4	--	N/A
F1-371	31	N/A
F1-372	100	N/A
F1-372R1	--	N/A
F1-372R2	--	N/A
F1-378	58	N/A
F1-378R1	--	N/A
F1-378R2	--	N/A
F1-378R3	--	N/A
F1-379	101	17 February 1966
F1-379R1	--	N/A
F1-379R2	--	N/A
F1-380	99	N/A
F1-381	31	N/A
F1-391	102, 103	N/A
F1-391R1	103, 166	N/A
F1-392	137	17 March 1967
F1-393R1	--	N/A
F1-392R2	--	N/A
F1-405	128	N/A
F1-405R1	--	N/A
F1-405R2	--	N/A
F1-406	--	N/A
F1-407	109	N/A
F1-407R1	--	N/A
F1-408	104	N/A
F1-408R1	--	N/A
F1-409	105	26 May 1966
F1-410	128	N/A
F1-410R1	--	N/A
F1-415	107	N/A
F1-416	120	N/A
F1-416R1	--	N/A
F1-417	--	N/A
F1-418	--	N/A
F1-418R1	--	N/A
F1-419	--	N/A
F1-419R1	--	N/A

Approved ECP Number	MD Number	Incorporated In Manual Dated
F1-420	--	N/A
F1-420R1	--	N/A
F1-421	--	N/A
F1-421R1	--	N/A
F1-421R2	--	N/A
F1-422	113, 114	26 May 1966
F1-422R1	--	N/A
F1-423	119	7 March 1968
F1-423R1	--	N/A
F1-424	110	26 May 1966
F1-424R1	--	N/A
F1-426	117	N/A
F1-426R1	--	N/A
F1-427	111	N/A
F1-427R1	--	N/A
F1-427R2	--	N/A
F1-428	87	17 March 1967
F1-428R1	--	N/A
F1-430	112	N/A
F1-431	137	N/A
F1-431R1	--	N/A
F1-431R2	--	N/A
F1-432	125	17 March 1967
F1-432R1	--	N/A
F1-432R2	--	N/A
F1-434	121	N/A
F1-434R1	--	N/A
F1-436	123	N/A
F1-437	115	10 November 1966
F1-437R1	--	N/A
F1-437R2	--	N/A
F1-437R3	--	N/A
F1-438	131	N/A
F1-439	146	N/A
F1-439R1	--	N/A
F1-441	140	N/A
F1-441R1	--	N/A
F1-441R2	--	N/A
F1-441R3	--	N/A
F1-443	129	10 November 1966
F1-444	139	26 July 1967
F1-444R1	--	N/A
F1-444R2	--	N/A
F1-445	129	N/A
F1-445R1	--	N/A
F1-447	138	N/A
F1-447R1	--	N/A
F1-447R2	--	N/A
F1-448	149	N/A
F1-448R1	--	N/A
F1-448R2	--	N/A
F1-449	127	10 November 1966
F1-449R1	--	N/A
F1-452	126	10 November 1966
F1-452R1	--	N/A

Figure 3 Configuration Changes--Manual Effectivity (Sheet 3 of 5)

Approved ECP Number	MD Number	Incorporated In Manual Dated
F1-453	123	17 March 1967
F1-454	118	N/A
F1-454R1	--	N/A
F1-454R2	--	N/A
F1-456	124	N/A
F1-456R1	--	N/A
F1-457	136	17 March 1967
F1-459	130	N/A
F1-464	--	N/A
F1-467	--	N/A
F1-467R1	--	N/A
F1-468	128	N/A
F1-470	140	28 June 1968
F1-470R1	--	N/A
F1-470R2	--	N/A
F1-475	--	17 March 1967
F1-475R1	--	N/A
F1-475R2	--	N/A
F1-476	135	17 March 1967
F1-476R1	--	N/A
F1-478	137	10 November 1966
F1-478R1	--	N/A
F1-478R2	--	N/A
F1-480	132	17 March 1967
F1-480R1	--	N/A
F1-482	133,134,142	17 March 1967
F1-482R1	--	N/A
F1-495	144	26 July 1967
F1-495R1	--	N/A
F1-498	145	3 November 1968
F1-498R1	--	N/A
F1-498R2	--	N/A
F1-499	137	N/A
F1-499R1	--	N/A
F1-500	150, 151	28 June 1968
F1-500R1	--	N/A
F1-502	148	N/A
F1-504	141	N/A
F1-504R1	--	N/A
F1-505	161	N/A
F1-505R1	--	N/A
F1-505R2	--	N/A
F1-506	159	6 November 1967
F1-507	--	N/A
F1-509	143	N/A
F1-510	152	26 July 1967
F1-510R1	--	N/A
F1-511	146	28 June 1968
F1-511R1	--	N/A
F1-512	177	28 June 1968
F1-512R1	--	N/A
F1-515	147	N/A
F1-515R1	--	N/A
F1-521	154	N/A
F1-521R1	--	N/A
F1-521R2	--	N/A
F1-521R3	--	N/A
F1-521R4	183	N/A
F1-522	--	N/A
F1-523	--	N/A
F1-524	153	N/A
F1-525	157, 158	6 June 1968
F1-525R1	--	N/A
F1-526	156	N/A
F1-526R1	--	N/A
F1-530	162, 163	28 June 1968
F1-530R1	--	N/A
F1-530R2	--	N/A
F1-530R3	--	N/A
F1-535	--	N/A
F1-543	165	N/A
F1-543R1	--	N/A
F1-545	154	N/A
F1-546	--	N/A
F1-547	169	N/A
F1-548	160	N/A
F1-548R1	--	N/A
F1-552	170	N/A
F1-552R1	--	N/A
F1-552R2	--	N/A
F1-568	--	N/A
F1-570	--	N/A
F1-574	--	N/A
F1-578	--	11 April 1969
F1-578R1	--	N/A
F1-579	--	N/A
F1-580	--	N/A
F1-581	167, 168	7 March 1968
F1-581R1	--	N/A
F1-581R2	--	N/A
F1-581R3	--	N/A
F1-581R4	--	N/A
F1-586	--	N/A
F1-587	--	N/A
F1-590	176	11 April 1969
F1-590R1	--	N/A
F1-590R2	--	N/A
F1-590R3	--	N/A
F1-590R4	--	N/A
F1-591	172	N/A
F1-592	173	3 November 1968
F1-592R1	--	N/A
F1-594	--	N/A
F1-594R1	--	N/A
F1-596	174	N/A
F1-596R1	--	N/A
F1-597	175	N/A
F1-601	--	N/A
F1-602	178	N/A
F1-604	180	N/A

Figure 3. Configuration Changes--Manual Effectivity (Sheet 4 of 5)

Approved ECP Number	MD Number	Incorporated In Manual Dated
F1-607	181	N/A
F1-607R1	--	N/A
F1-607R2	--	N/A
F1-607R3	--	N/A
F1-612	184,185	N/A
F1-612R1	--	N/A
F1-612R2	--	N/A
F1-613	186,187	N/A
F1-617	--	N/A
F1-618	188,189,190	N/A
F1-618R1	--	N/A

Figure 3. Configuration Changes--Manual Effectivity (Sheet 5 of 5)

SECTION I

GENERAL MAINTENANCE AND REPAIR

1-1. SCOPE. This section contains general maintenance and repair information to support sections III and IV of this volume and component repair procedures in R-3896-3, Volume II. All parts required for maintenance-level support of the F-1 rocket engine are listed in R-3896-4. Engine configuration and component identification and location are shown in figures 1-1 and 1-2.

1-2. SAFETY PRECAUTIONS.

NOTE

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.

1-3. The following safety precautions have been prepared for personnel accomplishing maintenance and repair tasks. These safety precautions list specific precautions to take when the task involves working with potentially dangerous materials or under hazardous conditions. Warnings and cautions are used in the text to indicate potentially dangerous steps; these warnings and cautions must be strictly observed. The following examples explain warnings and cautions:

WARNING

The warning note indicates a procedure or practice that, if not followed correctly, can cause injury or death.

CAUTION

The caution note indicates a procedure or practice that, if not followed correctly, can cause damage to equipment.

1-4. ELECTRICAL SYSTEM. The following precautions must be taken by personnel working with an electrical system:

WARNING

Connecting or disconnecting electrical connectors without turning off electrical power can result in injury to personnel and damage to equipment.

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

b. Before connecting a power source to electrical equipment check that circuit breaker for facility electrical outlet and all switches on electrical equipment are in off or deenergized position.

c. Do not leave electrical controls unattended when an electrical system is energized.

d. Ground engine and each console with separate ground cables to a common ground point.

1-5. PRESSURIZED SYSTEMS. The following precautions must be taken to provide safety for personnel working with high-pressure pneumatic or hydraulic systems:

a. Make sure connections on all systems and components have full thread engagement.

b. Follow specified recommendations for gasket sealants and lubricants.

WARNING

Removing fittings, parts, or components from a pressurized system can result in injury to personnel and damage to equipment.

c. Never tighten or loosen any fitting in a system that is pressurized.

d. Do not leave controls unattended when pressure is applied to system.

e. Make sure test equipment hoses or lines are depressurized before disconnecting.

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

g. Wear safety glasses or face shield when working on a pressurized system.

h. Protect all openings against entry of foreign material when any part is removed.

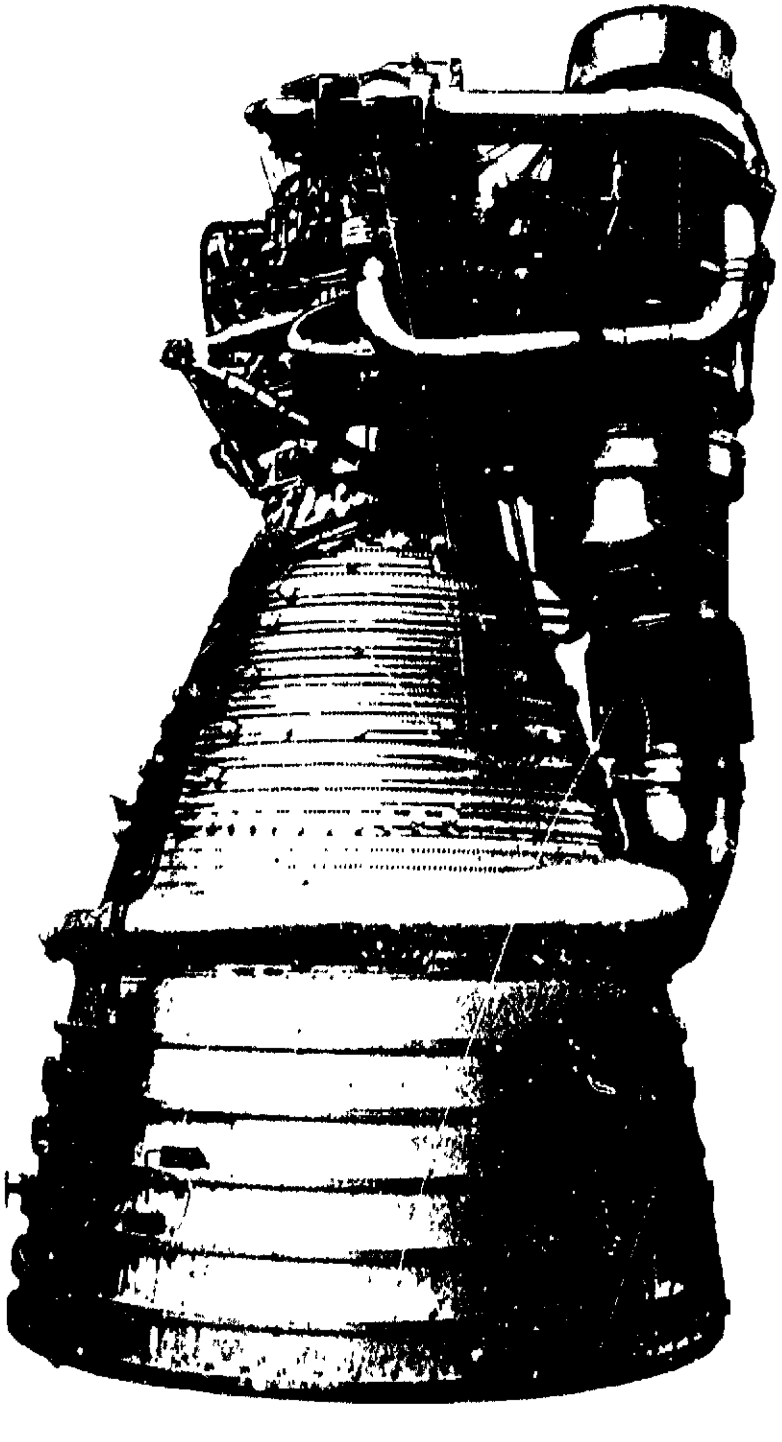


Figure 1-1. F-1 Rocket Engine (Typical Flight Configuration)

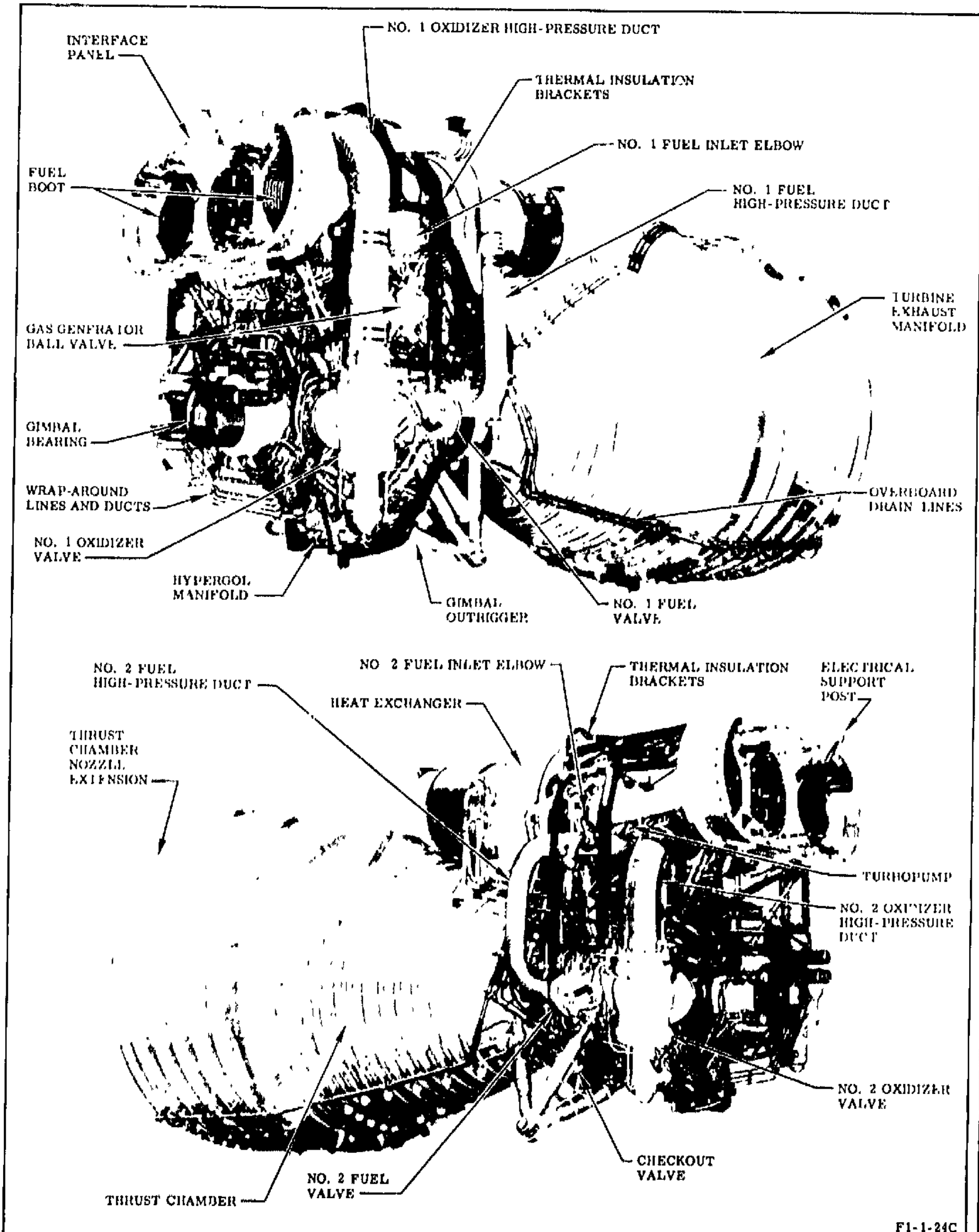


Figure 1-2. Engine Component Identification and Location

i. In the event oxidizer propellant feed system is depressurized when fuel propellant feed system is pressurized, make certain nitrogen purge overboard drain is open.

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

1-6. THRUST CHAMBER ENTRY. The following precautions must be taken to provide safety for personnel entering thrust chambers:

a. Obtain permission to enter thrust chamber, and secure a thrust chamber entry permit.

b. Make sure that main propellant and prevalves are closed and ducting between is vented.

c. Tag power and control switches with a red tag if their operation could create a hazard to person in thrust chamber.

cA. 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

d. In cases where an immediate post-test inspection is required, use an oxygen analyzer to check for an oxygen atmosphere. Entry is not permitted if oxygen content is less than 19.5 percent or exceeds 24.5 percent.

e. Have breathing equipment available on a standby basis.

f. Comply with local industrial hygiene and safety regulations.

g. Post a standby outside thrust chamber to monitor well-being of person in thrust chamber.

1-7. CLEANING SOLVENTS. The hazard associated with a solvent is specified in the requirement or procedure by a warning, 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 skin, leaving it susceptible to infection.

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

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

(5) Do not expose trichloroethylene to excessive temperatures.

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

(1) Avoid excessive inhalation of vapors of cleaning compound since 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 chemically dries skin, leaving it susceptible to infection.

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

(4) Wear 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 least amount of isopropyl alcohol consistent with performing 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.

(3) Solvent must be kept from all possible contact with liquid oxygen.

1-8. ACIDS. Nitric acid (Federal Specification O-N-350) is a hazardous material. In addition, Iridite 14-2 powder (Allied Research Products) and alodine 1200 powder (Amchem Products) become acid in solution, and the precautions applying to acids must be observed. Acids in either concentrated or diluted liquid form will soak through clothes causing severe burns, dissolve metals, give off harmful vapors, generate explosions, and cause fires upon contact with combustible material. The following safety precautions must be taken by personnel handling acids:

a. Wear rubber or plastic gloves, apron, boots, and chemical-type safety goggles.

b. Avoid inhalation of vapors from liquids and dust from acid powder mixes.

c. Open acid containers, and use acid in well-ventilated areas. Avoid spilling and splashing.

d. Do not pour water into acid; slowly add acid to water, and constantly stir mixture with an acid-resistant implement.

e. Cloths, sponges, and brushes used to apply acid solutions must be thoroughly rinsed in tap water. If allowed to dry out without rinsing, they constitute a fire hazard.

f. If acid contacts skin, drench affected area in clean water for a minimum of 5 minutes.

g. Do not store acid near heat, caustics, water, or combustible materials.

1-9. LIQUID NITROGEN. This material is characterized by its extremely low temperature and high vapor pressure. The following precautions must be taken by personnel handling liquid nitrogen:

a. Use only approved container and storage vessels.

b. Wear safety goggles or face shield and loose, well-insulated gloves or mittens.

c. Avoid splashing on exposed skin to prevent painful "burns."

d. Use in well-ventilated area to prevent oxygen depletion.

e. Avoid direct contact with liquid nitrogen or surfaces chilled by liquid nitrogen.

1-10. INCOMPATIBLE MATERIALS. Some materials, such as preservative compounds, lubricating oil, cleaning solvents, fuel, hydraulic fluid, and grease, used for maintenance purposes are incompatible with the oxidizer, liquid oxygen. When introduced into an oxidizer system, liquid oxygen mixes with the incompatible materials that have not been removed by cleaning, flushing, and purging and becomes impact-sensitive and explosive. The detection of all incompatible materials in an engine or test equipment is difficult. Protection of an engine and equipment by the methods outlined in the applicable maintenance procedures makes unnecessary the extensive disassembly required for the detection and removal of incompatible materials.

1-11. SEALS AND GASKETS. Seals and gaskets must be compatible with, and serviceable in, the system in which they are used. Many fluids are extremely corrosive and volatile, and others decompose violently when exposed to certain substances. Personnel must take all safety precautions and avoid bringing materials into contact with each other unless they are known to be compatible. Some types of seal and gasket material, such as Teflon and Kel-F, are used with the oxidizer system because of their flexibility at low temperatures. However, these materials form a toxic fluorocarbon gas when burned or overheated.

1-12. ENVIRONMENTAL REQUIREMENTS.

1-13. Component repair procedures contained in R-3896-3, Volume II, must be performed in a controlled area to prevent contamination of engine components and systems. Controlled-area requirements are satisfied when the following conditions exist:

a. Special housekeeping procedures are issued by local area supervision.

b. All personnel authorized to enter the area are properly indoctrinated in controlled-area procedures.

c. Smoking and/or eating is not permitted.

d. Nylon or polyethylene gloves are worn when handling parts or components where hand contact is made with sealing surfaces or surfaces that contact operating fluid (liquid or gas).

e. Components and assemblies are appropriately covered with polyethylene sheeting at all times when work is not being performed.

NOTE

The establishment of temperature, humidity, and airborne contaminant limits is not required.

1-14. CONTAMINATION AND DAMAGE PREVENTION.

1-15. All maintenance and repair procedures must be performed in such a manner as to prevent contamination of engine components and systems. Materials used must be compatible with the applicable engine system. Figure 1-4 lists recommended materials for cleaning, corrosion prevention, testing, repairing, and lubricating components. The following requirements must be used where applicable to a specific maintenance task:

a. Clothing worn by personnel is free of loose particles and fibers and pockets emptied of foreign objects that could contribute to contamination when working with internal areas of systems or in controlled areas.

b. Parts, tools, materials, and test equipment actually used in a maintenance task must be accounted for to make sure that none of these items has been left inside a system or component.

c. All test equipment and tools must meet the cleanness requirements for use in liquid oxygen, fuel, and pneumatic systems if equipment will be exposed to sealing or fluid contacting surfaces.

d. Tools are properly tethered to the carrying individual or carried in a suitably tethered bag when work is being performed above the engine to prevent tools from falling and damaging the engine or injuring personnel.

e. Proper measures are taken to prevent contamination if an engine or facility system is to be opened in an outdoor location during rain or high winds.

f. Areas are checked above, around, and below the system being opened for operations that may cause or allow contamination of the system. Proper measures are taken to prevent contamination of other systems from the system being opened.

g. A suitable container is provided to catch residual fluids when a system is opened to prevent fluid from contaminating adjacent areas.

h. Aluminum foil is never used in lieu of closures and/or covers on engine openings or on removed components or assemblies.

i. Only pressure-sensitive tape RB0195-002 (Rocketdyne), or equivalent, is used in direct contact with engine assembly. Tape is not used on threads, mating faces, or direct fluid surfaces. Tape alone is not used as a closure and/or cover on engine openings or on removed components or assemblies.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

j. Prior to opening any engine system, 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 is used to blow area free of loose contaminants; then, a clean, lint-free cloth moistened with trichloroethylene (MIL-T-27602) is used to wipe area free of visible contaminants.

CAUTION

Closures with sponge rubber seals must not be used, since contamination of component or system can result.

k. Components and assemblies removed from the engine and engine connections are immediately provided with suitable closures and/or covers. (Refer to R-3896-4.) If closures or covers are not available, flange areas may be protected as shown in figure 1-3 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 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). Film must be wrapped over the periphery of the flange and secured to the body of the 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. 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.

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 minimum thickness.

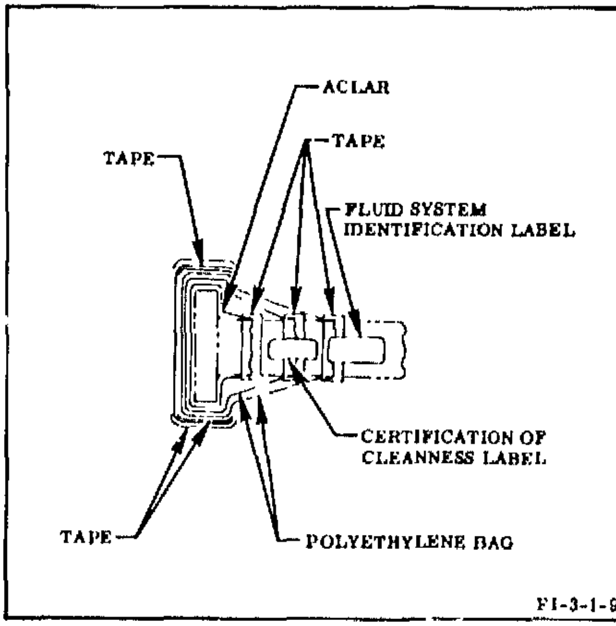


Figure 1-3. Protective Closure for Engine Lines

(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.

1. Protective closures and/or covers are secured with the required number of attaching parts. If fewer than the required number of attaching parts are used, the closure or cover will not provide adequate protection.

1A. 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 minimum thickness.

m. The following standard plugs and caps of appropriate size are used to protect engine and component openings:

(1) Plug AN806-JX- in tube coupling nuts.

(2) Plug AN814-XXJ- and O-ring MS28775 in threaded ports.

(3) Cap AN929-XXJ- on threaded male fittings.

n. Components or assemblies requiring rework or reinspection are transported to a controlled area before removing protective closures and/or coverings.

o. Rework of components or assemblies that generates chips, dust, or other contaminants is prohibited unless proper preventative measures have been taken to eliminate possible contamination.

CAUTION

All protective closures and coverings must be removed before engine components or assemblies are installed or connected, to prevent damage to equipment.

p. Protective closures and coverings are not removed from the components, assemblies, or engine until just before installation.

q. Protective closures are not used as storage trays for removed hardware or hardware to be installed.

r. The integrity of all gaskets, O-rings, packings, and seals is verified before installation.

s. The proper lubricant is used on fittings, gaskets, O-rings, packings, and seals when required by the applicable procedures and only in the amount required.

t. Leak-test compound is not applied to vent, bleed, or pilot openings; braided portions of flex hoses; or convolutions in bellows assemblies.

u. All cavities in parts are checked for lockwire clippings or any foreign material before installing protective closures or installing removed assemblies.

v. Clean nylon or polyethylene gloves are worn when handling parts or components where hand contact is made with sealing surfaces or surfaces that contact operating fluid (liquid or gas).

1-16. DAMAGE PREVENTION. All maintenance and repair procedures must be performed in such a manner as to prevent damage to the engine and components. Damage to engine and components will be greatly reduced by observing the following precautions:

CAUTION

Closures with sponge rubber seals must not be used, since contamination of component or system can result.

a. Install covers and closures as outlined in R-3896-9 and section II of this manual to protect engine components in work area.

b. Do not use lines, ducts, or tubing for handholds or steps.

c. Do not apply unnecessary loads to harnesses, lines, or components.

d. Protect components adjacent to work area from spillage and dropped hardware.

e. Observe all warnings, cautions, and notes in repair and handling procedures.

f. Before use, inspect ground support and handling equipment for condition and evidence of proof loading.

g. Use procedures outlined in R-3896-9 and section II of this manual to remove, install, raise, lower, or transport engine or thrust chamber nozzle extension.

h. Do not exceed handling equipment towing speed, turning radius, ramp angle, or load limits when moving engine.

i. Use proper tools and equipment correctly.

j. Protect sealing surfaces, parting surfaces, and adjacent hardware from damage during removal and installation of large component.

k. Use tools that are free of sharp edges, burs, or other conditions which damage tubes or fittings.

l. Avoid using adjustable wrenches.

1-17. ENGINE CLOSURES AND COVERS.

1-18. Engine closures and covers provide a seal against contaminants and/or physically protect ports, threads, electrical connectors, and sealing surfaces. All parts of the engine that require protective closures or covers must be protected at all times unless closures and covers are removed for the performance of an authorized activity. Refer to R-3896-11 for closure usage and desiccant installation. Refer to R-3896-9 for closure installation and removal. Engine and component closure and cover part numbers are specified in R-3896-4. General closure and cover requirements are as follows:

CAUTION

Closures with sponge rubber seals must not be used, since contamination of component or system can result.

a. Inspect for cleanness, contamination, and damage.

b. All closures and covers must be cleaned before use. Clean as outlined in paragraph 1-46.

c. Closures and covers to be installed on fluid system joints must be cleaned immediately before installation or must be individually packaged and certified clean.

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.

d. 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 closures 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.

e. 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 minimum thickness.

f. Remove and replace humidity indicators when indicator coloration overruns the established circular border or when indicators have lost all coloration, as follows:

(1) Remove indicator by breaking free retaining nut that secures indicator to closure.

(2) Place new indicator under a heat lamp until the 3 circular spots are blue in color.

(3) Install new humidity indicator and gasket; install retaining nut and tighten by hand.

WARNING

The following procedure uses methyl-ethyl-ketone, 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.

(4) Bond retaining nut to indicator with methyl-ethyl-ketone (Federal Specification TT-M-261), or equivalent.

g. Install protective closures and/or covers on components and assemblies immediately after removal from engine. Threaded plugs and caps must be installed fingertight. Threaded fasteners for attaching covers or closures must be torqued fingertight plus 1/4 turn.

h. Immediately install closures and/or covers on engine joints when a component or assembly is removed. Use applicable torque values outlined in step g. Temporary openings (48 hours maximum) may be closed with polyethylene bags or sheet material secured with pressure-sensitive tape RB0195-002 (Rocketdyne). Do not use tape on threads, sealing surfaces, or direct fluid surfaces.

i. Transport component or assemblies that require rework to an environmentally controlled area before removing closures or covers.

CAUTION

> All protective closures and coverings must be removed before engine components or assemblies are installed or connected, to prevent damage to equipment.

j. Do not remove closures or covers from components, assemblies, or engine joints until immediately before installation of components or assemblies.

1-19. REMOVING AND CONTROLLING CORROSION.

1-20. Corrosion is the attack of a metal by a chemical or electrochemical reaction with its environment. Temperature, humidity, structure, and composition of metals, and galvanic factors can retard or accelerate the rate of corrosion. The F-1 engine is constructed of metals that resist corrosion and metals that are protected from corrosion by plating, anodizing, passivating, painting, and applying protective coatings. If the engine is exposed to an adverse environment or the protective surfaces are penetrated, certain of these metals are subject to corrosion. This corrosion can vary from superficial corrosion to severe, heavy corrosion.

1-21. SUPERFICIAL CORROSION. Superficial corrosion is a uniform surface condition without significant penetration of the metal surface. Light rusting of iron and tarnishing of silver are examples of this type of corrosion. Superficial corrosion normally affects only the aesthetics and when on exterior surfaces is not detrimental to the functional integrity of the part. Superficial corrosion is metal's natural way of protecting itself. Superficial corrosion is usually found on such parts as gas generator fuel duct yokes, AN-type fittings (as-forged surfaces), heat-affected areas of 300-series CRES, thrust chamber outrigger arms, cadmium-plated boltheads, and thermal insulation system brackets. Corrosion removal and control must be considered on an individual part basis. The process of removing superficial corrosion from some parts may be more detrimental to the parts than the superficial corrosion itself, since it may destroy the anodized or passivated surfaces of the part. Removal will subject other components in the system to damage from the cleaning media. Removal and control of all other corrosion or the disposition of the part is to be coordinated with a Rocketdyne representative. Corrosion removal and control procedures on the exterior of the engine for each type of metal are provided in paragraphs 1-23 through 1-33.

1-22. MATERIALS AND EQUIPMENT. The materials listed in figure 1-4 are required for cleaning, paint stripping, and protecting metals from corrosion. The equipment listed in figure 1-5 is required for the examination of metals and for cleaning, paint stripping, corrosion removing, and protecting metals from corrosion. After use, all materials must be thoroughly cleaned of all chemical and corrosion residue before reuse. All cloths and bristle brushes must be thoroughly washed and rinsed in tap water before reuse. Carbon steel wool and wire brushes must be used on carbon steel or low-alloy steel materials. Stainless-steel wool and wire brushes must be used on CRES materials. Aluminum wool must be used on aluminum and magnesium. Brass wire brushes must be used to clean copper and copper alloy materials. It is recommended that a color code be established and that the handles of stainless-steel wire brushes and carbon-steel wire brushes be painted different colors to avoid possible misuse. Carborundum paper that is not discarded after use must be marked to indicate the type of metal on which it was used and must not be used on any other type of metal.

Identification	Name	Use
Aclar No. 33C (Allied Chemical Corp)	Film	Protecting parts.
Alodine 1200 (Amchem Products)	Powder	Mixed with Nitric Acid O-N-350 (Federal Specification) to form solution for chemical film touchup of anodic-coated parts.
ARP No. 2 (Allied Research Products)	Detergent	Mixed with Iridite 14-2 powder to form solution for chemical film touchup of anodic-coated parts.
BB-A-106 (Federal Specification)	Acetylene	Welding and brazing thrust chamber.
BB-O-925 (Federal Specification)	Gaseous oxygen	Welding and brazing thrust chamber.
Borax (Federal Standard)	Soap powder	Removing dry film lubricant.
Brayco 777 (Bray Oil Co)	Hydraulic fluid	Lubricating thrust chamber hot gas seals.
C-328 RTV (Connecticut Hard Rubber Co)(a)	Viton elastomer	Repairing turbopump oxidizer volute plastic foam elastomer seal.
C-5A (Felt Products)	Thread compound	Lubricating thrust chamber injector, turbine manifold, heat exchanger, and gas generator injector and combustor hot gas fitting threads; lubricating gas generator closure fasteners; lubricating turbine bolt threads; and lubricating thermal insulation frame bolt threads.
Centerpoint Lube No 3 (Chicago Mfg and Distributing Co)	Lubricant	Lubricating ignition monitor valve bolt and cap threads.
Ethafoam (Dow Chemical Co)	Ethafoam (cushioning material)	Protecting engine cover from chafing.
Extreme-pressure Lube No. 3 (Evans Products Co)	Lubricant	Lubricating ignition monitor valve bolt and cap threads.

(a) Compound has limited shelf life. Refer to paragraph 3-141 for usability tests.

Figure 1-4. Materials Specified in This Manual (Sheet 1 of 10)

Identification	Name	Use
FS1281 (Dow Corning Corp)	Grease	Lubricating thrust chamber injector to fuel upper seal, gas generator ball valve fuel housing tee retainers and packings, gas generator fuel O-rings, electrical connector gasket and threads, and fuel valve position transducer shaft; lubricating oxidizer valve and sequence valve packings, hypergol installed switch packing, engine and GSE hydraulic supply check valve packings, and checkout valve bearings and ball; and lubricating specified fuel valve parts, hypergol manifold closure threads, hypergol manifold piston O-ring, and hypergol simulator shaft O-ring.
Iridite 14-2 (Allied Research Products)	Powder	Mixed with detergent ARP No. 2 (Allied Research Products) to form solution for chemical film touchup of anodic-coated parts.
Kelite N-11 (Kelite Chemicals Corp)	Rust remover	Removing corrosion from gas generator fuel duct and oxidizer duct gimbal sections.
Krytox 143AZ (Du Pont)	Fluorinated oil	Lubricating thrust chamber oxidizer dome bolt seals and thrust chamber oxidizer and fuel instrumentation tap and purge port seals.
Kulgrid or Kulgrid 28 (Sylvania Electric Products, Inc)	Wrapping wire	Repairing electrical harness armored braid.
LBO125-103, Type II (NR, Los Angeles Division)	Hard anodic coating for aluminum and aluminum alloys	Replacing checkout valve retainer and cap anodic coating.
LBO190-002 (NR, Los Angeles Division)	Pressure-sensitive tape	Masking electrical harness for repair of heat shrinkable overmolds.
L-P-378, Type II (Feder. Specification)	Plastic sheet and strip	Protecting and wrapping parts and the engine control valve to prevent entry of contaminants when removing four-way solenoid valve.
MIL-A-18455	Argon	Purging thrust chamber tubes before brazing and welding and backing up weld repairs on heat exchanger shell, thrust chamber tube, and nozzle extension shingles.

Figure 1-4. Materials Specified in This Manual (Sheet 2 of 10)

Identification	Name	Use
MIL-A-8625, Type II	Anodic coating	Refinishing anodic-coated parts.
MIL-C-16173, Grade I	Corrosion-preventive compound	Protecting stationary unpainted carbon steel surfaces from corrosion.
MIL-C-25769	Alkaline cleaning compound	Cleaning corrosion from aluminum alloys.
MIL-C-5410, Type II	Cleaning compound	Deoxiding anodic-coated parts before applying chemical film touchup.
MIL-C-5541, Type I	Chemical film	Refinishing aluminum alloy surface after corrosion removal.
MIL-C-81302	Cleaning compound	Handcleaning covers and closures, CRES steel and nickel alloys, cadmium-, chrome-, nickel-, and silver plated parts, gas generator fuel feed duct and oxidizer feed duct gimbal sections, rigid CRES steel tubing, and flexible CRES and heat-resistant alloy ducts; handcleaning nonmetallic, metal, and combinations of metal and nonmetallic parts, exterior of pressure transducers, seal plates, fuel valve position transducer, engine control valve, exterior of thrust OK pressure switches and turbopump, turbopump tools, and joints of valves tested with leak test compound; flushing rigid CRES steel tubing, flexible CRES and heat-resistant alloy ducts, quick-disconnects, and parts of pressure transducers and thrust OK pressure transducer; and verifying cleanness of engine control valve filters and for cleaning filters.
MIL-D-6998	Dichloromethane	Removing paint from areas where a thick paint remover cannot be used.
MIL-E-21562, Type MIL-RN62	Inconel 62 wire	Welding thrust chamber Inconel X tubes.
MIL-E-25558	RJ-1 fuel	Leak-testing fuel valve nose seal.

Figure 1-4. Materials Specified in This Manual (Sheet 3 of 10)

Identification	Name	Use
MIL-G-23827	Gear grease	Lubricating interface panel pins.
MIL-H-5606	Hydraulic fluid	Lubricating packings in GSE hydraulic supply check valve, engine hydraulic supply check valve, engine control valve, four-way solenoid valve, bearing coolant control valve, and redundant shutdown valve and lubricating stem and armature in the redundant shutdown valve.
MIL-P-27401	Gaseous nitrogen	Blowing contaminants from parts before parts removal; drying covers, closures, and engine parts; purging oxidizer pump seal, thrust chamber tubes, and engine control valve ports; testing components; and holding oxidizer valve poppet closed during poppet torquing.
MIL-P-27401	Liquid nitrogen	Flushing all metal hoses; chilling gas generator oxidizer purge check valve and oxidizer valve during assembly; chilling turbopump oxidizer inducer during inducer removal; and cryogenic testing oxidizer valve.
MIL-P-11414	Lacquer primer	Refinishing painted carbon steel surfaces.
MIL-P-8585, Color Y, Type I[a]	Zinc chromate primer	Refinishing painted carbon steel surfaces and priming areas to be painted and interface panel holes.
MIL-R-5031	347 CRES filler rod or wire	Welding 347 CRES on thrust chamber manifold.
MIL-S-22473, Grade AV	Locking compound	Securing oxidizer valve position transducer arm and screw.

(a) Compound has limited shelf life. Refer to paragraph 3-141 for usability tests.

Figure 1-4. Materials Specified in This Manual (Sheet 4 of 10)

Identification	Name	Use
MIL-S-22473, Grade N	Locking compound primer	Priming oxidizer valve position transducer arm and screw.
MIL-T-27602	Trichloroethylene	Handcleaning CRES steel and nickel alloys, cadmium-, chrome-, nickel-, and silver plated parts, orifice plates, fuel valve position transducer, engine control valve, oxidizer valve seal blanks, and turbopump oxidizer seal lock; vapor degreasing rigid aluminum tubing, aluminum ducts, corrosion and heat resistant alloys, corrosion and heat resistant alloy ducts, rigid CRES steel tubing, flexible CRES and heat resistant alloy ducts, teflon lined hoses, all metal hoses, and orifice plates; ultrasonic cleaning rigid aluminum tubing, aluminum ducts, corrosion and heat resistant alloy ducts, rigid CRES steel tubing, flexible CRES and heat resistant alloy ducts, metal parts, combinations of metal and nonmetal parts, and bearing coolant control valve filters; flushing metal parts, quick-disconnects and thrust chamber tubes; and leak testing quick-disconnects.
MIL-T-8808, Type I	321 CRES tubing	Fabricating new drain tubes.
Molykote Z (Dow Corning Corp)	Powder	Lubricating turbopump bearing lube seal packing.
MS20995N (Military Standard)	Inconel lockwire	Safetywiring fittings and threaded fasteners with lockwire holes.
Mylar film (Du Pont)	Film	Barrier material for replacing plastic foam in turbopump oxidizer volute cavities.
Nicrobraz (Wall Colmonoy)	Brazing flux	Brazing thrust chamber tubes.
No number	Aluminum wool	Removing corrosion from aluminum.
No number	Carbon-steel wool (Class II pads)	Removing corrosion from carbon steel material.

Figure 1-4. Materials Specified in This Manual (Sheet 5 of 10)

Identification	Name	Use
No number	Carborundum paper (Grit No. 240, 280, 400, and 600)	Removing corrosion.
No number	CRES welding rod (0.040-, and 0.045-inch diameter)	Welding nozzle extension.
No number	Disodium phosphate hepta-hydrates (commercial grade)	Mixed with ethylenediamine tetra acetic acid, wetting agent Triton X-100 and water for cleaning engine control valve filters.
No number	Ethylenediamine tetra acedic acid (commercial grade)	Mixed with disodium phosphate heptahydrates, wetting agent (Triton X-100, and water for cleaning engine control valve filters.
No number	Hastelloy C sheet metal 0.034-inch thick	Repairing nozzle extension.
No number	Hastelloy C or W weld rod 0.040-, 0.047-, and 3/32-inch diameter	Repairing nozzle extension.
No number	Hastelloy W filler rod	Repairing thrust chamber exhaust manifold
No number	Helium (commercial grade)	Welding inert gas backup fluid.
No number	Methylene chloride (commercial grade)	Cleaning thrust chamber areas for brazing.
No number	Plastic sheet and strip (commercial grade)	Protecting heat exchanger inlet when turbine is disconnected.
No number	Stainless-steel wool (class O pads)	Removing corrosion from CRES material.
No number	321 CRES sheet metal 0.125-inch thick	Repairing nozzle extension.
No number	347 CRES sheet metal 0.125-inch thick	Repairing nozzle extension.
No number	75 He-25 Argon (commercial grade)	Welding inert gas backup fluid.

Figure 1-4. Materials Specified in This Manual (Sheet 6 of 10)

Identification	Name	Use
O-A-51 (Federal Specification)	Acetone	Stripping dye from parts; handcleaning metal parts before applying lubricating powder; and cleaning surfaces to be welded on heat exchanger, thrust chamber, and nozzle extension.
O-N-350 (Federal Specification)	Nitric acid	Mixed with alodine 1200 powder (Amchem Products) to form solution for chemical film touchup of anodic-coated parts.
O-O-670 (Federal Specification)	Phosphoric Acid (85%)	Mixed with isopropyl alcohol (Federal Specification TT-I-735), Thiourea (J. T. Baker Chemical Co), and distilled or deionized water to form solution for cleaning tarnish from electrical connector pins.
Ospho (Rusticide Products Co)	Rust remover	Removing corrosion from gas generator fuel feed and oxidizer feed duct gimbal sections.
O-T-620 (Federal Specification)	Trichloroethane (Methyl chloroform)	Cleaning molded rubber seal orifice plates and handcleaning surface before installing identification plates
P-D-680, Type I (Federal Specification)	Dry cleaning solvent	Handcleaning painted areas, hypergol manifold cartridge container inlet port, corroded surfaces, and carbon steel surfaces in areas where flammable liquids can be used.
PPP-T-60 (Federal Specification)	Waterproof tape	Sealing packaged parts and securing barrier material to engine cover frame.
PR-1553 (Products Research and Chemical, SEMCO)[a]	Potting compound	Repairing electrical harness black overmold.
QQ-S-571, SN60 or SN63 (Federal Specification)	Lead-tin solder	Repairing electrical harness.
RB0120-017 (Rocketdyne)[a]	Sealant and antiseize dispersion	Lubricating turbopump oxidizer inlet seal.
RB0120-034 (Rocketdyne)[a]	Gasket sealant	Lubricating flat seals.
RB0140-010 (Rocketdyne)	Fluorinated lubricant	Lubricating turbopump primary seal lock.

(a) Compound has limited shelf life. Refer to paragraph 3-141 for usability tests.

Figure 1-4. Materials Specified in This Manual (Sheet 7 of 10)

Identification	Name	Use
RB0140-012 (Rocketdyne)	Lubricant grease	Lubricating closure fasteners on components with inserts; plugs and seals in fuel, oxidizer, hydraulic, helium, and overboard drain systems; and fasteners on fuel valve, engine control valve, interface panel adapter, and thrust chamber dome.
RB0170-064 (Rocketdyne)	Gold-nickel braze alloy	Brazing thrust chamber tubes.
RB0170-065 (Rocketdyne)	Gold-nickel-copper brazing alloy	Welding certification.
RB0195-002 (Rocketdyne)	Pressure-sensitive tape	Securing film or bags to engine, sealing parts in bags, and masking surfaces before applying lubricants.
RB0210-002 (Rocketdyne)	Alkaline cleaner	Cleaning rubber lined hoses that have CRES fittings, all metal hoses, and combinations of metal and nonmetal parts.
RB0210-003 (Rocketdyne)	Trichloroethylene	Flushing thrust chamber tubes.
RB0210-016 (Rocketdyne)	Corrosion preventative	Protecting unpainted stationary carbon steel surfaces, cadmium-, chrone-, nickel-, and silver plated parts, gas generator fuel feed and oxidizer feed duct gimbal yokes and sections, thrust chamber outrigger arms, turbopump mounts, and bearing surface of turbopump forward mount lug.
RTV-102 (General Electric)(a)	White sealant	Repairing thrust chamber internal tube leaks.
RTV-108 (General Electric)(a)	Adhesive sealant	Repairing electrical junction box potting compound.
RTV-615 (General Electric)(a)	Silicone resin and curing agent	Repairing electrical junction box potting compound.
SK-D-NF (Magnaflux Corp)	Spot check developer	Indicating metal surface defects.
SKL-4 (Magnaflux Corp)	Dye-penetrant	Preparing metal surface for non-destructive testing.

(a) Compound has limited shelf life. Refer to paragraph 3-141 for usability tests.

Figure 1-4. Materials Specified in This Manual (Sheet 8 of 10)

Identification	Name	Use
SS-4120 (General Electric)[a]	Silicone primer	Repairing electrical junction box potting compound.
Stayfoam 308 (American Latex Corp)	Foam filler	Repairing turbopump oxidizer volute cavity foam.
ST0130RB0078, Type I (Rocketdyne)	Silicone rubber tape	Repairing electrical harness green overmold.
ST0170GB0001 (NR, Los Angeles Division)	Filler wire (Deoxidized copper) 1/16 and 3/32-inch diameter	Repairing thrust chamber.
TEC 901 (TEC Chemical Co)	Aluminum cleaner	Handcleaning aluminum alloys.
Thiourea (J. T. Baker Chemical Co)	Thiourea	Mixed with isopropyl alcohol (Federal Specification TT-I-735), phosphoric acid (Federal Specification O-O-670 and distilled or deionized water to form solution for cleaning tarnish from electrical connector pins.
Triton X-100 (Rohm and Haas Co)	Wetting agent	Mixed with disodium phosphate heptahydrates and ethylenediamine tetra acetic acid and water for cleaning engine control valve filters.
TT-I-735 (Federal Specification)	Isopropyl alcohol	Mixed with phosphoric acid (Federal Specification O-O-670), Thiourea (J. T. Baker Chemical Co), and distilled or deionized water to form solution for cleaning tarnish from electrical connector pins. Handcleaning covers and closures, exterior of electrical connectors, orifice plate RD251-5001, electrical harness plug protective boot, and electrical junction box electrical connectors. Stripping dye from parts.
TT-L-32 (Federal Specification)	Cellulose lacquer	Refinishing painted carbon steel surfaces.
TT-L-50 (Federal Specification)	Lacquer (aerosol can)	Refinishing painted carbon steel surfaces.
TT-M-261 (Federal Specification)	Methyl-ethyl-ketone	Stripping dyed parts; bonding humidity indicators; removing resin and catalyst from turbopump oxidizer volute; and cleaning electrical harness, harness overmold, and oxidizer valve position transducer arm and screw.
TT-N-95, Type I (Federal Specification)	Solvent	Handcleaning surfaces for installation of identification plates.
TT-R-248 (Federal Specification)	Paint and lacquer remover	Removing paint from areas where a thick paint remover can be used.

(a) Compound has limited shelf life. Refer to paragraph 3-141 for usability tests.

Figure 1-4. Materials Specified in This Manual (Sheet 9 of 10)

Identification	Name	Use
Turco WO1 (Turco Products)	Rust remover	Removing corrosion from gas generator fuel feed duct and oxidizer feed duct gimbal sections.
Turco 4215 (Turco Products)	Additive	Cleaning rubber lined hoses and cleaning O-rings and packings on start and stop solenoid valves.
VV-L-800 (Federal Specification)	Lubricating oil	Protecting unpainted carbon steel surfaces.
WD-40 (Rocket Chemical Co)	Preservative	Lubricating turbopump torque gear shaft and protecting untreated carbon steel surfaces, heat resistant and nickel alloy surfaces, and cadmiun-, chrome-, nickel-, and silver-plated parts.
101A (Leeder Chemicals, Inc)	Cleaner	Cleaning rubber lined hoses and cleaning O-rings and packings on start and stop solenoid valves.
1200 RTV (Dow Corning Corp)[(a)]	Primer	Priming metal surfaces of repair areas for heat shrinkable overmolds.
205233 (Rocketdyne)	Tube (aged in F-1 braze cycle)	Repairing thrust chamber tubes.
425 (Minnesota Mining and Mfg)	Aluminum-foil tape	Repairing thrust chamber tube leaks.
7862 (Victor Gloves, Inc)	Nylon gloves	Handling parts.
8105-LCO-6811 (Federal Stock Number)	Polyethylene bags	Protecting and packaging parts.
8135-782-7460 (Federal Stock Number)	Polyethylene tubing	Protecting and packaging parts.
92-018 (Dow Corning Corp)[(a)]	Aerospace sealant	Repairing electrical harness heat shrinkable overmolds and plug boots.

(a) Compound has limited shelf life. Refer to paragraph 3-141 for usability tests.

Figure 1-4. Materials Specified in This Manual (Sheet 10 of 10)

Part No. or Specification	Name	Use
	1/2-inch magnet (local purchase)	Distinguishes between low-alloy ferrous metals and stainless steels or nonferrous metals (except nickel).
263-D	Soft-bristle brush (Osborne Mfg Co)	Applies paint remover and cleaning compounds.
253	Brass wire brush (Osborne Mfg Co)	Removes corrosion from electrical components, copper, and copper alloys.
1777	Carbon-steel wire brush (Osborne Mfg Co)	Removes corrosion from carbon steel material.
1777-SV-48	Stainless-steel wire brush (Osborne Mfg Co)	Removes corrosion from CRES material.
263-A	Stiff-bristle brush (Osborne Mfg Co)	Applies paint remover and cleaning compounds.
	Heat gun, Model B (Zonne Ind Tool Co)	Dehydrates fungi on electrical components.

Figure 1-5. Equipment for Corrosion Removal and Control

1-23. CLEANING CORRODED SURFACES. Before corrosion removal and control procedures can be performed, grease, paint, oil, dirt, and other foreign substances must be removed from the surface of the metal.

a. Wipe excess dirt, oil, and other foreign substances from surface.

CAUTION

Failure to comply with the requirements of steps b through d may result in future corrosion and/or damage to equipment.

b. If possible, isolate all surfaces near corroded area from cleaning and corrosion-removing solution. Use moisture-proof cloth, tape, and drip pans.

c. Apply cleaning compound or solvent to surface with clean cloth or soft-bristle brush.

WARNING

The following procedure uses stoddard 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.

- 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.

d. If nearby surfaces cannot be completely sealed off from corroded area, clean corroded area with stoddard solvent (Federal Specification P-D-680, Type I). In areas where flammable solvents cannot be used, clean corroded area with cleaning compound (MIL-C-81302).

e. Allow corrosion cleaner to remain on surface for several minutes; then scrub with cloth or bristle brush. Do not allow cleaner to dry on surface.

f. Wipe surface thoroughly with a clean, dry cloth.

g. If alkaline cleaning compound (MIL-C-25769) is used, rinse surface thoroughly with distilled or deionized water before cleaning compound dries. Allow surface to dry completely.

1-24. REMOVING PAINT FROM CORRODED AREAS. All paint must be removed from the corroded area and from at least 2 inches of uncorroded metal around the area before corrosion removal and control procedures can be applied. Paint can be removed chemically or with a wire brush. Chemical paint removers must not be used in areas where the remover can become trapped.

a. Remove paint from areas where chemical removers can become trapped, with a wire brush and 280-grit Carborundum paper. Wipe area clean with a damp cloth.

b. To remove paint from areas where structural complexities make it impossible to use a thickened paint remover, proceed as follows:

(1) Using a stiff-bristle brush, apply dichloromethane (MIL-D-6998) to paint on corroded area.

(2) Allow chemical to remain on surface until paint softens and lifts.

CAUTION

Paint remover that remains on the surface can cause corrosion.

(3) Wash away loosened paint and remover or wipe from surface with a clean cloth frequently rinsed in tap water.

(4) Repeat substeps 1 through 3 until all paint is removed from surface.

(5) Wipe surface dry with clean, dry cloth.

c. To remove paint from areas where a thickened paint remover can be used, proceed as follows:

WARNING

The following procedure uses paint and lacquer remover (Federal Specification TT-R-248), which is corrosive and forms an explosive gel when mixed with liquid oxygen, creating a hazard to both personnel and equipment.

(1) Using a stiff-bristle brush, apply paint and lacquer remover (Federal Specification TT-R-248) to paint on corroded area.

(2) Allow remover to remain on surface until paint softens and lifts.

CAUTION

Paint remover that remains on the surface can cause corrosion.

(3) Wash away loosened paint and remover or wipe from surface with a clean cloth frequently rinsed in tap water.

(4) Repeat substeps 1 through 3 until all paint is removed from corroded area.

(5) Wipe surface dry with dry, clean cloth.

1-25. CARBON STEEL. Remove corrosion from small areas as follows:

WARNING

The following procedure uses stoddard 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.

a. Clean area in accordance with instructions in paragraph 1-23. Use stoddard solvent (Federal Specification P-D-680, Type I).

b. If surface is painted, remove paint in accordance with instructions in paragraph 1-24.

c. On small or complex components, remove all corrosion using carbon steel wool or 400-grit Carborundum paper. On larger components, a carbon-steel wire brush may be used to remove surface corrosion deposits.

WARNING

The following procedure uses stoddard 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.

d. Rinse area with stoddard solvent (Federal Specification P-D-680, Type I) and wipe dry.

NOTE

Corrosion preventative RB0120-016 must be thoroughly mixed at 70° to 95° F immediately prior to each application.

e. Apply lubricating oil (VV-L-800) to unpainted working surfaces, or corrosion-preventive compound (MIL-C-16173, Grade I) or corrosion preventative RB0210-016 (Rocketdyne) to unpainted stationary surfaces, or apply a thin, even coat of preservative WD-40 (Rocket Chemical Co) to untreated surfaces. Do not apply more than one coat of WD-40 at a time.

f. On painted surfaces, refinish as follows:

WARNING

The following specifies primer (MIL-P-8585), which is flammable and must not be used near heat, sparks, or open flame. It is toxic. Inhalation of its vapors or prolonged contact with the primer can cause serious bodily harm. In case of prolonged exposure, immediately obtain fresh air and wash skin with soap and water.

(1) Thoroughly mix and apply one coat of rust-inhibiting lacquer primer (MIL-P-11414) or zinc chromate primer (MIL-P-8585, color Y.) Allow primer to dry a minimum of 30 minutes.

(2) Apply 2 coats of cellulose lacquer (TT-L-32) or lacquer (TT-L-50) to match existing color in surrounding area.

1-26. CORROSION-RESISTANT STEEL AND NICKEL ALLOYS. Remove corrosion as follows:

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 trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

a. Clean area in accordance with instructions in paragraph 1-23. Use cleaning compound (MIL-C-81302) or trichloroethylene (MIL-T-27602).

b. On small or complex components, clean corroded area with stainless-steel wool or 400-grit Carborundum paper until no corrosion is visible.

c. On larger components, use a stainless-steel wire brush to remove surface corrosion deposits.

d. Wipe surface with clean cloth dampened in distilled or deionized water.

NOTE

Corrosion preventative RB0210-016 must be thoroughly mixed at 70° to 95° F immediately prior to each application.

e. Apply corrosion preventative RB0210-016 (Rocketdyne) to untreated stationary surfaces, or apply a thin, even coat of preservative WD-40 (Rocket Chemical Co) to untreated surfaces. Do not apply more than one coat of WD-40 at a time.

1-27. CADMIUM-, CHROME-, NICKEL-, AND SILVER-PLATED PARTS. When a plated surface has become pitted and the condition is general (not restricted to small areas), the part or component may have to be replaced or refinished. Coordinate disposition with a Rocketdyne representative. For light corrosion in small areas, perform the following:

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.

- 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.

a. Clean area in accordance with instructions in paragraph 1-23. Use trichloroethylene (MIL-T-27602) or cleaning compound (MIL-C-81302).

b. Remove corrosion from plated surface using a wire brush and wool made of same material as base metal or 400-grit Carborundum paper. Repeat step a.

c. Inspect area for corrosion.

d. If corrosion remains, repeat steps a through c.

NOTE

Corrosion preventative RB0210-016 must be thoroughly mixed at 70° to 95° F immediately prior to each application.

e. Apply a thin, even coat of preservative WD-40 (Rocket Chemical Co) to plated surface. Do not apply more than one coat of WD-40 at a time, or apply corrosion preventative RB0210-016 (Rocketdyne) to untreated stationary surfaces.

1-28. ALUMINUM ALLOYS. Remove corrosion from aluminum alloy as follows:

a. Preclean aluminum alloy surfaces in accordance with instructions in paragraph 1-23. Use alkaline cleaning compound (MIL-C-25769).

b. (Deleted)

c. Final clean aluminum alloy surfaces as follows:

CAUTION

Avoid using excessive amounts of solvent to prevent uncontrolled running or dripping. Excessive solvent could remove paint or the protective finish from adjacent surfaces, causing serious corrosion of equipment.

(1) Apply TEC 901 (TEC Chemical Co) to exterior surfaces with a clean, soft cloth. Apply in long strokes to remove all foreign deposits and accumulations of grease and dirt.

(2) Do not wipe surfaces dry. Use a fresh application of solvent on a clean cloth. For final wipe, squeeze cloth as dry as possible.

CAUTION

When abrading clad aluminum, extreme care must be used not to rub through pure aluminum coat. Without clad coating, some aluminum alloys corrode quickly.

d. Remove all corrosion using aluminum wool or 400-grit Carborundum paper.

e. Rinse with distilled or deionized water, and dry.

f. Inspect area, and if all corrosion has not been removed, repeat steps d and e.

g. After removing corrosion, refinish metallic surfaces as follows:

(1) Clean area with TEC 901 (TEC Chemical Co).

(2) Clean area with distilled water. Do not dry.

NOTE

Chemical film solution must be mixed with distilled or deionized water in accordance with the instructions of the manufacturer.

(3) While surface is still damp, apply chemical film (MIL-C-5541) with a clean brush.

(4) Keep area wet with fresh solution for 15-20 minutes.

(5) Rinse area with distilled water. Dry area as outlined in paragraph 1-35A or allow to airdry. Do not wipe dry.

1-29. (Deleted)

1-30. REMOVING AND CONTROLLING CORROSION ON GAS GENERATOR FUEL AND OXIDIZER FEED DUCT GIMBAL SECTIONS.

1-31. The following procedures outline the corrective action necessary to remove and control corrosion (rust) on the yokes and bellows of the fuel feed duct gimbal section and on the bellows and weld areas of the oxidizer feed duct gimbal section.

a. Isolate all surfaces near corroded area from cleaning and corrosion-removing solution. Use moisture-proof cloth, tape, and drip pans.

WARNING

The following procedure uses stoddard 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.

- 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.

b. Clean corroded area by wiping with a clean, lint-free cloth or cotton swab moistened with stoddard solvent (Federal Specification P-D-680, Type I), and wipe dry. Substitute cleaning compound (MIL-C-81302) for stoddard solvent in areas where flammable solvents cannot be used. Do not allow solvent to dry on corroded area.

CAUTION

Carborundum paper must not be allowed to contact the bellows of the gimbal, since damage to the bellows can result.

- Rust removers will cause etching on aluminum. If any of these materials contact aluminum, the affected area must be immediately rinsed with clean water and dried.

c. Remove corrosion from accessible corroded areas on yokes of fuel feed duct using 400-grit Carborundum paper. Remove corrosion from less accessible corroded areas on yokes and bellows of fuel feed duct using a clean, lint-free cloth or cotton swab moistened with rust remover Turco WO1 (Turco Products), Kelite N-11 (Kelite Corp), or Ospho (Rusticide Products Co).

CAUTION

Rust removers will cause etching on aluminum. If any of these materials contact aluminum, the affected area must be immediately rinsed with clean water and dried.

d. Remove corrosion from bellows and weld areas of oxidizer feed duct using a clean, lint-free cloth or cotton swab moistened with rust remover Turco WO1 (Turco Products), Kelite N-11 (Kelite Corp), or Ospho (Rusticide Products Co).

e. Keep area wet with rust remover for 5-10 minutes using a scrubbing action on each application. Do not allow rust remover to dry on affected area.

f. Remove rust remover, clean-treated area by wiping with a clean, lint-free cloth or cotton swab moistened with distilled or deionized water, and wipe dry.

g. Apply a thin, even coat of corrosion preventative RB0210-016 (Rocketdyne) to treated area of yokes. Do not apply corrosion preventative to bellows.

NOTE

Corrosion preventative RB0210-016 must be thoroughly mixed at 70° to 95° F immediately prior to each application.

1-32. PREVENTING THRUST CHAMBER CORROSION.

1-33. The thrust chamber outrigger arms, turbopump mounts, and bearing surfaces of the forward mount lug (used to attach the thrust chamber to the engine handler) must have continuous protection. Provide continuous protection to these surfaces by applying corrosion preventative RB0210-016 (Rocketdyne) and by maintaining this protective film. Corrosion preventative RB0210-016 must be thoroughly mixed at 70° to 95° F prior to each application.

1-34. CLEANING.

1-35. All parts must be free of dirt, oil, grease, and foreign matter. Parts with dyed surfaces, to be cleaned for oxidizer compatibility, must be stripped of dye (paragraph 1-35B) before cleaning. Parts and components must be inspected thoroughly during cleaning with particular attention paid to crevices, threads, and other areas where cleaning solvent could become trapped. All parts must be cleaned before items such as threaded fittings and inserts are installed. Items such as inserts and fittings on reworked parts that are exposed to areas containing liquid oxygen, fuel, or pneumatic gases must be removed before cleaning unless they can be masked off during cleaning. All new parts that are not properly packaged, sealed, or marked must be cleaned as described in this section. Parts cleaned by this procedure meet the cleanness requirements for use in liquid oxygen, fuel, pneumatic, and hydraulic systems. Cleaning solvent used for final rinsing, flushing, or hand cleaning must meet the following particle count and nonvolatile residue determination (Whatman Particle Counting and Gravimetric (NVR) Techniques): For a size range of 100-175 microns, the particle count is five particles per 500 milliliters maximum; for a size range greater than 175 microns, the particle count is zero. The nonvolatile residue is 10 milligrams per 500 milliliters maximum. Figure 1-4 lists materials for cleaning the engine and engine parts.

1-35A. DRYING CLEANED PARTS. Immediately after cleaning, parts must be thoroughly dried to remove the cleaning solution and remaining moisture. Unless otherwise specified, parts are to be dried as follows:

a. Observe facility safety requirements.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

b. Thoroughly dry parts 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. Do not exceed pressures specified in procedural steps.

c. Apply gaseous nitrogen or air only to surface area to be dried. Flow must not be directed towards other personnel in work area.

1-35B. STRIPPING DYED PARTS. This procedure is required only when dyed parts are to be cleaned for oxidizer compatibility.

a. Observe facility safety requirements.

WARNING

The following procedure uses methyl-ethyl-ketone, 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.

b. Strip dye from part by brushing or wiping dyed surface with a natural-bristle brush or a clean, lint-free cloth dipped in methyl-ethyl-ketone (Federal Specification TT-M-261). If dye is removed, omit steps c and d and proceed to step e.

WARNING

The following procedure uses acetone 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. Strip dye from part by brushing or wiping dyed surface with a natural-bristle brush or a clean, lint-free cloth dipped in acetone (Federal Specification O-A-51). If dye is removed, omit step d and proceed to step e.

WARNING

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.

d. Strip dye from part by brushing or wiping dyed surface with a natural-bristle brush or a clean, lint-free cloth dipped in isopropyl alcohol (Federal Specification TT-I-735).

e. Clean part as outlined in paragraph 1-42 or 1-43, as applicable.

1-36. CLEANING RIGID ALUMINUM TUBING, ALUMINUM DUCTS, AND RIGID CORROSION-RESISTANT ALLOY AND HEAT-RESISTANT ALLOY DUCTS.

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.

a. Vapor-degrease tubing or ducts in trichloroethylene (MIL-T-27602).

b. Ultrasonically clean aluminum tubing and ducts in trichloroethylene (MIL-T-27602) for a maximum of one minute. Ultrasonically clean corrosion- and heat-resistant-alloy ducts in trichloroethylene (MIL-T-27602) for a maximum time period of 5 minutes. Do not allow parts to dry.

c. Final-rinse tubing or ducts in trichloroethylene (MIL-T-27602) for a minimum of 2 minutes at a minimum linear flowrate of 35 feet per minute for tubing and a minimum of 5 gal/min for ducts.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

d. Dry parts in an air-circulating oven at a temperature of 250° ±10° F for a minimum of one hour, or thoroughly dry part with 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. (Refer to paragraph 1-35A for drying procedure.)

e. Previously cleaned, lightly soiled parts may be recleaned by handwiping and flushing with trichloroethylene (MIL-T-27602). Dry parts with 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. (Refer to paragraph 1-35A for drying procedure.)

f. Inspect parts for cleanness (paragraphs 1-51 through 1-58).

g. Handle and package cleaned parts as outlined in paragraph 1-47.

1-37. CLEANING RIGID CORROSION-RESISTANT STEEL TUBING AND FLEXIBLE CORROSION-RESISTANT ALLOY AND HEAT-RESISTANT ALLOY DUCTS.

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.

a. Vapor-degrease tubing or ducts in trichloroethylene (MIL-T-27602).

b. Ultrasonically clean tubing or ducts in trichloroethylene (MIL-T-27602) for a maximum continuous time period of 5 minutes.

c. Rinse parts with trichloroethylene (MIL-T-27602) for at least 2 minutes at a minimum linear flowrate of 35 ft/min for tubing and a minimum flowrate of 5 gallons per minute for ducts. During rinsing, hold duct in a vertical position and lightly rap each convoluted section about its entire circumference and length with a rawhide mallet to dislodge loose particles without damaging the duct.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

d. Dry parts in an air-circulating oven at a temperature of 250° ±10° F for one hour, or thoroughly dry part with 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. When drying flexible ducts, gaseous nitrogen or air velocity must not exceed a maximum of 30 ft/sec and an inlet pressure of 60 psig. (Refer to paragraph 1-35A for drying procedure.)

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.

e. Previously cleaned, lightly soiled parts may be recleaned by handwiping and flushing with trichloroethylene (MIL-T-27602) or cleaning compound (MIL-C-81302). Dry parts with 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. (Refer to paragraph 1-35A for drying procedure.)

f. Inspect parts for cleanness (paragraphs 1-51 through 1-58).

g. Handle and package cleaned parts as outlined in paragraph 1-47.

1-38. CLEANING TEFLON-LINED HOSES.

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.

a. Vapor-degrease hoses in trichloroethylene (MIL-T-27602).

b. Rinse hoses with trichloroethylene (MIL-T-27602) for at least 2 minutes at a minimum linear flowrate of 35 ft/min.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

c. Dry hoses in an air-circulating oven at a temperature of 160° ±10° F for 3 hours, or thoroughly dry hose with 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. (Refer to paragraph 1-35A for drying procedure.)

d. Inspect hoses for cleanness (paragraphs 1-51 through 1-58).

e. Handle and package cleaned parts as outlined in paragraph 1-47.

1-39. CLEANING RUBBER-LINED HOSES.

NOTE

Use step a to clean hoses that have aluminum fittings, and use step b to clean hoses that have CRES fittings.

a. Flush hoses that have aluminum fittings, with a 3-3.5 percent solution by volume of cleaning compound Turco 4215 (Turco Products) or cleaner 101A (Leeder Chemicals, Inc) in water heated to 125° to 140° F. Flush for a minimum of 2 minutes at a linear flowrate of 35 ft/min.

b. Prepare a solution of 4-6 ounces of alkaline cleaner RB0210-002 (Rocketdyne) to each gallon of water, and heat to 125° to 140° F. Flush hoses that have CRES fittings for at least 2 minutes at a minimum linear flowrate of 35 ft/min.

c. Immersion-rinse in dionized water heated to 130° to 150° F for at least 2 minutes.

d. Rinse internally and externally with deionized water for at least 2 minutes.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

e. Dry hoses in an air-circulating oven at a temperature of 160° ±10° F for 3 hours, or thoroughly dry hose with 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. (Refer to paragraph 1-35A for drying procedure.)

f. Inspect hoses for cleanness (paragraphs 1-51 through 1-58).

g. Handle and package cleaned parts as outlined in paragraph 1-47.

1-40. CLEANING ALL-METAL HOSES.

WARNING

The following procedure uses liquid nitrogen, which must not be allowed to come in contact with any part of the body. Human tissues will freeze upon contact, causing serious injury. Eye protection and protective clothing must be worn by personnel handling liquid nitrogen. Liquid nitrogen must be used in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

a. Flush hose with liquid nitrogen (MIL-P-27401) at a maximum velocity of 50 ft/sec and an inlet pressure of 60 psig. Continue flow until after full liquid flow has been attained. Do not let gaseous nitrogen velocity exceed 30 ft/sec during chilldown.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

b. Warm hose by purging with 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. Gaseous nitrogen or air velocity must not exceed a maximum of 30 ft/sec and an inlet pressure of 60 psig. (Refer to paragraph 1-35A for drying procedure.)

c. Repeat step a, except reverse direction of flow.

d. Repeat step b.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

e. Dry hose in an air-circulating oven at a temperature of 250° ±10° F for one hour, or thoroughly dry hose with 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. (Refer to paragraph 1-35A for drying procedure.)

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.

f. Vapor-degrease in trichloroethylene (MIL-T-27602).

g. Dry in an air-circulating oven at 250° ±10° F for one hour.

h. Flush with a solution of 4-6 ounces of alkaline cleaner RB0210-002 (Rocketdyne) to each gallon of water heated to 125° to 140° F. Flush for a minimum of 2 minutes at a minimum linear flowrate of 35 ft/min.

i. Immersion-rinse in deionized water heated to 130° to 150° F for a minimum of 2 minutes.

j. Rinse internally and externally with deionized water for at least 2 minutes.

k. Dry in an air-circulating oven at 250° ±10° F for one hour minimum.

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.

l. Final-rinse with trichloroethylene (MIL-T-27602) for a minimum of 2 minutes at a minimum linear flowrate of 35 ft/min.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

m. Dry hose in an air-circulating oven at a temperature of 250° ±10° F for one hour, or thoroughly dry hose with 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. Gaseous nitrogen or air velocity must not exceed a maximum of 30 ft/sec and an inlet pressure of 60 psig. (Refer to paragraph 1-35A for drying procedure.)

n. Inspect for cleanness (paragraphs 1-51 through 1-58).

o. Handle and package cleaned parts as outlined in paragraph 1-47.

1-41. CLEANING NONMETALLIC PARTS.

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.

a. Hand-clean with a lint-free cloth or brush moistened with cleaning compound (MIL-C-81302).

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

b. Dry part with 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. (Refer to paragraph 1-35A for drying procedure).

c. Inspect for cleanness (paragraphs 1-51 through 1-58).

d. Handle and package cleaned parts as outlined in paragraph 1-47.

1-42. CLEANING METAL PARTS. Dyed parts, to be cleaned for oxidizer compatibility, must have the dye stripped from the part, as outlined in paragraph 1-35B, before cleaning.

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

Parts must not be allowed to dry before final rinse.

a. Ultrasonically clean parts in trichloroethylene (MIL-T-27602). Clean plated anodized or chemically filmed parts for a maximum continuous time period of one minute. Clean all other parts for a maximum continuous time period of 5 minutes.

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.

b. Final-rinse parts in trichloroethylene (MIL-T-27602) or cleaning compound (MIL-C-81302) for a minimum of 2 minutes.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

c. Dry parts in an air-circulating oven at a temperature of 250° ±10° F for one hour, or thoroughly dry part with 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. (Refer to paragraph 1-35A for drying procedure).

d. Previously cleaned, lightly soiled parts may be recleaned by handwiping and flushing with trichloroethylene (MIL-T-27602) or cleaning compound (MIL-C-81302). Dry parts with 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. (Refer to paragraph 1-35A for drying procedure).

e. Inspect parts for cleanness (paragraphs 1-51 through 1-58).

f. Handle and package cleaned parts as outlined in paragraph 1-47.

1-43. CLEANING COMBINATIONS OF METAL AND NONMETALLIC PARTS. Dyed parts, to be cleaned for oxidizer compatibility, must have the dye stripped from the part, as outlined in paragraph 1-35B, before cleaning. Parts with nonmetallic constituents that are attacked by solvent flushing or immersion must be cleaned as outlined in paragraph 1-41. Clean parts with nonmetallic constituents that withstand solvent flushing or immersion as follows:

a. Immerse and rotate parts in a solution of 4-6 ounces of alkaline cleaner RB0210-002 (Rocketdyne) to each gallon of water heated to 125° to 140° F for 2 minutes.

b. Immersion-rinse in deionized water heated to 130° to 160° F for a minimum of 2 minutes.

c. Rinse in deionized water for at least 2 minutes.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

d. Dry parts in an air-circulating oven at a temperature of 160° ±10° F for 3 hours, or thoroughly dry part with 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. (Refer to paragraph 1-35A for drying procedure).

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.

e. Ultrasonically clean in trichloroethylene (MIL-T-27602). Clean plated, anodized, and chemically filmed parts for a maximum continuous time period of one minute. Clean other parts for a maximum continuous time period of 5 minutes.

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.

f. Final-rinse parts in cleaning compound (MIL-C-81302) for 2 minutes.

g. Dry in an air-circulating oven at 160 ±10° F for one hour.

h. Inspect parts for cleanness (paragraphs 1-51 through 1-58).

i. Handle and package cleaned parts as outlined in paragraph 1-47.

1-44. CLEANING ELECTRICAL HARNESSES AND CONNECTORS. Electrical connectors are easily damaged. Protection must be provided against pin damage and the entry of foreign particles and moisture during the following procedure.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

a. Remove dust, moisture, and foreign particles from harnesses and connectors by blowing with 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. (Refer to paragraph 1-35A for drying procedure).

WARNING

The following procedure uses methyl-ethyl-ketone, 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.

b. Remove dirt, grease, etc, from exterior surfaces of harnesses, including protective boot, by brushing or wiping with a natural-bristle brush or a clean, lint-free cloth dampened (not saturated) with methyl-ethyl-ketone (Federal Specification TT-M-261). Do not allow methyl-ethyl-ketone to contact Loctite compound on clamping nut and inserts of connector.

WARNING

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.

c. Clean interior and exterior surfaces of connectors by brushing lightly with a natural-bristle brush dipped in isopropyl alcohol (Federal Specification TT-I-735).

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

d. Immediately dry harness or connector surfaces that have been cleaned with alcohol (step c), with 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, for 2 minutes minimum. (Refer to paragraph 1-35A for drying procedure).

1-44A. CLEANING TARNISH FROM ELECTRICAL CONNECTOR PINS.

WARNING

The following procedure specifies isopropyl alcohol which is flammable and must not be used near heat or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

- The following procedure specifies phosphoric acid, which is a toxic and corrosive liquid. Inhalation of its vapors or contact with the liquid can cause serious injury. Eye protection and protective clothing must be worn by personnel handling phosphoric acid.

- The following procedure specifies thiourea, which is toxic and poisonous. Inhalation of its vapors or prolonged contact with or ingestion of the material can cause serious injury or death.

a. Prepare a cleaning solution of the following ingredients:

Ingredient	Percent by Weight
Phosphoric Acid (85%) (Federal Specification O-O-670)	6
Isopropyl Alcohol (Federal Specification TT-I-735)	6
Thiourea (J. T. Baker Chemical Co)	15
Deionized or distilled water	73

b. Using a clean cotton swab moistened in cleaning solution prepared in step a, lightly burnish pin until tarnish is removed. Do not burnish pin to the extent that pin plating is damaged or base metal is exposed.

c. Using a clean cotton swab, moistened in deionized or distilled water, remove residual cleaning solution from cleaned pin.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

d. Using a clean cotton swab moistened in isopropyl alcohol (Federal Specification TT-I-735), remove residual water from electrical connector; then thoroughly dry electrical connector with low-pressure (less than 30 psig) gaseous nitrogen (MIL-P-27401).

1-45. CLEANING TRANSDUCERS. Pressure transducers are delicate instruments and must be handled with extreme care. Solid material must not be inserted in the sensing cavity. Cleaning solution temperatures must not exceed 165° F.

WARNING

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.

a. Clean exterior surfaces of connector by brushing lightly with a natural fiber brush dipped in isopropyl alcohol (Federal Specification TT-I-735). Install protective cap.

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.

b. Clean exterior surface of transducer by handwiping with a clean, lint-free cloth moistened in cleaning compound (MIL-C-81302).

c. Flush sensing port with cleaning compound (MIL-C-81302).

CAUTION

The tube used to flush or rinse the sensing cavity must not be inserted more than 1/4 inch.

d. Rinse transducer in cleaning compound (MIL-C-81302).

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

e. Immediately dry transducer with 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. (Refer to paragraph 1-35A for drying procedure).

1-46. CLEANING PROTECTIVE CLOSURES AND COVERS. Clean protective closures and covers using the following procedures:

a. Clean closures RD265-2001 and RD. 65-5016 and all metal closures and covers by vapor degreasing, as outlined in this section. Wear clean, lint-free nylon gloves when handling cleaned closures and covers.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

b. Dry covers and closures with 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 (refer to paragraph 1-35A for drying procedure) or by handwiping with a clean, hemmed nylon cloth.

WARNING

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.

- 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.

c. Clean closures of plastic or combinations of plastic, metal, and elastomeric material as follows:

(1) Clean by handwiping with a clean, hemmed nylon cloth or by scrubbing with a clean brush wetted with unused cleaning compound (MIL-C-81302) or isopropyl alcohol (Federal Specification TT-I-735).

(2) Wear clean, lint-free nylon gloves when handling cleaned closures.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

(3) Dry closure with 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 (refer to paragraph 1-35A for drying procedure) or by handwiping with a clean, hemmed nylon cloth.

d. Inspect closures and covers for cleanness (paragraph 1-51).

e. Handle and package cleaned closures and covers as outlined in applicable procedures of paragraph 1-47.

1-47. HANDLING AND PACKAGING CLEANED PARTS.

1-48. Improper handling and packaging of clean parts can result in unnecessary expenditure of time and effort to reclean or teardown parts. The recommended methods of handling and packaging cleaned parts are defined in the following procedure and illustrated in figure 1-6A. The protective material used in this procedure is plastic sheet and strip, (Federal Specification L-P-378, Type II), or commercial grade polyethylene.

NOTE

Clean polyethylene bags Federal Stock No. 8105-LC0-6811) or clean polyethylene tubing (Federal Stock No. 8135-782-7460) may be used for packaging.

- Clean, lint-free nylon gloves No. 7862 (Victor Gloves, Inc) or disposable polyethylene gloves must be worn when handling parts where hand contact is made with critical surfaces that will contact operating fluid (liquid or gas).
- Packaging materials, when used as an inner wrap, must be new, visually clean and dry. Closures used to protect cleaned parts must be cleaned as specified in paragraph 1-46.

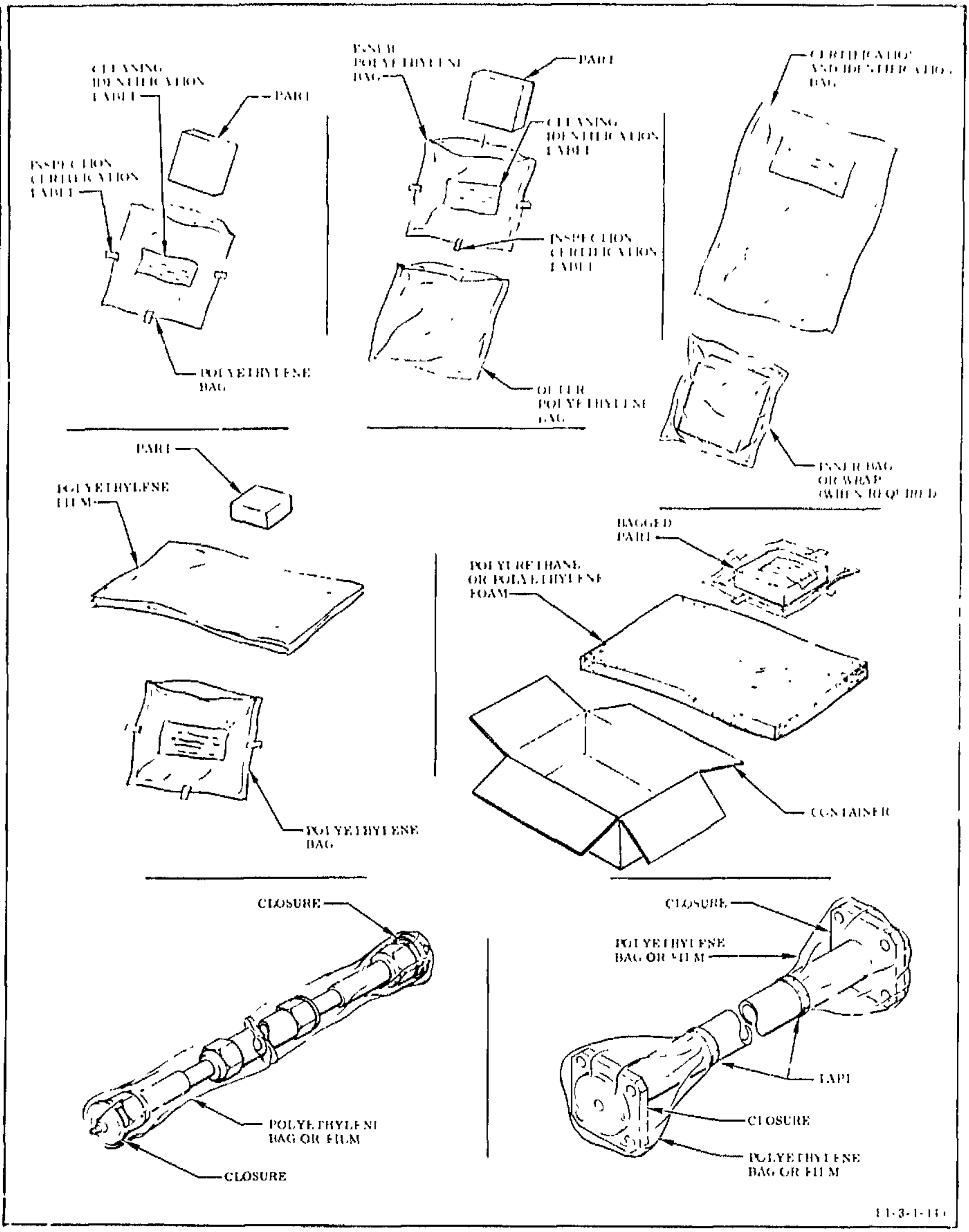


Figure 1-6A. Methods of Packaging Cleaned Parts

a. Package parts immediately after being cleaned, except when parts are to be assembled immediately, and at all times before removing parts from cleaning area.

b. Protect parts that have been cleaned and are to be assembled in the same area, with clean protective covers and/or closures.

c. Package each part individually in a certification and identification bag, or in a new, visually clean, dry polyethylene bag. Seal bag by heat sealing or, if a temporary package, with pressure-sensitive tape (Federal Specification PPP-T-60). Tape must not be applied on threads, critical machined surfaces, mating surfaces, or surfaces that will contact operating fluid. Tape used to secure packaging material must be prepared for ease of removal from the part by folding the outer end of the tape back upon itself, adhesive to adhesive, forming a tab approximately 1/2 inch long.

NOTE

Metal fasteners, staples, or paper clips must not be used to seal packages.

d. Package small, lightweight parts, sealed with protective closures, in a visually clean, dry, polyethylene bag (minimum thickness of 0.004 inch). Heat-seal bag. Prior to sealing, remove excess air from bag by manually forming bag around enclosed part. If part weighs more than 3 pounds, use bag with a minimum thickness of 0.006 inch.

e. Package part with sharp projections, sealed with protective closures, in 2 polyethylene bags, one within the other, to minimize the possibility of puncturing the bags. If this method is inadequate, an initial wrap of several layers of polyethylene film may be used instead of the inner bag. Heat-seal bag. Prior to sealing, remove excess air from bag by manually forming bag around enclosed part. Whenever an oversized bag is used, isolate part in one area of bag and make a single additional heat seal to maintain part in required position.

f. For parts with such configuration (fragility, finish, or weight) that packaging instructions in steps d and e are inadequate, wrap part in clean polyurethane foam or polyethylene foam. The minimum thickness of the polyurethane foam for a part weighing less than 7 pounds must be 1/2 inch, and for a part weighing 7-10 pounds, one inch. If polyethylene foam is used, the minimum thickness must be 1/8 inch for a part weighing less than 7 pounds, 1/4 inch for a part weighing 7-10 pounds, 3/8 inch for a part weighing 10-15 pounds, and 1/2 inch for a part weighing 15-20 pounds. Sheets of various thicknesses may be combined to obtain the required thickness. Pack part in a suitable snug-fitting container and mark container with same information as on the part, except for serial number.

g. Seal large lines, hoses, and ducts with suitable protective closures and cover ends with new, visually clean, dry polyethylene bags or film. Secure bags or film by heat sealing or with pressure-sensitive tape RB0195-002 (Rocketdyne). Tape must not contact threads, critical surfaces, or sealing surfaces that will contact operating fluid. Seal small lines, hoses, and ducts with suitable protective closures and package in a new, visually clean, dry polyethylene bag or film. Secure bag or film by heat sealing.

h. When it is not possible to package a part in a bag with a certification label, the required protective closures installed with bolts or other fastener devices must be certified by applying lead or aluminum seals to the bolts or fastener devices and an inspection stamp imprinted on the seal, or a certification label affixed (two places) half on the closure and half on the part. Markings, decals, or labels applied to a part for certification, must not be placed on any critical machined surface, sealing surface, or surface that will contact operating fluid.

i. To certify cleanness of a packaged part, an inspection certification label must be placed over each heat seal of the bag, and must contain the identification of the inspection agency and the specific inspector's stamp. In addition, the bag must be identified with certification and identification labels which contain the following minimal information:

(1) Precautionary statement that package must not be opened until ready for immediate use and that certification is void if seal is prematurely broken

(2) Level of cleanness or service

(3) Part number

(4) Serial number

(5) Design activity

(6) Date

(7) Manufacturing activity

(8) Inspection stamp

j. Identify part that has been lubricated for a special service with appropriate label or decal indicating type of service, such as lubricated for liquid oxygen service or lubricated for pneumatic service.

k. Seal decal or label to bag or affix decal or label to part. Decals or labels applied to a part for certification or identification must not be placed on any critical machined surface, sealing surface, or surface that will contact operating fluid.

l. Parts removed from protective packages for test purposes may be repackaged without being recleaned, provided contamination has not been introduced during testing. Use only new, visually clean, dry polyethylene bags or film to repackage parts. Do not reuse original bag.

m. Protective closures removed from a part for test purposes, must be immediately packaged in a new, visually clean, dry polyethylene bag or film and sealed by heat sealing, by using pressure-sensitive tape (Federal Specification PPP-T-60), or by tying. Closures must remain packaged until immediately prior to reinstallation.

WARNING

> 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.

n. For parts that have been cleaned, that utilize protective closures as the only cleanness integrity barrier, and that have been subjected to other than a controlled environment, accomplish the following prior to temporary removal of protective closures:

(1) Clean exterior surfaces of closures with a clean, unused, hemmed nylon cloth, saturated with clean, unused isopropyl alcohol (Federal Specification TT-I-735).

(2) After surfaces are dry, remove closures from part and package closure in new, visually clean, dry polyethylene bags or film and seal by heat sealing, by using pressure-sensitive tape (Federal Specification PPP-T-60), or by tying. Closures must remain packaged until immediately prior to reinstallation on part.

o. Inspection certification seals and labels, cleaning identification labels, or certification and identification bag seals must not be broken except for reinspection or use of the part. If any one of the required certification seals or labels are broken or missing, perform the following, as applicable, in an approved clean area:

(1) Reinspect part if inspection certification labels or seals, required for protective closure certification, are broken or missing. If inspection reveals that no contamination has occurred, part may be repackaged without cleaning.

(2) Replace broken bags and broken or missing inspection certification labels only if sealed protective closures are intact and if inspection reveals that no contamination has occurred.

(3) Replace broken or missing precautionary and cleaning identification labels only if certification decals or labels are intact. If certification decals or labels show evidence of being disturbed, broken or missing precautionary and cleaning identification labels must not be replaced until inspection ascertains that the part will meet applicable cleaning requirements.

p. Inspect each protective closure and/or item of packaging material removed from clean part, to make certain that complete protective item is removed and that portions do not remain that could contaminate part.

1-49. INSPECTING.

1-50. The following paragraphs list the methods by which parts may be inspected for cleanness (paragraphs 1-51 through 1-58) and damage (paragraphs 1-59 through 1-62).

1-51. INSPECTING PARTS FOR CLEANNESS.

1-52. Methods that may be used to determine if parts are clean are: a particle count and nonvolatile residue determination test, visual test, water-break test, soiling test, and inspection for residual halogenated solvents.

1-53. PARTICLE COUNT AND NONVOLATILE RESIDUE DETERMINATION TEST. After final cleaning, a minimum of 5 percent of all items cleaned, but not less than one item for each group of 20 or less, must be selected at random for quantitative particulate and nonvolatile residue analysis. The sample selected must be representative of the items cleaned. In a clean container, obtain a sample of the final-rinsing fluid after it has passed over the critical surface area of the cleaned items. The size of required samples is noted in step a. Critical surface areas are defined as all hardware surfaces that may come in contact (directly or indirectly) with the respective service medium.

a. For components with a critical surface area of 1.0 to 5.0 square feet, obtain a 500-milliliter sample. For components with a surface area less than 1.0 square foot, a quantity of cleaned components sufficient to make up a minimum of 1.0 square foot must be combined. For components with a critical surface area greater than 5.0 square feet, obtain a 100-milliliter sample for each square foot of critical surface area.

b. Process component sample (filtration) for particle counting. Filter only a 500-milliliter portion of the sample taken from components with a surface area greater than 5.0 square feet. Filtrate collected in vacuum flask must be saved for nonvolatile residue content analysis (step e).

c. Using a magnification of 40 ±10X, count all particles on total effective filter paper surface area which are 175 microns or larger. Record particles in 3 groups: 175-700, 700-2,500, and over 2,500 microns. There is no difference between a particle or fiber, regardless of size and/or composition. Total effective filter paper surface area is defined as that area bounded by the inside diameter of the filtration apparatus funnel.

d. Count all particles in each range per square foot of critical surface area, and calculate as follows:

$$\text{Particles per square foot} = \frac{N}{a}$$

where

N = number of particles (within a size range) on total effective filter paper surface area

a = square feet of critical surface area sampled

Size Range (Microns)	Particles Allowable per Square Foot of Critical Surface Area
Smaller than 175	Unlimited
175-700	5
700-2,500	1
Larger than 2,500	None

e. Analyze filtrate collected in step b for determination of nonvolatile residue, using gravimetric technique. Nonvolatile residue (NVR) per square foot of surface area must not exceed 1.0 milligram. Calculate NVR as follows:

$$NVR = \frac{W_1 - W_2}{a}$$

where

W_1 = milligrams NVR weighed in component sample

W_2 = milligrams NVR weighed in blank sample

a = square feet of critical surface area sampled

1-53A. ACIDITY AND ALKALINITY TEST.

This test is performed after final cleaning of parts with critical surfaces that have been subjected to the particle count and nonvolatile residue determination test outlined in paragraph 1-53.

a. Wet external and accessible internal cleaned surfaces with a few drops of distilled water neutralized to a pH factor of 6.0 to 8.0.

b. Using pH indicating paper, test wetted surfaces. Acidity and alkalinity indicated must be within 6.0 and 8.0 pH.

c. Make sure residual water is removed from test surfaces.

1-54. VISUAL TEST. Inspect parts for presence of moisture, rust, scale, dirt, chips, oil, grease, or other debris. The presence of any of these requires recleaning. Discoloration caused by welding or passivation is not grounds for recleaning unless accompanied by rust or scale. Water-break and soiling tests may be performed, as required.

1-55. WATER-BREAK TEST. This test is performed on metallic parts by pouring a small amount of distilled water over visible and completely accessible cleaned areas of the part. An unbroken water film should form on the metal surface. If the water forms into small droplets, reclean the part. After testing, dry part as outlined in paragraph 1-35A, or hand-wipe with a clean, hemmed nylon cloth.

NOTE

Some materials, even if clean, do not present a water-break-free surface and require additional tests.

1-56. SOILING TEST. Lightly wipe cleaned part with a clean, lint-free, white cloth. Any visible deposit on the cloth requires recleaning of the part.

NOTE

Soft materials, such as aluminum, must not be rubbed hard, since metal removal can occur and be confused with dirt.

1-57. INSPECTING FOR RESIDUAL HALOGENATED SOLVENTS.

1-58. Perform this inspection with halogen leak detector 5797934G1 with probe detector H-5P (General Electric), or equivalent.

a. Connect leak detector power cable to 110-vac electrical source; then move function switch to HEATER position.

b. Allow leak detector to warm up for at least 15 minutes. Reading must be between 5 and 7 on 0-10 scale.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

c. Check that trichloroethylene vapors from cleaned parts are not at a concentration level that can be detected by odor. Purge part with 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, to reduce trichloroethylene vapors to a level that cannot be detected by odor. (Refer to paragraph 1-35A for drying procedure).

d. Open leak-detector probe needle valve 2 full turns from fully closed position by rotating probe tip.

e. Move leak detector function switch to MANUAL ZERO position, and move RANGE selector switch to 3 x 10^{-6} position.

f. Place leak-detector probe within 10 feet of part to be inspected. Then move ZERO adjustment knob until scale reading is zero. Do not change RANGE selector switch in order to obtain a steady zero indication. If a steady scale indication of zero cannot be obtained, move detection operation to an area where a steady zero can be obtained.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

g. Insert leak-detector probe into one end of part. Then supply 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 to opposite end at a flowrate of 0.1 to 0.3 cfm for 3 minutes. (Refer to paragraph 1-35A for drying procedure.) Leak-detector scale must indicate zero after approximately 30 seconds.

NOTE

A positive indication at the start of detecting may be due to an accumulation of residual trichloroethylene vapors. If the leak detector continues to give a positive indication and does not return to zero, trichloroethylene is present. The part containing trichloroethylene must be purged with heated low-pressure (less than 30 psig) gaseous nitrogen (MIL-P-27401) or heated, clean dry air conforming to the cleanness and humidity requirements of MIL-P-27401, as necessary, to accomplish the requirements of step g.

h. Repeat step g for remaining openings or passages in part.

i. Remove source of gaseous nitrogen, and secure leak detector.

1-59. INSPECTING FOR DAMAGE.

1-60. Visual inspection is normally a satisfactory method for determining damage. For parts where damage is suspected but not apparent, the dye penetrant or magnetic particle inspection methods may be used, as applicable. If inspection of a component, part, or weld reveals a defect that does not have an acceptability or repair disposition within this manual, the defect must be referred to the manufacturer's representative for acceptability and repair disposition. A component or part that cannot be repaired must be replaced with a component or part bearing the same part number.

1-61. DYE-PENETRANT INSPECTION METHOD. The dye-penetrant inspection method is used for parts treated by chemical film or anodic coatings and parts used for direct or indirect liquid oxygen service. This method of inspection may be used to detect surface defects or indications of possible defects in parts made of nonabsorbent, nonporous material. Dye-penetrant indications are not necessarily cause for rejection. It is the responsibility of a dye-penetrant inspector, certified by MIL-STD-410, to evaluate indications and to determine whether an indication actually represents a defect. Perform the dye-penetrant inspection as follows:

a. Clean part (paragraph 1-34) using appropriate method for type of service in which part is used.

b. Brush or spray a light, even coat of SKL-4 dye-penetrant (Magnaflux Corp) on areas to be inspected.

c. Allow penetrant to remain on part for a minimum of 5 minutes at 60° to 90° F. Parts that have been in an environment of less than 60° F must be preheated 60° to 150° F and allowed to remain at normal room temperature (60° to 90° F) for a minimum of 30 minutes prior to application of penetrant.

d. Remove excess penetrant with a clean, dry cloth followed by a water-dampened cloth.

e. Air-dry part for a minimum of one minute, or wipe part with clean, dry cloth or paper towel, prior to application of developer.

f. Thoroughly mix SKD-NF spot-check developer (Magnaflux Corp), and spray a thin even coat on area to be inspected.

g. Wait a minimum of 5 minutes, and inspect area for defects.

h. Clean part after inspection (paragraph 1-34) using appropriate method for type of service in which part is used.

1-62. MAGNETIC PARTICLE INSPECTION METHOD. Magnetic particle inspection is a nondestructive method of inspecting ferromagnetic materials. It reveals defects that cannot be detected by normal visual inspection. Magnetic particle inspection must be performed on equipment, and by personnel certified in accordance with MIL-STD-410. The magnetic particle inspection process consists of magnetizing the part to be inspected and applying a suitable inspection medium. When an electric current flows through a conductor magnetic lines of force are produced in and around the conducting element. These magnetic lines of force assume a position at right angles to the direction of current flow, requiring two methods of magnetization, circular and longitudinal. The method chosen depends upon the shape of the part and the direction of the required magnetic field. It is the responsibility of a certified magnetic particle inspector to evaluate indications to determine whether they actually represent defects. Demagnetize parts after magnetic particle inspection except parts inspected by yoke and powder method.

1-63. <u>REFINISHING ANODIC-COATED, PASSIVATED, AND PAINTED SURFACES.</u>

1-64. Damage consisting of scratches or abrasions on anodized surfaces may be touched up by the brush-on method, using chemical film materials and treatments meeting the requirements of MIL-C-5541. When damage to the anodized surface is extensive and requires that the part be completely reanodized, strip anodic coating and reanodize in accordance with MIL-A-8625. Damage consisting of scratches, abrasions, or corroded areas on CRES may be repassivated by the swab passivation method.

1-65. APPLYING CHEMICAL FILM TOUCHUP TO ANODIC-COATED PARTS.

1-66. Either Iridite 14-2 solution (Allied Research Products) or Alodine 1200 (Amchem Products) (steps d and e) may be used for applying chemical film touchup to parts after repair. The procedure for application of chemical touchup is as follows:

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.

a. Clean part using trichloroethylene (MIL-T-27602), and wipe part dry with soft, clean cloth.

b. Wearing rubber gloves, deoxidize part by applying a mixture of one part by volume of cleaning compound (MIL-C-5410, Type II) and one part distilled or deionized water at 65° to 95° F. Use a soft-bristle brush or clean cloth to apply mixture, and keep surface wet for 5-10 minutes.

c. Using a spray, rinse part in clean tap water at room temperature, or wipe part with a clean cloth frequently wrung out in clean water. Surface must rinse to a water-break-test (paragraph 1-55) condition.

WARNING

The following procedure uses Iridite and Alodine solutions, which are acids. Contact with these solutions can cause serious injury to personnel or damage to equipment.

d. Prepare Iridite 14-2 solution by mixing 6 ounces of Iridite 14-2 powder (Allied Research Products) and 0.01 ounce of ARP No. 2 detergent (Allied Research Products) in one gallon of water.

e. Prepare Alodine solution by mixing 4 ounces of Alodine 1200 powder (Amchem Products) with 0.5 ounce of nitric acid (Federal Specification O-N-350) in one gallon of water.

f. Wearing face shield and rubber gloves and using a soft-bristle brush or clean cloth, coat part with Iridite 14-2 solution for 3-5 minutes or with Alodine 1200 solution for 1-3 minutes. Coat only a small area at a time. If no color develops, repeat steps b, c, and f.

g. Rinse part by flushing with tap water. Avoid hand-rubbing, since wet film is easily removed.

CAUTION

Organic material upon which Iridite or Alodine solutions have dried becomes highly flammable.

h. Thoroughly rinse solution from brushes and cloths.

1-67. REPASSIVATING 300- AND 400-SERIES CORROSION-RESISTANT STEEL.

1-68. Reworked areas on CRES may be repassivated by swab passivation as follows: (Parts brazed with silver, copper, or nickel alloys must not be passivated. Do not passivate the following alloys: Hastelloy B, 440 A (annealed), Monel 440, 440 B (annealed), Monel K-500, 440 C (annealed), nickel 200, 440 F (annealed) or nickel 201.)

a. If area is corroded, remove corrosion as outlined in paragraph 1-26.

CAUTION

Wire brush must not be used on bellows sections.

b. If scratched or abraded, brush area to be passivated with fine-wire stainless-steel brush.

c. Polish area with crocus cloth.

WARNING

The following procedure uses trichloroethylene or trichloroethane, which are toxic solvents. Inhalation of the vapors or prolonged contact with the liquids 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.

d. Thoroughly clean area with a clean, hemmed nylon cloth dampened with clean trichloroethylene (MIL-T-27602) or cleaning compound (MIL-C-81302). Dry area with 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. (Refer to paragraph 1-35A for drying procedure).

WARNING

The following procedure uses nitric acid. Contact with nitric acid solution can cause serious injury to personnel or damage to equipment.

e. Prepare a 40-50 percent, by volume, solution of nitric acid (Federal Specification O-N-350). Slowly pour acid into required amount of distilled or deionized water.

eA. Obtain a cotton-tipped applicator and break off end containing cotton tip. Form a new tip on remaining portion of applicator using a suitable amount of Pyrex brand glass wool filtering fiber (Corning Glass Works). Remove excess fibers.

f. Using applicator, passivate area by swabbing with nitric acid solution at 10-minute intervals for a minimum of 60 minutes. If necessary, provide a barrier to prevent solution from contacting other surface or equipment.

g. Thoroughly rinse passivated area with tap water. Rinse and discard applicator.

h. Final-rinse area with deionized or distilled water.

i. Dry area with clean, dry cloth.

1-69. PAINTING.

1-70. Painted areas that have been damaged by handling, rework, or corrosion removal must be touched up to eliminate all bare or worn spots, as follows:

a. Using 400-grit Carborundum paper, feather edges of existing finish adjacent to damaged areas.

WARNING

The following procedure uses solvent (Federal Specification P-D-680, Type I), which is flammable and must not be used near heat or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

b. Clean reworked and surrounding area with a clean cloth dampened with solvent (Federal Specification P-D-680, Type I).

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

c. Dry area with 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. (Refer to paragraph 1-35A for drying procedure).

WARNING

The following specifies primer (MIL-P-8585), which is flammable and must not be used near heat, sparks, or open flame. It is toxic. Inhalation of its vapors or prolonged contact with the primer can cause serious bodily harm. In case of prolonged exposure, immediately obtain fresh air and wash skin with soap and water.

d. Within one hour after cleaning, prime area with a thin coat of zinc chromate primer (MIL-P-8585, color Y). Allow to air-dry for 30 minutes.

e. Apply a thin coat of nitrocellulose lacquer (Federal Specification TT-L-50). Allow to dry tack-free.

f. Apply a second coat of nitrocellulose lacquer (Federal Specification TT-L-50) and blend to obtain uniform coverage and appearance.

1-71. APPLYING LUBRICANTS, SEALANTS, AND COMPOUNDS.

1-72. Lubricants, sealants, and compounds that are contaminated, whose shelf-life has expired, or whose container labels are missing or unidentifiable must not be used. Clean nylon or polyethylene gloves must be worn where hand contact is made with sealing surfaces or surfaces that contact operating fluids (liquid or gas). Parts that will be reinstalled must have the original lubricant, sealant, or compound removed from the part and mating surfaces before lubricating. Lubricants, sealants, and compounds must be applied only to the areas designated. All stored containers must be tightly capped and excess lubricant, sealants, or compounds must not be returned to the original container. All lubricants, sealants, and compounds must be free of grit, dirt, metal chips, or other foreign matter. The methods outlined below which will be referenced in the following procedures, must be used to apply lubricants, sealants, and compounds. The following definitions apply to these methods:

(1) O-ring: A circular packing, gasket, or seal having a torus or doughnut shape. The O-ring cross section is usually round and has a small diameter relative to the inside and outside diameter of the O-ring.

(2) Seal: Any sealing device other than an O-ring.

(3) Static Condition: When an installed part encounters no movement except for vibrational or load forces.

(4) Dynamic Condition: Where an installed part encounters planned movement.

NOTE

Only the lubrication methods used in R-3896-3, Volume I, R-3896-3, Volume II, and R-3896-11 are listed.

1-73. METHOD A - APPLYING LUBRICANT TO STRAIGHT THREADS (STATIC CONDITION).

a. Apply lubricant in a streak, flush with outside peaks of male threads, and across all threads except leading edge of first thread.

NOTE

The number and width of streaks vary with the outside diameter of threads.

b. Where more than one application is required, apply lubricant in equally spaced streaks around circumference of threads as follows:

(1) Threads up to 1/2 inch in diameter, one application 1/8 to 1/4 inch wide.

(2) Threads 1/2 to 1 inch in diameter, one application 3/8 inch wide.

(3) Threads 1 to 1-3/4 inches in diameter, two applications 1/2 inch wide.

(4) Threads 1-3/4 to 2-1/2 inches in diameter, three applications 1/2 inch wide.

(5) Threads 2-1/2 to 3 inches in diameter, four applications 1/2 inch wide.

(6) Threads over 3 inches in diameter, five applications 1/2 inch wide.

c. Distribute lubricant streaks uniformly around threads with a clean nylon brush. Remove excess lubricant. Make sure there is no lubricant on leading edge of first thread, in fitting openings, or on flared or chamfered sealing surfaces.

1-74. METHOD F - APPLYING LUBRICANT TO WASHERS.

a. Apply a thin film of lubricant to both sides of washer.

b. Remove excess lubricant.

1-75. METHOD G - APPLYING LUBRICANT TO TUBE COUPLING NUTS.

a. Slide coupling nut back on tube and remove any existing lubricant with a clean nylon cloth.

b. Apply a thin uniform film of lubricant to exterior thrust surface of sleeve or machined seat as shown in figure 1-7.

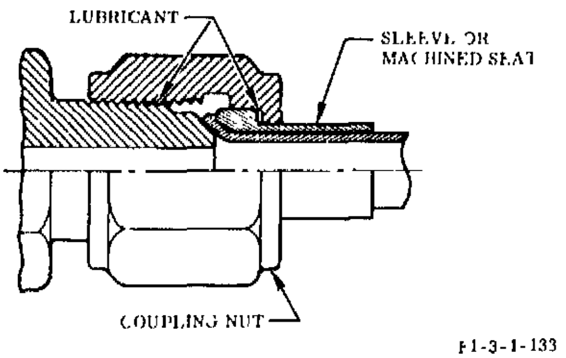


Figure 1-7. Flared Tube Lubrication

c. Remove all excess lubricant from end face and sealing surface of flare, to prevent contamination of system.

1-76. METHOD J - APPLYING LUBRICANT TO O-RINGS (STATIC CONDITION).

a. Distribute lubricant over O-ring surface to form a thin, uniform film.

b. Remove excess lubricant.

1-77. METHOD K - APPLYING LUBRICANT TO O-RINGS FOR RETENTION.

a. Distribute lubricant over O-ring surface to form a thin, uniform film. Remove excess lubricant.

b. Apply a volume of lubricant approximating 10-15 percent of O-ring volume or groove volume on O-ring or in groove during installation of O-ring.

1-78. METHOD L - APPLYING LUBRICANT TO O-RINGS (DYNAMIC CONDITION).

a. Apply a thin, uniform film of lubricant on O-ring surface. Remove excess lubricant.

b. Apply a volume of lubricant approximating 25-30 percent of O-ring volume or groove volume on O-ring or in groove during installation of O-ring. Apply excess to dynamic surface mating with the O-ring to form a uniform film.

c. Apply additional lubricant, if required, to mating surface to provide a thin, uniform film over the working surface. Remove excess lubricant from mating surface.

1-79. METHOD M - APPLYING OIL TO O-RINGS (STATIC CONDITION).

a. Apply a thin film of oil uniformly over O-ring surface.

b. Remove excess oil.

1-80. METHOD N - APPLYING OIL TO O-RINGS (DYNAMIC CONDITION).

a. Dip O-ring into oil and let excess oil drip from O-ring.

b. Install O-ring while it is thoroughly wet with oil.

1-81. METHOD O - APPLYING SEALANTS TO FLAT SEALS (STATIC CONDITION).

a. Apply sealant to both flat sides of seal until sides are thoroughly wet.

b. Remove excess sealant globules by wiping.

c. Allow applied sealants that contain solvents to air-dry for 3 to 5 minutes before installing part. Sealants containing solvents include gasket sealant RB0120-034 (Rocketdyne) and all Permatex (Permatex Co) sealants.

1-82. METHOD Q - APPLYING SEALING COMPOUNDS TO CHEVRON SEALS.

a. Apply sealing compound to both sides of seal until surfaces are thoroughly wet.

b. Work sealing compound into areas between spirals.

c. Remove excess sealing compound from inner and outer diameters of seal.

d. Remove sealing compound from groove of inner diameter of seal.

1-83. METHOD R - APPLYING LUBRICANTS TO METAL BOSS SEALS.

a. Apply lubricant with a clean lint-free application to both sides of seal.

b. Remove excess lubricant until a thin, uniform film remains on sides of seal. Make sure that no lubricant is on inner diameter of seal.

1-84. METHOD T - APPLYING SEALANT AND ANTIZEIZE DISPERSION TO GASKETS, SEALS. AND WASHERS.

a. Mix sealant and antiseize dispersion RB0120-017 (Rocketdyne) by following instructions packaged with kit. Date mixture.

CAUTION

Dispersion may be used up to 60 days after mixing. A preparation that has not been dated or is more than 60 days old must not be used.

b. Shake container to completely disperse particles and using a clean nylon brush, apply dispersion to sealing surfaces of part. Allow dispersion to dry for 5 to 7 minutes.

c. Apply a second coat of dispersion and install part while dispersion is still damp.

1-85. METHOD V - APPLYING LUBRICATING POWDER. Parts that have been special-cleaned need not be recleaned as outlined in this procedure. Soiled parts must be cleaned and lubricated as follows:

WARNING

The following procedure uses acetone (Federal Specification O-A-51), 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.

a. Clean all-metal parts with acetone (Federal Specification O-A-51). Dry parts as outlined in paragraph 1-35A.

b. Clean and dry nonmetal parts in mild alkaline cleaner as outlined in paragraph 1-41.

c. Using a clean nylon cloth, rub powdered lubricant on surface until a film of uniform luster appears on all surfaces to be lubricated.

NOTE

Pressure-sensitive tape RB0195-002 (Rocketdyne) may be used for masking, if required.

d. Remove loose or caked powder.

e. Rub part with a clean, nylon cloth. The finished film must still appear after rubbing.

1-86. METHOD W - APPLYING LUBRICANT TO PLAIN BEARING SURFACES.

a. Apply lubricant to part during installation or pack clearance volume during assembly.

b. Remove excess lubricant by wiping.

1-87. METHOD Y - APPLYING LUBRICANTS TO BALL, ROLLER, AND NEEDLE BEARINGS.

a. Coat races and bearings with lubricant.

b. Hand-pack approximately 1/3 of clearance volume with lubricant during assembly.

1-88. METHOD Z - APPLYING LUBRICANTS TO METAL SLIDING SURFACES.

a. Apply a uniform coat of lubricant to mating parts.

b. Assemble parts and remove excess lubricant. Make sure that lubricant does not enter vent, pilot, or bleed openings.

1-89 through 1-92A. (Deleted)

1-93. ENGINE SEALS.

1-94. During maintenance and repair, all seals except seal plates and K-seals used on seal monitoring port plugs, must be replaced by parts with the same part number. For K-seal usability refer to paragraph 1-97. Pressure-actuated (Naflex) seals and seal plates must be handled as outlined in paragraphs 1-95 and 1-96. When it becomes necessary to replace an orifice with in-place seals, the replacement must bear the same part number and have the same orifice diameter. The replacement for an engine variable orifice must meet the cleaning requirements of paragraph 1-137.

1-95. PRESSURE-ACTUATED (NAFLEX) SEALS. A new seal must be installed whenever a joint is opened. Handle Teflon-coated and metallic-plated Naflex seals as follows:

CAUTION

Naflex seals are to be handled with extreme caution. Sliding a seal out of a partially opened package can damage its sealing surface. The touch of a fingernail on the sealing surface of a Teflon-coated Naflex seal can destroy its sealing capability.

a. Completely open package and remove seal just before installation only.

b. Handle seal by outside diameter only.

c. Do not slide seal across any surface.

d. Before installing seal, visually inspect flange sealing surfaces that seal will contact to determine that foreign particles, nicks, and scratches are not present. Machining marks on flanges are acceptable.

e. Visually inspect the following areas of copper-plated and silver-plated seals. The presence of any of the conditions listed for each area, as observed with the unaided eye, is justification for rejection of the seal.

(1) Primary sealing surface: Scratches, dents, pinholes, blisters, pits, nodules, lack of adhesion, oxidation as indicated by green discoloration on copper-plated seals, or other obvious defects.

(2) Secondary sealing surface: Pinholes, blisters, or nodules exceeding 0.030 inch in diameter; more than 6 pinholes, blisters, or nodules on a side for each measured inch of inside diameter of seal; 2 pinholes, blisters or nodules closer than 0.030 inch to each other; pinholes, blisters, scratches, or nodules forming a radial leakage path; more than 2 scratches extending less than halfway across a sealing surface; or a scratch extending more than halfway across a sealing surface.

eA. Visually inspect the following areas of Teflon-coated seals. The presence of any of the conditions listed in substeps 1 and 2 are justification for rejection of the seal if detected with the unaided eye. The presence of any of the conditions listed in substep 3 are justification for rejection of the seal if detected with magnification not exceeding 4 diameters.

(1) Primary sealing surface: Variations in surface roughness, particle entrapment in coating, mud cracks, craters, pinholes, sags, runs, bubbles, blisters, peeling, shredding, tears, grooves, or ridges in coating.

(2) Secondary sealing surface: Pinholes or depressions exceeding 0.030 inch in diameter; 2 pinholes or depressions closer than 0.030 inch to each other; more than 2 pinholes or depressions on a side for each measured inch of the inside diameter of the seal; pinholes or depressions clustered in more than groups of 4; pinholes, scratches, or depressions forming a radial leakage path; more than 2 scratches extending less than halfway across a sealing surface; or a scratch extending more than halfway across a sealing surface.

(3) Electroless nickel-plated surfaces: Blisters, cracks, pitting, or other surface defects.

f. When positioning seal on a flange, hold seal-flange movement to a minimum.

g. When installing seals between bolted flanges, carefully place seal between flanges; then install 2 opposite bolts and tighten just enough to close joint. Install remaining bolts, and tighten all bolts to required torque using cross-torquing method outlined in paragraph 1-115.

h. Take extreme care when removing seals from engine, since seals may be reprocessed to a like-new condition.

i. Package and return all seals for refurbishment through normal supply channels.

j. Store seals in a safe place to prevent damage and contamination.

1-96. SEAL PLATES. Seal plates that contain molded rubber seals must be handled with care to protect the sealing surfaces from damage. Any damage to the sealing surfaces can destroy the sealing capability and cause the seal to be rejected. Seal plates are reusable if they are visually inspected to determine that no damage exists. Handle seal plates as follows:

a. Open flanged joints far enough to allow seal plate to be removed without scraping flange surfaces.

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. Clean seal plate with a clean cloth moistened with cleaning compound (MIL-C-81302).

c. Inspect sealing surfaces for nicks, scratches, and other imperfections that can impair sealing capability.

d. If a seal plate is considered acceptable for reuse, package it in a clean polyethylene bag until ready for installation.

NOTE

When a seal plate is removed from an engine, the molded rubber seal may have a set (flattened rubber seal). Seal plates with this condition may be reused if the rubber seal extends above the surrounding metal surface and no damage (nicks, scratches, or other imperfections) that would affect sealing capability is present. Normally within 24 hours and depending on conditions of material and time, the molded rubber seal will return to near original configuration (0.015 inch to 0.020 inch above the metal surface).

e. Prior to installing seal plate, visually inspect flange, spacer, and other component sealing surfaces that seal will contact to determine that foreign particles, nicks, and scratches are not present. Machining marks on flanges are acceptable.

f. Inspect reusable or new seal plate sealing surfaces for nicks, scratches, and other imperfections that can impair sealing capability.

g. Open flanged joint far enough to allow seal plate to be installed without scraping flange and seal surfaces.

1-97. K-SEALS. A new K-seal must be installed whenever a K-seal joint, except for seal monitoring port plugs, is loosened or opened after the K-seal is torqued using the following method. Torque fittings using K-seals to torque value specified in the detail procedure. To obtain optimum even seating of the K-seal, the fitting may be backed off one full turn (one time only); then retorqued to the torque value specified in the detail procedure. The RE261-3004-XXXX-series K-seals are interchangeable with 12100AA and 12100CR K-seals of equivalent dash number, size, and type. The disposition of seal monitoring port K-seals may be determined as follows:

a. If radial scratches are visually detectable (without magnification) on leg and flat-face surfaces, replace seal.

b. If damage, such as nicks or dents on any part of seal is obvious, replace seal.

c. If irregular coating or plating is removed from flat face as a result of peeling or flaking, replace seal.

d. Scratches with no apparent depth are acceptable.

e. Circular contact marks resulting from normal installation wear are acceptable.

f. All seals are to be checked for possible contamination and cleaned as outlined in paragraph 1-34, if necessary, prior to reinstallation.

1-98. AGE CONTROL OF SYNTHETIC RUBBER PARTS.

1-99. Age control of synthetic rubber parts and assemblies containing synthetic rubber parts begins the date the raw materials are cured and governs the shelf life, installed life, acceptable life, and replacement date. The allowable ages of controlled parts are in quarters of years. Parts are considered one quarter old at the end of the first full quarter after curing or installation, as applicable. Installation date markings on parts show the quarter of the year, the letter Q, and the last two numerals of the year. For example, 2Q67 indicates that the item was installed the second quarter of the year 1967. Refer to R-3896-11 for verification and documentation of engine-installed synthetic rubber parts. Definitions of terms used for age-controlled items are as follows:

a. Cure date: The date the basic raw material is cured by the manufacturer.

b. Shelf life: The period of time the item is stored from cure date to installation/assembly date or to expiration of the acceptable shelf life.

c. Installation date: The date the item is removed from its protective package for installation.

d. Installed life: That period of time from installation date to replacement date.

e. Replacement date: The date the installed life expires.

f. Acceptable life: The maximum is 12 quarters for shelf life and as specified in R-3896-11 for installed life.

1-99A. COMPONENT PREINSTALLATION TEST REQUIREMENTS.

1-99B. Selected F-1 engine components require additional testing as outlined in R-3896-3, Volume II before installing a replacement component on engine. Test requirements are as follows:

Component	Test Requirements
Thrust OK pressure switch	(1) Perform insulation resistance test, leak test, and function test within 6 months. (2) Perform actuation and deactuation test within one week.
Checkout valve	Perform outlet No. 1 seal reverse leak test, reverse flow and reseat test, timing test, leak test, and poppet leak test within 6 months.
Engine control valve	Perform surface wetting leak test, external leak test, and check valve seat leak test within 12 months.
Four-way solenoid valve	Perform surface wetting leak test and external leak test within 12 months.
Fuel valve position transducer, oxidizer valve position transducer, and gas generator ball valve position switch	Perform open and closed position switch continuity verification test within one week.
Volumetric liquid oxygen transducer (oxidizer flowmeter)	Perform coil continuity test within one week.
Temperature transducers	(1) Perform insulation resistance test on oxidizer pump bearing temperature transducer within one week. (2) Perform resistance test on all temperature transducers within one week.
Pressure transducers	Perform function test within one week.

Component	Test Requirements
Flight instrumentation junction box	Perform insulation resistance test and continuity test within one week.
Electrical harnesses and cables	Perform insulation resistance test and continuity test within one week.

1-100. RIGID AND FLEXIBLE TUBING INSTALLATION REQUIREMENTS.

1-101. Rigid and flexible tubing must be routed and supported as outlined in detailed installation procedures and meet the requirements of paragraphs 1-102 through 1-108.

1-102. RIGID TUBING INSTALLATION.

1-103. Place the tubing (line) in position loosely supported by clamps and blocks. The line or tubing must be able to float in clamps and blocks without restraint. Aline both flared ends with the sealing surfaces of the fittings. Tighten coupling nuts with fingers to seat flares. Hold fittings with wrench and torque coupling nuts. Tighten line clamps and blocks after tube or line is secured at both ends.

1-104. RIGID TUBING SUPPORT. Clamps and line blocks must be positioned to meet the maximum allowable distance between supports, as applicable for tubing (line) size. Recommended maximum spacing in inches between line supports is as follows:

a. 1/4 to 3/8 inch outside diameter lines, 18 inches maximum spacing

b. 1/2 to 3/4 inch outside diameter lines, 25-1/2 inches maximum spacing

c. One inch and larger outside diameter lines, 30 inches maximum spacing

1-105. RIGID TUBING CLEARANCE. When either of two parts is designed for dynamic motion (independent of vibration) 1/2-inch clearance must be maintained between the tubing and the adjacent part. Lines or tubing under static conditions must have a minimum of 1/8-inch clearance between the line or tubing and any adjacent part except as specified in detailed installation procedure or in the following areas:

a. Between the turbopump insulation and the transducer clamp at tap LB1b, 0.060 inch minimum allowable clearance

b. Between the propellant valves open tube and the propellant valves close tube, adjacent to No. 1 oxidizer valve, 0.030 inch minimum allowable clearance

c. Between No. 1 oxidizer valve dome purge tube tee and fuel inlet manifold, 0.060 inch minimum allowable clearance

d. Between fuel inlet seal drain tubes and turbine manifold clevis cover, 0.015 inch minimum allowable clearance.

1-106. FLEXIBLE HOSE INSTALLATION REQUIREMENTS.

1-107. Flexible hoses must be supported and protected during installation from flexing beyond the minimum bend radii used in final installation. The following general requirements are applicable:

a. Hoses are not to be stretched between end fittings; allow 5 percent of hose length for slack.

b. Route and support hose to provide a minimum of 1/2-inch clearance between hose and adjacent parts.

c. Avoid sharp bends (1-1/2-inch minimum installed radii), distortion, or excessive strain at hose ends or supports.

1-108. FLEXIBLE HOSE INSTALLATION. Flexible hoses with flared ends must not be twisted (torsionally deflected) during installation.

a. Position clamps and supports to provide hose clearance, routing, and loose support during installation.

b. Place hose in clamp and aline; hand-tighten coupling nut at one end. Hold fitting with a wrench and torque hose coupling nut.

c. Make sure that hose is not twisted, is free from binds or restraints, and floats in clamps and supports.

d. Hand-tighten coupling nut on opposite end of hose. Hold fitting with a wrench and torque coupling nut.

e. Check hose for installed twist and sharp bends. Tighten clamps and supports.

1-109. INSTALLING THREADED FASTENERS.

1-110. During maintenance and repair, the installation of threaded fasteners is governed by the following general requirements:

a. Structural bolts or screws one dash number above that called out may be used to join pressurized or load-carrying components provided that the thickness of the joint thinner flange at the bolthole location is 0.125 inch or greater.

b. For structural joints (load carrying or pressurized), additional washers of the same callout may be added up to a total added thickness of 10 percent of the thinner flange, at the bolthole location.

c. Deviation of bolt-length dash numbers and the number of washers used in steps a and b is not permitted for bolts and screws used with screw thread inserts.

d. For nonstructural applications, bolts or screws three dash numbers above or below those called out may be used if there is full thread engagement and no interference occurs.

e. Single washers, except countersunk washers, are installed at the nut end; however, when more than one is specified, the washers must be evenly divided between the head and nut ends of the bolt.

f. There must be no threads in bearing in any part of a joint where the bolts or screws transmit a shear load, except one or two threads may be in bearing when the material next to the nut meets the minimum thickness requirements. Parts having relative movement at the fastener must not have threads in bearing.

g. Bolts used with self-locking nuts or inserts must not have cotter pin holes in the threaded shank.

h. Threaded parts must not be lubricated unless all of the following conditions prevail:

(1) Both parts are bare, corrosion-resistant steel.

(2) A lubricant for the service encountered is specified.

(3) A specific torque value is given.

i. Torquing of fasteners is performed by applying specified torque to the fastener. Fastener groups utilize the cross-torque method outlined in paragraph 1-116.

j. When a fastener is installed in a nut (except castellated nuts), at least one full thread must protrude through the top of the nut. Fasteners installed in inserts must penetrate the full length of the perfect threads of the insert.

1-111. REPAIRING THREADS. Threads may be repaired if the total damage to the threads does not exceed 50 percent of one thread. Threads that are considered repairable must be repaired with the proper size tap or die. Replace parts whenever total thread damage exceeds 50 percent of one thread.

1-112. INSTALLING COUNTERSUNK HIGH-STRENGTH AND HIGH-BEARING WASHERS. Whenever countersunk washers RD153-5003-XXXX or MS20002 are required, the washer countersunk side must be installed adjacent to the bolt fillet radii. Figure 1-8 shows a high-tensile-strength bolt and nut installation using countersunk, high-bearing washers.

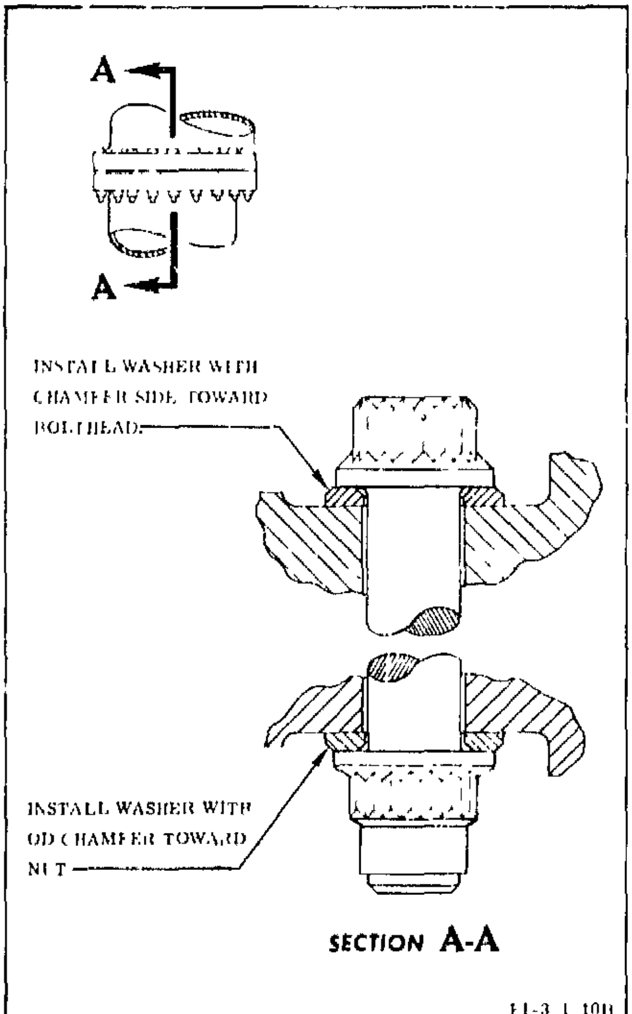


Figure 1-8. Installing Countersunk High-Strength and High-Bearing Washers

1-113. TORQUING.

1-114. Torque is a twisting force used to apply tension to fasteners. Proper torque produces sufficient tension in tube fittings to create a tight seal while staying below the elastic limits of the part. To achieve proper tension by torque measurement, the parts must be clean, and when required, lubricated correctly, or false torque readings will result. The torque values called out in procedures in other sections of this manual are design requirements that result in maximum strength and sealing characteristics in the parts.

1-115. USING TORQUE WRENCH. Torque wrenches are precision tools and must not be subjected to abuse or misuse. The use of an extension (figure 1-9) on a torque wrench will result in greater torque application than indicated on the dial. To obtain correct torque readings, the following steps must be strictly adhered to:

a. All torque wrenches must meet the calibration requirements of Federal Specification GGG-W-00686, to compensate for wear. Do not use torque wrenches after the void date shown on each wrench, and never keep them in tool boxes or line supply cabinets.

b. Select the correct torque wrench so that wrench will be operated in its upper range (20-100 percent).

NOTE

When a torque wrench is calibrated to Federal Specification GGG-W-00686, it is not necessary to compensate for calibration tolerances when applying torque values specified in the manual.

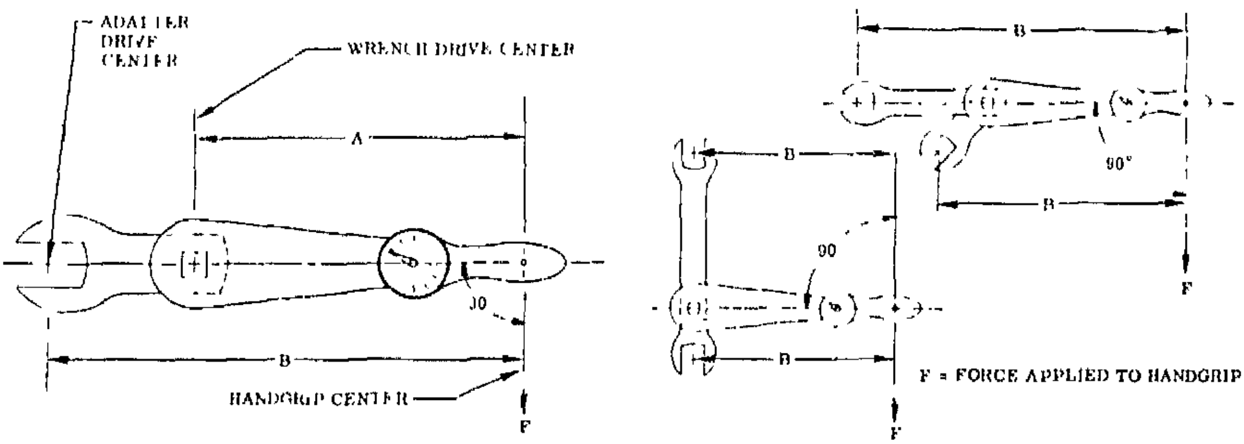
c. Take torque readings only while tightening the fastener. Do not overtighten and then loosen to the desired torque value.

d. Never jerk torque wrench. Apply force slowly and at 90 degrees to torque wrench handle for an accurate indication of torque being applied to fastener.

e. Do not attempt to use torque wrench to tighten fastener to a higher value than maximum value shown on torque wrench indicator.

f. Sockets must be installed fully on the nut or bolt. Maintain a slight inload on the tool to lessen the changes of damage to the fastener.

1-116. FASTENER CROSS-TORQUE METHOD. The cross-torquing method shown in figure 1-10 must be used for multibolt applications of bolted



When using an extension adapter on a torque wrench the actual torque value applied may be widely different from the indicated torque value and may be above or below the allowable tolerance unless the proper conversion is used. When the adapter is used at right angles to the torque wrench centerline, dimensions A and B are equal the conversion factor is 1.00, and the indicated and applied torque values are the same. When the adapter is attached to the torque wrench to effectively lengthen or shorten the moment of applied force the B dimension changes, and the indicated torque value must be converted to make sure that the proper torque value is applied as follows:

1. Measure length of torque wrench from handgrip center to wrench drive center. This is dimension A.
2. With adapter attached to torque wrench in position for use measure length of torque wrench and adapter. This measurement (dimension B) is taken from handgrip center to adapter drive center.
3. Divide dimension A by dimension B to obtain conversion factor.
4. Multiply required torque value (applied) by conversion factor to obtain torque reading (indicated) that must be used with adapter on wrench. For example:

   Dimension A on torque wrench is 12 inches. With adapter installed dimension B is 17.365 inches. A ÷ B = 12 ÷ 17.365 = 0.691. Assuming the torque wrench with the adapter installed as a straight extension is to be used to tighten a bolt for which the torque value is 570-630 in-lb, 0.691 × 570 = 393.87 and 0.691 × 630 = 435.33. The torque reading (indicated) to be used when this particular adapter is installed on the torque wrench is 394-435 in-lb. If this adapter were installed on the torque wrench in any other position, dimension B would be different and a different torque reading would apply.

Figure 1-9. Recomputing Torque Values

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, in the pattern shown in figure 1-10, until all fasteners are evenly torqued to the desired torque value.

1-117. SAFETYWIRING.

1-118. Safetywiring is the securing together of two or more parts with a wire that is installed in such a manner that the lockwire will be put in tension on at least one side of the bolt or screw head when the part tends to loosen.

1-119. SAFETYWIRING METHODS. The lockwire must be as short as possible and attached in the most direct manner. A pigtail of 1/4 to 1/2 inch (3-6 twists) must be made at the end of the wiring and bent back or under in a direction that increases tension to prevent it from becoming a snag. When installation of an aluminum seal is specified in detail procedures, use seal RD199-0001-0001 on the lockwire pigtail. Damage to seal anodizing due to installation, assembly, or marking is permissible. The lockwire must pass around the fastener head; however, on MS-type, internal-wrenching, taper-head bolts the wire must pass over the head, and on 12-point, external-wrenching-head bolts the wire or wires must pass through the head. The single-wire method may be used for small screws in a closely spaced, closed geometrical pattern, or on parts in electrical systems and in places that are difficult to reach. The double-twist method of safetywiring is normally used for most fasteners. When safetywiring widely spaced (maximum spacing is 6 inches) multiple groups by the double-twist method, three units is the maximum number in-series. When safetywiring closely spaced multiple groups, the number of units that can be

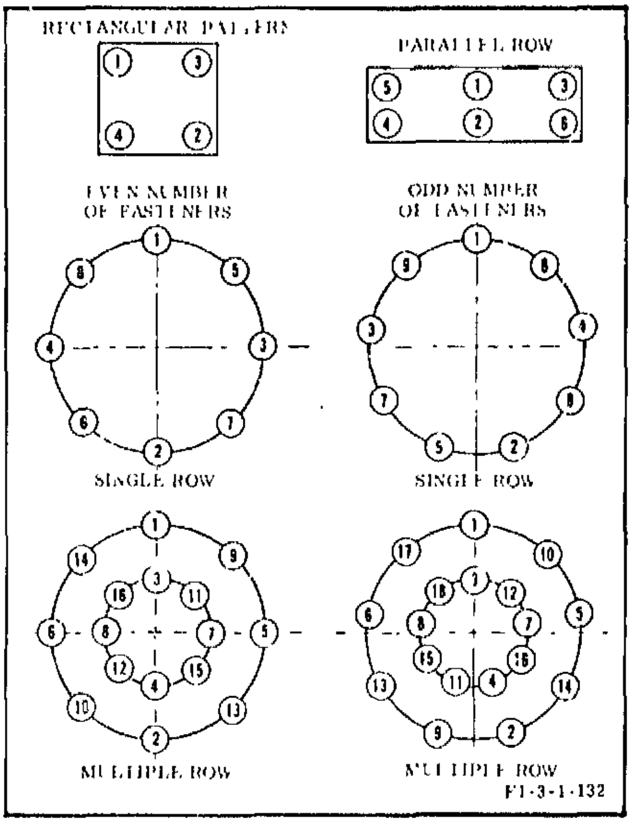


Figure 1-10. Fastener Cross-Torquing Method

safetywired by a 24-inch length of wire is the maximum number in series. Any lockwire application that complies with Military Standard MS33540 and meets maximum number in series. Any lockwire application that complies with Military Standard MS33540 and meet the requirements of paragraphs 1-118 and 1-119 is acceptable. Typical safetywiring methods are shown in figure 1-11. Caution must be used during the twisting operation to keep the wire tight without overstressing. Abrasions caused by commerically available wire-twisting pliers are acceptable, but nicks, kinks, and other mutilations caused by improper tooling and wiring techniques are not acceptable. Lockwire must be installed only one time; destroy wire if removed for any reason. Parts having lockwire holes must be lockwired unless otherwise specified in applicable procedure. In all cases, wiring must be done through the holes provided. In the event that no wire hole is provided, wiring must be to a convenient neighboring part in a manner so as not to interfere with the function of the part. Inconel lockwire MS20995N is used for safetywiring when specified in detailed installation and assembly procedures, and the following items are drilled for lockwire:

(1) Bolts and screws (drilled heads and not secured with nuts)

(2) Nuts

(3) Electrical connectors

(4) Tubing coupling nuts

1-120. REMOVING AND INSTALLING THREAD INSERTS, HI-LOK FASTENERS, AND BLIND NUTS.

1-121. These procedures provide data for removing and installing thread inserts and studs, Hi-Lok fasteners, and blind nuts. Keenserts inserts and studs and Heli-Coil inserts may be removed and replaced if damaged. The same-size replacement insert is installed in the undamaged, originally tapped hole. (Refer to R-3896-4 for correct part numbers of inserts and fasteners.)

1-122. REMOVING KEENSERTS INSERTS AND STUDS. (See figure 1-12.)

a. Remove insert by drilling to diameter and depth indicated in Removal Data column of figure 1-13.

b. Bend exposed portion of kees inward and break off.

c. Drive in extractor tool, and back out insert.

d. Remove stud by cutting off stud just above parent metal, exposing internal pilot hole in stud.

e. Drill out pilot hole to diameter and depth indicated in Removal Data column of figure 1-14.

f. Bend exposed portion of kees inward and break off.

g. Drive in extractor tool, and back out stud.

NOTE

Chrome molybdenum studs, identified by two parallel marks on top, that are under 1/4 inch in diameter do not have pilot holes.

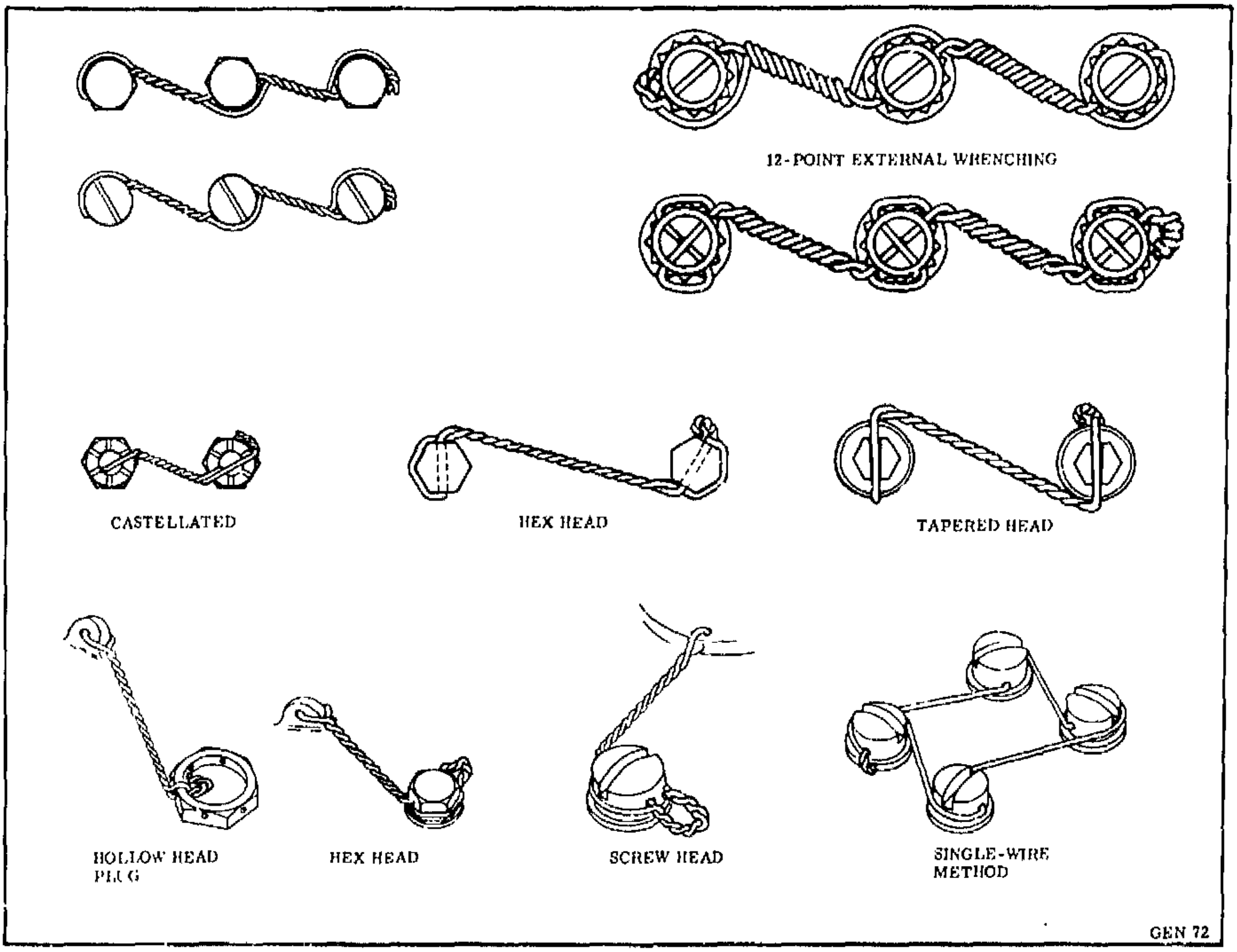


Figure 1-11. Safetywiring Methods

1-123. INSTALLING KEENSERTS INSERTS AND STUDS. (See figure 1-12.)

a. Select correct replacement insert using R-3896-4. See figure 1-13 for tap size and installing tool required for insert selected. Comply with step g, if applicable.

b. If necessary, chase threads to remove burs.

c. Clean tapped hole to remove all chips.

d. Install insert by turning with fingers, or fit kees into tool slots and turn tool.

e. Install insert to a depth of 0.010 to 0.030 inch below surface of parent metal. Aline insert kees with original slots in parent metal.

f. Lift and turn installing tool so slots clear kees. Drive in kees using a hammer or an arbor press and installing tool.

g. (Deleted)

NOTE

Keenserts studs are installed by the same method as Keenserts inserts, except that the installing tool has an internal pilot hole to fit over the stud. (See figure 1-14.)

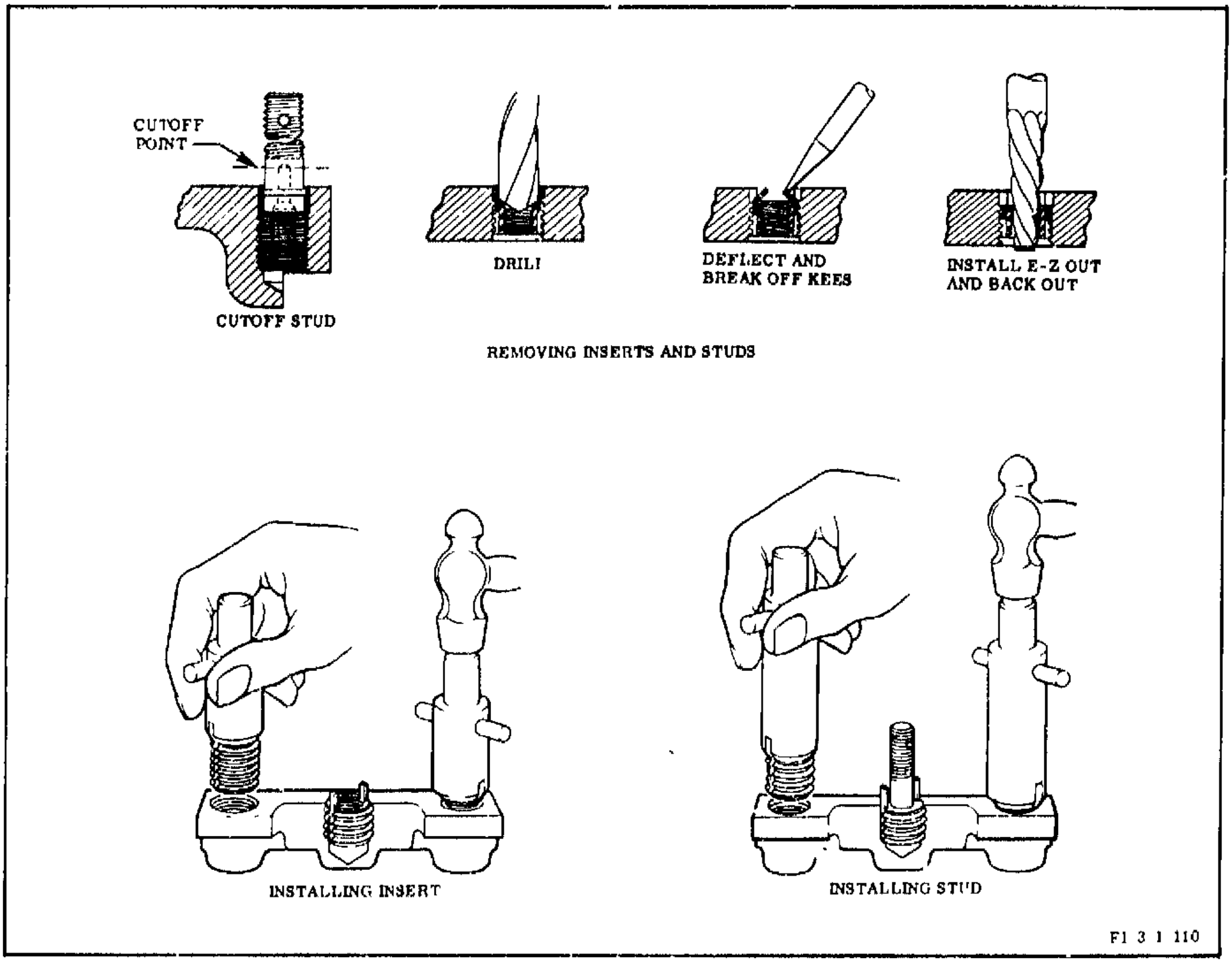


Figure 1-12. Removing and Installing Keenserts Inserts and Studs

Insert Number (Internal Thread)	NAS Number	Installation Data: Tap (UNC-2B) Size	Installation Data: Tap (UNC-2B) Min Depth (Inch)	Installation Data: Tool Number	Removal Data: Drill Size (Inch)	Removal Data: Drill Depth (Inch)
LIGHTWEIGHT INSERTS						
KN 0832	NAS1394C-08	1/4-20	0.31	T 0832	3/16	1/8
KN 1032	NAS1394C-3	5/16-18	0.37	T 1032	7/32	5/32
KN 1024		5/16-18	0.37	T 1024	7/32	5/32
KN 428	NAS1394C-4	3/8-16	0.43	T 428	9/32	3/16
KN 420		3/8-16	0.43	T 420	9/32	3/16
KN 524	NAS1394C-5	7/16-14	0.50	T 524	11/32	3/16
KN 518		7/16-14	0.50	T 518	11/32	3/16
KN 624	NAS1394C-6	1/2-13	0.56	T 624	13/32	3/16
KN 616		1/2-13	0.56	T 616	13/32	3/16
KN 720	NAS1394-7	9/16-12	0.62	T 720	15/32	3/16
KN 714		9/16-12	0.62	T 714	15/32	3/16
KN 820	NAS1394C-8	5/8-11	0.68	T 820	17/32	3/16
KN 813		5/8-11	0.68	T 813	17/32	3/16
LIGHTWEIGHT LOCKING INSERTS						
KNL 0832	NAS1394C-08L	1/4-20	0.31	T 0832L	3/16	1/8
KNL 1032	NAS1394C-3L	5/16-18	0.37	T 1032L	7/32	5/32
KNL 1024		5/16-18	0.37	T 1024L	7/32	5/32
KNL 428	NAS1394C-4L	3/8-16	0.43	T 428L	9/32	3/16
KNL 420		3/8-16	0.43	T 420L	9/32	3/16
KNL 524	NAS1394C-5L	7/16-14	0.50	T 524L	11/32	3/16
KNL 518		7/16-14	0.50	T 518L	11/32	3/16
KNL 624	NAS1394C-6L	1/2-13	0.56	T 624L	13/32	3/16
KNL 616		1/2-13	0.56	T 616L	13/32	3/16
KNL 720	NAS1394C-7L	9/16-12	0.62	T 720L	15/32	3/16
KNL 714		9/16-12	0.62	T 714L	15/32	3/16
KNL 820	NAS1394C-8L	5/8-11	0.68	T 820L	17/32	3/16
KNL 813		5/8-11	0.68	T 813L	17/32	3/16

Figure 1-13. Keenserts Insert Removal and Installation Data (Sheet 1 of 3)

Insert Number (Internal Thread)	NAS Number	Installation Data			Removal Data	
		Tap (UNC-2B)				
		Size	Min Depth (Inch)	Tool Number	Drill Size (Inch)	Drill Depth (Inch)
HEAVY-DUTY INSERTS						
KNH 0440	NAS1395C-04	12-24	0.31	TH 0440	5/32	1/8
KNH 0632	NAS1395C-06	1/4-20	0.31	TH 0632	3/16	1/8
KNH 0832	NAS1395C-08	5/16-18	0.37	TH 0832	7/16	1/8
KNH 1032 KNH 1024	NAS1395C-3	3/8-16	0.37	TH 1032 TH 1024	9/32	1/8
KNH 428 KNH 420	NAS1395C-4	7/16-14	0.43	TH 428 TH 420	11/32	3/16
KNH 524 KNH 518	NAS1395C-5	1/2-13	0.50	TH 524 TH 518	13/32	3/16
KNH 624 KNH 616	NAS1395C-6	9/16-12	0.56	TH 624 TH 616	15/32	3/16
KNH 720 KNH 714	NAS1395C-7	5/8-11	0.68	TH 720 TH 714	17/32	3/16
KNH 820 KNH 813	NAS1395C-8	11/16-11 (NS)	0.75	TH 820 TH 813	19/32	3/16
KNH 918 KNH 912	NAS1395C-9	13/16-16	0.94	TH 918 TH 912	23/32	3/16
KNH 1018 KNH 1011	NAS1395C-10	7/8-14	1.00	TH 1018 TH 1011	25/32	3/16
KNH 1216 KNH 1210		1-1/8-12	1.31	TH 1216 TH 1210	31/32	5/16
KNH 1414 KNH 1409		1-1/4-12	1.44	TH 1414 TH 1409	1-3/32	5/16
KNH 1612 KNH 1608		1-3/8-12	1.56	TH 1612 TH 1608	1-7/32	5/16
HEAVY-DUTY LOCKING INSERTS						
KNHL 0440	NAS1395C-04L	12-24	0.31	TH 0440L	5/32	1/8
KNHL 0632	NAS1395C-06L	1/4-20	0.31	TH 0632L	3/16	1/8
KNHL 0832	NAS1395C-08L	5/16-18	0.37	TH 0832L	7/32	1/8
KNHL 1032 KNHL 1024	NAS1395C-3L	3/8-16	0.37	TH 1032L TH 1024L	9/32	1/8
KNHL 428 KNHL 420	NAS1395C-4L	7/16-14	0.43	TH 428L TH 420L	11/32	3/16
KNHL 524 KNHL 518	NAS1395C-5L	1/2-13	0.50	TH 524L TH 518L	13/32	3/16

Figure 1-13. Keenserts Insert Removal and Installation Data (Sheet 2 of 3)

HEAVY-DUTY LOCKING INSERTS (continued)

Insert Number (Internal Thread)	NAS Number	Installation Data: Tap (UNC-2B) Size	Installation Data: Tap (UNC-2B) Min Depth (Inch)	Installation Data: Tool Number	Removal Data: Drill Size (Inch)	Removal Data: Drill Depth (Inch)
KNHL 624 KNHL 616	NAS1395C-6L	9/16-12	0.56	TH 624L TH 616L	15/32	3/16
KNHL 720 KNHL 714	NAS1395C-7L	5/8-11	0.68	TH 720L TH 714L	17/32	3/16
KNHL 820 KNHL 813	NAS1395C-8L	11/16-11 (NS)	0.75	TH 820L TH 813L	19/32	3/16
KNHL 918 KNHL 912	NAS1395C-9L	13/16-11	0.94	TH 918L TH 912L	23/32	3/16
KNHL 1018 KNHL 1011	NAS1395C-10L	7/8-14	1.00	TH 1018L TH 1011L	25/32	3/16
KNHL 1216 KNHL 1210		1-1/8-12	1.44	TH 1216L TH 1210L	31/32	5/16
KNHL 1414 KNHL 1409		1-1/4-12	1.56	TH 1414L TH 1409L	1-3/32	5/16
KNHL 1612 KNHL 1608		1-3/8-12	1.68	TH 1612L TH 1608L	1-7/32	5/16

Figure 1-13. Keenserts Insert Removal and Installation Data (Sheet 3 of 3)

HEAVY-DUTY STUDS

Stud Number (Nut End Thread)	Installation Data: Tap (UN-2B) Size	Installation Data: Tap (UN-2B) Min Depth (Inch)	Installation Data: Tool Number	Removal Data: Drill Size (Inch)	Removal Data: Drill Depth (Inch)
KNHS 0832(NL)[(a)]	5/16-18	0.37	THS 08	7/32	1/8
KNHS 1032(NL) KNHS 1024(NL)	3/8-16	0.37	THS 010	9/32	1/8
KNHS 428(NL) KNHS 420(NL)	7/16-14	0.43	THS 4	11/32	3/16
KNHS 524(NL) KNHS 518(NL)	1/2-13	0.50	THS 5	13/32	3/16
KNHS 624(NL) KNHS 616(NL)	9/16-12	0.56	THS 6	15/32	3/16
KNHS 720(NL) KNHS 714(NL)	5/8-11	0.68	THS 7	17/32	3/16
KNHS 820(NL) KNHS 813(NL)	11/16-11 (NS)	0.75	THS 8	19/32	3/16

(a) NL = Nut-end length in 1/16-inch increments.

Figure 1-14. Keenserts Stud Removal and Installation Data (Sheet 1 of 2)

HEAVY-DUTY STUDS (continued)					
Stud Number (Nut End Thread)	Installation Data			Removal Data	
	Tap (UN-2B)				
	Size	Min Depth (Inch)	Tool Number	Drill Size (Inch)	Drill Depth (Inch)
KNHS 918(NL) KNHS 912(NL)	13/16-16	0.94	THS 9	23/32	3/16
KNHS 1018(NL) KNHS 1011(NL)	7/8-14	1.00	THS 10	25/32	3/16
KNHS 1216(NL) KNHS 1210(NL)	1-1/3-12	1.31	THS 12	31/32	5/16
KNHS 1414(NL) KNHS 1409(NL)	1-1/4-12	1.44	THS 14	1-3/32	5/16
KNHS 1612(NL) KNHS 1608(NL)	1-3/8-12	1.56	THS 16	1-7/32	5/16

Figure 1-14. Keenserts Stud Removal and Installation Data (Sheet 2 of 2)

1-124. REMOVING HELI-COIL INSERTS. Remove an improperly installed or damaged insert as follows:

a. From figure 1-15, select extracting tool for insert to be removed.

b. Place extracting tool blade into first turn of insert so that one side of blade is 45-90 degrees from end of top coil of insert.

c. Strike top of tool with hammer so that edge of blade imbeds, gripping insert.

d. Apply heavy hand pressure on tool, simultaneously rotating tool counterclockwise until insert is removed.

1-125. INSTALLING HELI-COIL INSERTS. Two types of inserts, plain nonbolt-locking and midgrip bolt-locking, are used on the engine. For identification, the midgrip insert is dyed red and has a specially formed, polygonal grip coil located in the approximate center of the insert. The Commercial, Military Standards, and New Coordinated Military Standards are listed in figure 1-16 for reference. Install new inserts as follows:

a. Select correct replacement insert using R-3896-4 and figure 1-16. Comply with steps j and k, if applicable.

b. Obtain Heli-Coil STI tap, inserting tool, and tang break-off tool indicated for insert in figure 1-15.

c. If necessary, chase threads in tapped hole to remove burs.

d. Clean tapped hole to remove all chips. Gage threads of tapped hole with working gage indicated in figure 1-15.

e. Pull back handle, retracting inserting tool (prewinder tool) mandrel. Place insert in chamber of tool with tang end toward prewinder tip. Advance mandrel forward through insert until tang is fully engaged in mandrel slot.

f. Apply light forward pressure, and rotate mandrel clockwise until mandrel protrudes about 1/32 inch past prewinder tool tip. Do not permit tang of insert to screw out of threaded end of tool.

g. Position inserting tool against face of work, in line with tapped hole. Rotate mandrel clockwise at a continuous and uniform rate without forward pressure until insert is free of prewinder body and installed at a depth of 3/4 to 1-1/2 turns (pitches) below surface of tapped hole. Do not reverse direction of mandrel at any time.

h. If prewinder tool has a stop collar, adjust collar to contact prewinder tool body when required insert installation depth has been reached.

i. If original insert had tang removed, remove tang of replacement insert by holding breakoff tool against insert tang and striking protruding rod of tool with hammer. For insert sizes over one inch, use long-nose pliers and bend tang up and down to break off tang at notch.

j. (Deleted)

k. If installing inserts in components used for liquid oxygen service, remove red dye from midgrip inserts prior to installation. Strip dye from parts as outlined in paragraph 1-35B.

l. Inspect installed insert by inserting bolt or screw (of applicable size) 4 complete turns after locking coils are contacted. Bolt or screw should turn freely, by hand, until locking coil is contacted.

m. Remove installed bolt or screw, and check installed height of insert.

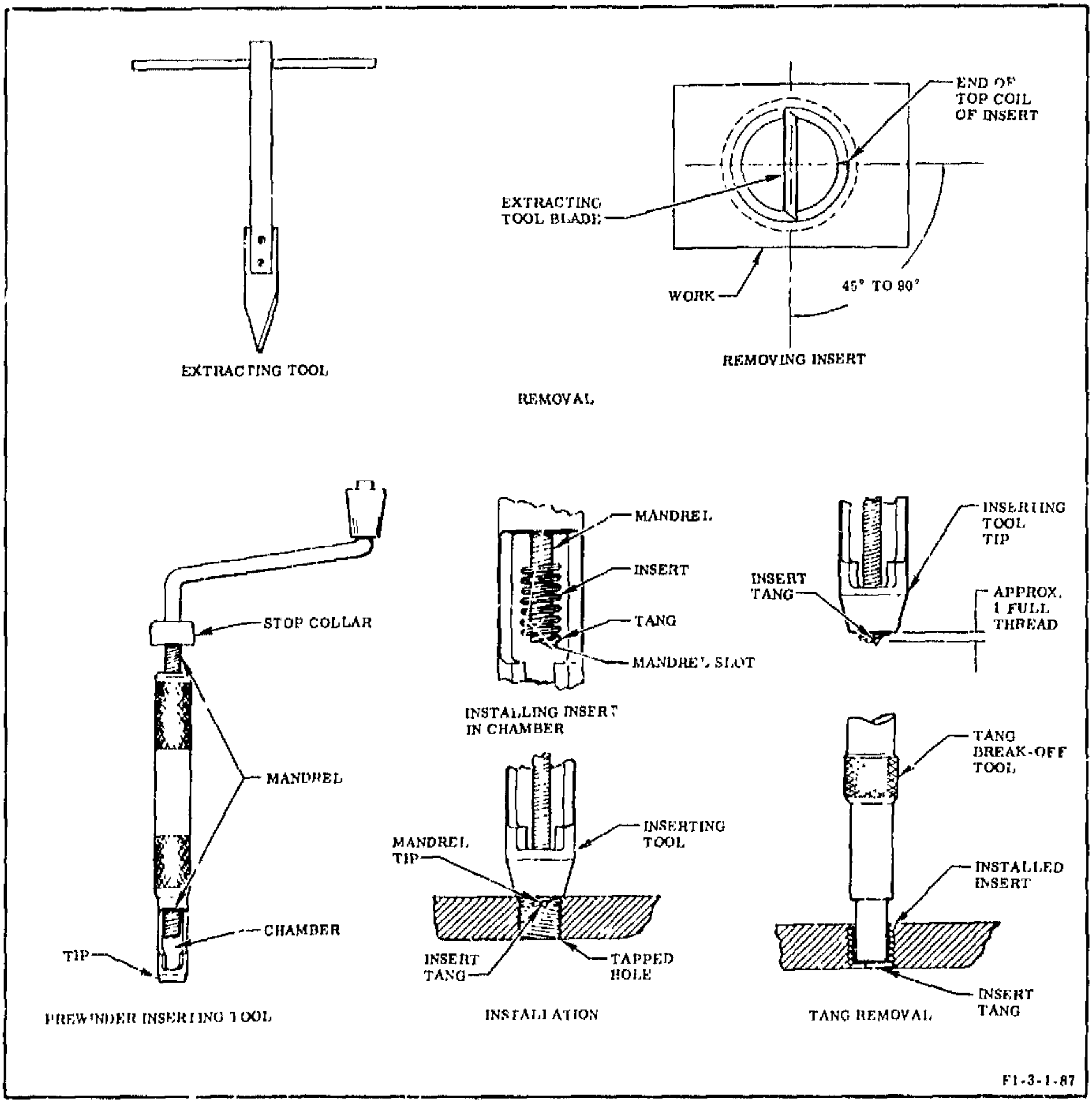


Figure 1-15. Heli-Coil Insert Removal and Installation Tools (Sheet 1 of 2)

Insert Internal Nominal Thread Size	STI Tap Numbers		Threaded Plug Gage Numbers		Insert Inserting Tool Numbers		Insert Tang Break-Off Tool Numbers		Insert Extracting Tool Number
	Plug Style	Bottoming Style	Reference Gage	Working Gage	Plain	Mid-Grip	Plain	Mid-Grip	
#4-40NC-3B	23187-04	27187-04	1688-04	3688-04	7551-04	7551-04	1194-04	3580-04	
#6-32NC-3B	23187-06	27187-06	1688-06	3688-06	7551-06	7551-06	1194-06	3580-06	1227-06
#8-32NC-3B	23187-2	27187-2	1688-2	3688-2	7551-2	7551-2	1194-2	3580-2	
#10-32NF-3B	23193-3	27193-3	1694-3	3694-3	7552-3	7552-3	1196-3	3581-3	
1/4-28UNF-3B	1193-4	5193-4	1694-4	3694-4	7552-4	7552-4	1196-4	3581-4	1227-6
5/16-24UNF-3B	1193-5	5193-5	1694-5	3694-5	7552-5	7552-5	1196-5	3581-5	
3/8-24UNF-3B	1193-6	5193-6	1694-6	3694-6	7552-6	7552-6	1196-6	3581-6	
7/16-20UNF-3B	42193-7	44193-7	1694-7	3694-7	7552-7	7552-7	1196-7	3581-7	
1/2-20UNF-3B	42193-8	44193-8	1694-8	3694-8	7552-8	7552-8	1196-8	3581-8	
9/16-18UNF-3B	42193-9	44193-9	1694-9	--	535-9	535-9	1196-9	1196-9	
5/8-18UNF-3B	9193-10	11193-10	1694-10	--	535-10	535-19	1196-10	1196-10	1227-16
3/4-16UNF-3B	9193-12	11193-12	1694-12	--	535-12	535-12	1196-12	1196-12	
7/8-14UNF-3B	99193-14	11193-14	1694-14	--	535-14	535-14	1196-14	1196-14	
1-12UNF-3B	9193-161	11193-161	1694-161	--	535-161	535-161	1196-16	1196-16	
1-14 UNF-3B	9193-16	11193-16	1694-16		535-16	--	1196-16	1196-16	
1-1/8-12UNF-3B	8193-18	10193-18	1694-18	--	535-18	535-18	--	--	
1-1/4-12UNF-3B	8193-20	10193-20	1694-20	--	535-20	535-20	--	--	
1-3/8-12UNF-3B	8193-22	10193-22	1694-22	--	535-22	535-22	--	--	1227-24
1-1/2-12UNF-3B	8193-24	10193-24	1694-24	--	535-24	535-24	--	--	

Figure 1-15. Heli-Coil Insert Removal and Installation Tools (Sheet 2 of 2)

PLAIN NONBOLT-LOCKING-TYPE INSERTS

Internal Thread Size	Length (Inches)	Part Numbers Commercial	New Coordinated Military Standards	Military Standards
4-40	0.112	1185-04CN 0112	21208-C0410	MS122076
4-40	0.168	1185-04CN 0168	21208-C0415	MS122116
4-40	0.224	1185-04CN 0224	21208-C0420	MS122156
4-40	0.280	1185-04CN 0280	--	MS122196
4-40	0.336	1185-04CN 0336	--	MS122236
5-40	0.125	1185-05CN 0125	--	MS122077
5-40	0.188	1185-05CN 0188	--	MS122117
5-40	0.250	1185-05CN 0250	--	MS122157
5-40	0.312	1185-05CN 0312	--	MS122197
5-40	0.375	1185-05CN 0375	--	MS122237
6-32	0.138	1185-06CN 0138	21208-C0610	MS122078
6-32	0.207	1185-06CN 0207	21208-C0615	MS122118
6-32	0.276	1185-06CN 0276	21208-C0620	MS122158
6-32	0.345	1185-06CN 0345	--	MS122198
6-32	0.414	1185-06CN 0414	--	MS122238
8-32	0.164	1185-2CN 0164	21208-C0810	MS122079
8-32	0.246	1185-2CN 0246	21208-C0815	MS122119
8-32	0.328	1185-2CN 0328	21208-C0820	MS122159
10-32	0.190	1191-3CN 0190	21208-F1-10	MS124655
10-32	0.285	1191-3CN 0285	21208-F1-15	MS124695
10-32	0.380	1191-3CN 0380	21208-F1-20	MS124735
10-32	0.475	1191-3CN 0475	--	MS124775
10-32	0.570	1191-3CN 0570	--	MS124815
1/4-28	0.250	1191-4CN 0250	21208-F4-10	MS124656
1/4-28	0.375	1191-4CN 0375	21208-F4-15	MS124696
1/4-28	0.500	1191-4CN 0500	21208-F4-20	MS124736
1/4-28	0.625	1191-4CN 0625	--	MS124776
1/4-28	0.750	1191-4CN 0750	--	MS124816
5/16-24	0.312	1191-5CN 0312	21208-F5-10	MS124657
5/16-24	0.469	1191-5CN 0469	21208-F5-15	MS124697
5/16-24	0.625	1191-5CN 0625	21208-F5-20	MS124737
5/16-24	0.781	1191-5CN 0781	--	MS124777
5/16-24	0.938	1191-5CN 0938	--	MS124817
3/8-24	0.375	1191-6CN 0375	21208-F6-10	MS124658
3/8-24	0.562	1191-6CN 0562	21208-F6-15	MS124698
3/8-24	0.750	1191-6CN 0750	21208-F6-20	MS124738
3/8-24	0.938	1191-6CN 0938	--	MS124778
3/8-24	1.125	1191-6CN 1125	--	MS124818

Figure 1-16. Heli-Coil Insert Sizes, Lengths, and Part Numbers (Sheet 1 of 4)

PLAIN NONBOLT-LOCKING-TYPE INSERTS (cont)

Internal Thread Size	Length (Inches)	Part Numbers		
		Commercial	New Coordinated Military Standards	Military Standards
7/16-20	0.438	1191-7CN 0438	21208-F7-10	MS124659
7/16-20	0.656	1191-7CN 0656	21208-F7-15	MS124699
7/16-20	0.875	1191-7CN 0875	21208-F7-20	MS124739
7/16-20	1.094	1191-7CN 1094	--	MS124779
7/16-20	1.312	1191-7CN 1312	--	MS124819
1/2-20	0.500	1191-8CN 0500	21208-F8-10	MS124660
1/2-20	0.750	1191-8CN 0750	21208-F8-15	MS124700
1/2-20	1.000	1191-8CN 1000	21208-F8-20	MS124740
1/2-20	1.250	1191-8CN 1250	--	MS124780
1/2-20	1.500	1191-8CN 1500	--	MS124820
9/16-18	0.562	1191-9CN 0562	21208-F9-10	MS124661
9/16-18	0.844	1191-9CN 0844	21208-F9-15	MS124701
9/16-18	1.125	1191-9CN 1125	21208-F9-20	MS124741
9/16-18	1.406	1191-9CN 1406	--	MS124781
9/16-18	1.688	1191-9CN 1688	--	MS124821
5/8-18	0.625	1191-10CN 0625	21208-F1010	MS124662
5/8-18	0.938	1191-10CN 0938	21208-F1015	MS124702
5/8-18	1.250	1191-10CN 1250	21208-F1020	MS124742
5/8-18	1.562	1191-10CN 1562	--	MS124782
5/8-18	1.875	1191-10CN 1875	--	MS124822
3/4-16	0.750	1191-12CN 0750	21208-F1210	MS124663
3/4-16	1.125	1191-12CN 1125	21208-F1215	MS124703
3/4-16	1.500	1191-12CN 1500	21208-F1220	MS124743
3/4-16	1.875	1191-12CN 1875	--	MS124783
3/4-16	2.250	1191-12CN 2250	--	MS124823
7/8-14	0.875	1191-14CN 0875	21208-F1410	MS124664
7/8-14	1.312	1191-14CN 1312	21208-F1415	MS124704
7/8-14	1.750	1191-14CN 1750	21208-F1420	MS124744
7/8-14	2.188	1191-14CN 2188	--	MS124784
7/8-14	2.625	1191-14CN 2625	--	MS124824
1-14	1.000	1191-16CN 1000	--	MS124665
1-14	1.500	1191-16CN 1500	--	MS124705
1-14	2.000	1191-16CN 2000	--	MS124745
1-14	2.500	1191-16CN 2500	--	MS124785
1-14	3.000	1191-16CN 3000	--	MS124825
1-12	1.000	1191-161CN 1000	21208-F1610	--
1-12	1.500	1191-161CN 1500	21208-F1615	--
1-12	2.000	1191-161CN 2000	21208-F1620	--
1-12	2.500	1191-161CN 2500	--	--
1-12	3.000	1191-161CN 3000	--	--

Figure 1-16. Heli-Coil Insert Sizes, Lengths, and Part Numbers (Sheet 2 of 4)

Internal Thread Size	Length (Inches)	Part Numbers: Commercial	Part Numbers: New Coordinated Military Standards	Part Numbers: Military Standards
PLAIN NONBOLT-LOCKING-TYPE INSERTS (cont)				
1-1/8-12	1.125	1191-18CN 1125	21208-F1810	MS124666
1-1/8-12	1.688	1191-18CN 1688	21208-F1815	MS124706
1-1/8-12	2.250	1191-18CN 2250	21208-F1820	MS124746
1-1/8-12	2.812	1191-18CN 2812	--	MS124786
1-1/8-12	3.375	1191-18CN 3375	--	MS124826
1-1/4-12	1.250	1191-20CN 1250	21208-F2010	MS124667
1-1/4-12	1.875	1191-20CN 1875	21208-F2015	MS124707
1-1/4-12	2.500	1191-20CN 2500	21208-F2020	MS124747
1-1/4-12	3.125	1191-20CN 3125	--	MS124787
1-1/4-12	3.750	1191-20CN 3750	--	MS124827
1-3/8-12	1.375	1191-22CN 1375	21208-F2210	MS124668
1-3/8-12	2.062	1191-22CN 2062	21208-F2215	MS124708
1-3/8-12	2.750	1191-22CN 2750	21208-F2220	MS124748
1-3/8-12	3.438	1191-22CN 3438	--	MS124788
1-3/8-12	4.125	1191-22CN 4125	--	MS124828
1-1/2-12	1.500	1191-24CN 1500	21208-F2410	MS124669
1-1/2-12	2.250	1191-24CN 2250	21208-F2415	MS124709
1-1/2-12	3.000	1191-24CN 3000	21208-F2420	MS124749
1-1/2-12	3.750	1191-24CN 3750	--	MS124789
1-1/2-12	4.500	1191-24CN 4500	--	MS124829
MIDGRIP-BOLT-LOCKING-TYPE INSERTS				
4-40	0.168	3585-04CN 0168	21209-C0415	
4-40	0.224	3585-04CN 0224	21209-C0420	
6-32	0.207	3585-06CN 0207	21209-C0615	
6-32	0.276	3585-06CN 0276	21209-C0620	
8-32	0.246	3585-2CN 0246	21209-C0815	
8-32	0.328	3585-2CN 0328	21209-C0820	
10-32	0.285	3591-3CN 0285	21209-F1-15	
10-32	0.380	3591-3CN 0380	21209-F1-20	
1/4-28	0.375	3591-4CN 0375	21209-F4-15	
1/4-28	0.500	3591-4CN 0500	21209-F4-20	
5/16-24	0.469	3591-5CN 0469	21209-F5-15	
5/16-24	0.625	3591-5CN 0625	21209-F5-20	
3/8-24	0.562	3591-6CN 0562	21209-F6-15	
3/8-24	0.750	3591-6CN 0750	21209-F6-20	
7/16-20	0.656	3591-7CN 0656	21209-F7-15	
7/16-20	0.875	3591-7CN 0875	21209-F7-20	

Figure 1-16. Heli-Coil Insert Sizes, Lengths, and Part Numbers (Sheet 3 of 4)

MIDGRIP-BOLT-LOCKING-TYPE INSERTS (cont)

Internal Thread Size	Length (Inches)	Part Numbers: Commercial		Part Numbers: New Coordinated Military Standards	Part Numbers: Military Standards
1/2-20	0.750	3591-8CN	0750	21209-F8-15	
1/2-20	1.000	3591-8CN	1000	21209-F8-20	
9/16-18	0.844	3591-9CN	0844	21209-F9-15	
9/16-18	1.125	3591-9CN	1125	21209-F9-20	
5/8-18	0.938	3591-10CN	0938	21209-F1015	
5/8-18	1.250	3591-10CN	1250	21209-F1020	
3/4-16	1.125	3591-12CN	1125	21209-F1215	
3/4-16	1.500	3591-12CN	1500	21209-F1220	
7/8-14	1.312	3591-14CN	1312	21209-F1415	
7/8-14	1.750	3591-14CN	1750	21209-F1420	
1-12	1.500	3591-161CN	1500	21209-F1615	
1-12	2.000	3591-161CN	2000	21209-F1620	

Figure 1-16. Heli-Coil Insert Sizes, Lengths, and Part Numbers (Sheet 4 of 4)

1-126. REMOVING HI-LOK FASTENERS.

a. Hold fastener pin with a hex key wrench to prevent pin from turning.

b. Using water-pump or vise-grip pliers, grip and turn fastener collar counterclockwise to remove collar.

c. Remove pin from part, and clean hole.

1-127. INSTALLING HI-LOK FASTENERS. (See figure 1-17.)

a. Select correct pin and collar assembly. The pin and collar assembly must bear the same part number as the part it replaces.

b. Insert pin into hole. (Press interference-fit pins into hole to flush and normal condition.)

c. Check projection of pin through hole. Shoulder of pin at thread end must not project more than 1/32 inch, as shown in figure 1-17.

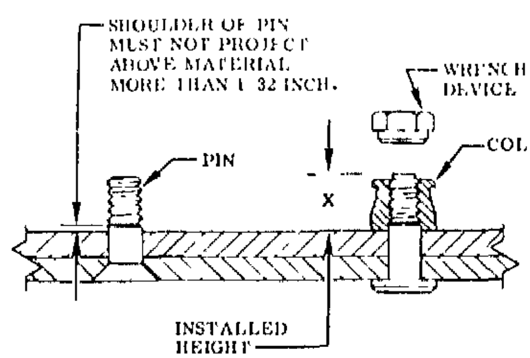
d. Hold pin with hex key wrench; turn and tighten collar with box open-end wrench. Continue tightening collar until wrenching device breaks away from collar.

e. Check installed height of pin and collar extending through material for limits shown in figure 1-17.

f. Normality, flushness, and concentricity of the installed fastener must meet the requirements of figure 1-18.

1-128. SECURING AND REPLACING BLIND NUTS.

1-129. Blind nuts may be secured, if loose, and removed and replaced, if damaged. Two methods are used to replace blind nuts: one method uses handtools, the other uses a hydraulic power unit, blind-nut gun, and driving tools. The blind nut must bear the same part number as the blind nut it replaces.



PIN FIRST DASH NO.	DIAMETER (INCH)	X (INCH) MIN	X (INCH) MAX
-6	3/16	0.315	0.397
-8	1/4	0.385	0.467
-10	5/16	0.490	0.572
-12	3/8	0.535	0.617

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Figure 1-17. Installing Hi-Lok Fasteners

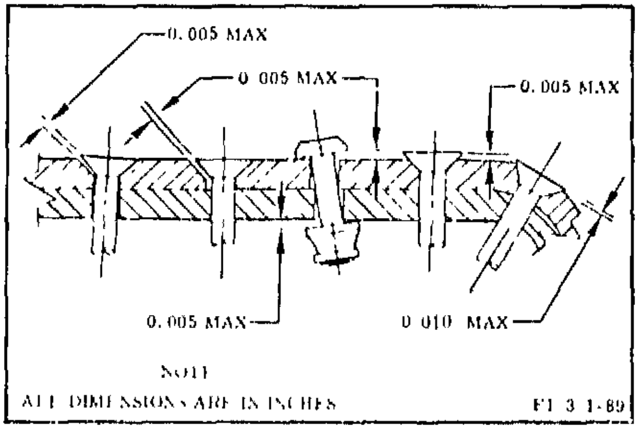


Figure 1-18. Fastener Normality, Concentricity, and Flushness Tolerances

1-130. SECURING LOOSE BLIND NUTS. When feasible, a loose blind nut should be tack-welded.

WARNING

The following procedure uses acetone, 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.

a. Using a fine-wire stainless-steel brush, clean area around blind nut. Wipe area clean with acetone (Federal Specification O-A-51).

b. After area is thoroughly dry, tack-weld sleeve with CRES welding rod in at least 4 places. Weld must withstand torque of installed bolt. (See figure 1-20.)

CAUTION

The remaining portion of the blind nut must not fall into an area where it could possibly cause damage to equipment.

1-131. REMOVING BLIND NUTS. Using a mini-grinder, grind off blind-nut flange. Drive out remaining portion.

1-132. INSTALLING BLIND NUTS WITH HANDTOOLS. Handtools are not recommended for installations of blind nuts larger than 1/4 inch. (See figure 1-19.)

a. Select correct replacement blind nut. Refer to R-3896-4 for part number and location.

b. From figure 1-20, determine handtool, mandrel, crowfoot wrench, and torque required for blind nut installation.

c. Install blind nut using procedures shown in figure 1-19.

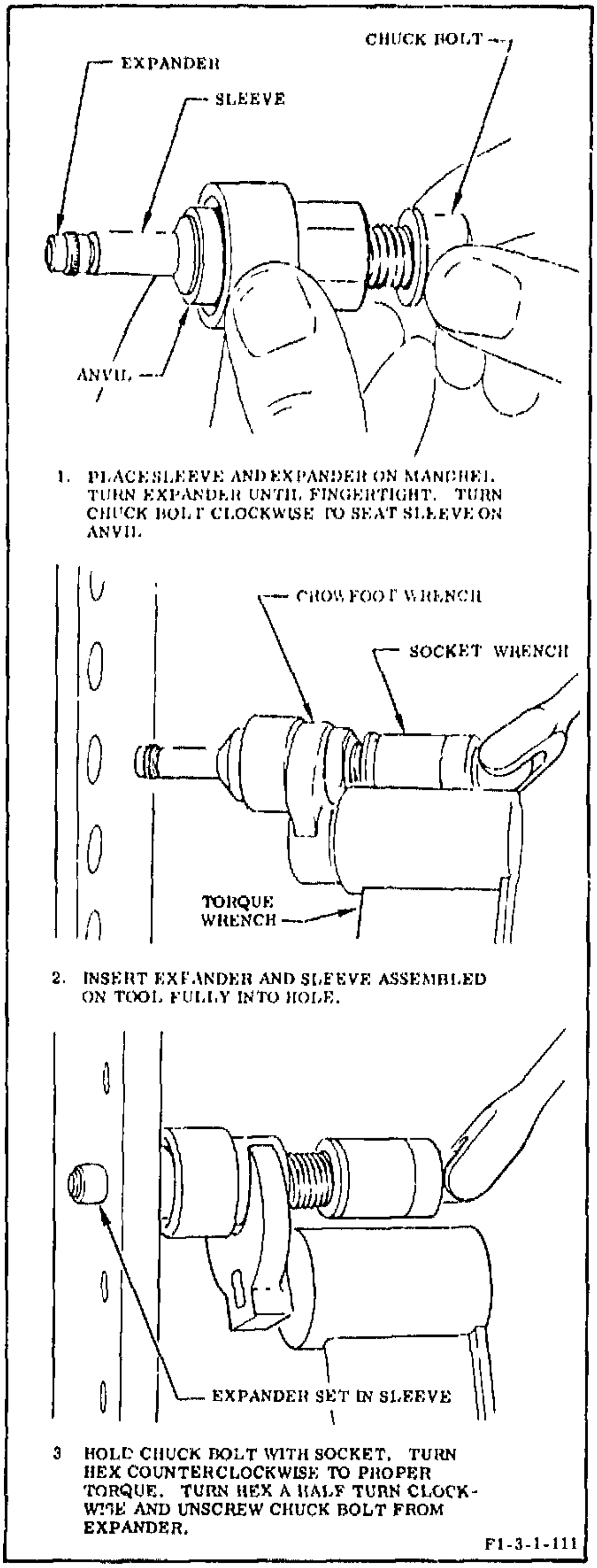


Figure 1-19. Blind Nut Installation With Handtools

Blind Nut Number	Handtool Number	Mandrel Number: 0-1 Inch Grip	Mandrel Number: 1-2 Inch Grip	Crowfoot Wrench	Torque Value (in-lb)
BN359-832	BH110-832-M2	M2-8	M3-8	AN8506-6	175-200
BN157-1032 BN359-1032	BH110-1032-M2	M2-1032	M3-1032	AN8506-6	250-275
BN359-428	BH210-428-M2	M2-12	M3-12	AN8506-10	425-450
BN360-440	BH120-440-M2	M2-5	M3-5	AN8506-6	60-70
BN360-632	BH120-632-M2	M2-632	M3-632	AN8506-6	90-100
BN360-832	BH120-832-M2	M2-8	M3-8	AN8506-6	175-200
BN360-1032 BN523-1032	BH120-1032-M2	M2-1032	M3-1032	AN8506-6	250-275
BN360-428 BN523-428	BH220-428-M2	M2-12	M3-12	AN8506-10	425-450
BN361-428	BH230-428-M2	M2-12	M3-12	AN8506-10	425-450

Figure 1-20. Blind Nut Part Numbers, Handtools, and Torque Values

1-133. INSTALLING BLIND NUTS WITH HYDRAULIC POWER UNIT AND TOOLS.

a. Select correct replacement blind nut. Refer to R-3896-4 for part number and location.

b. From figure 1-21, determine driving tools required for blind nut installation.

c. Install blind nut using procedures shown in figure 1-22 and instructions on hydraulic power unit.

1-134. ENGINE VARIABLE ORIFICES.

1-135. Engine variable orifices control fluid flowrates. The orifice diameters are determined for each engine before engine delivery. The orifice identification, part number, actual measured size, and engine serial number are permanently placed on each orifice (figure 1-23) or on a metal tag attached adjacent to the orifice. Engine orifices are listed in figure 1-23A. Refer to R-3896-4 for orifice effectivity. The orifice name, part number, nominal size, and location identification code are recorded in each Engine Log Book.

1-136. REPAIRING ORIFICES. Small, lightly scratched or nicked abraded areas, except orifice diameter and edges, may be smoothed out with a fine stone or abrasive cloth (320-grit or finer), as necessary, to meet the surface finish requirements. The reworked area, if in a sealing surface, must not impair the sealing function.

WARNING

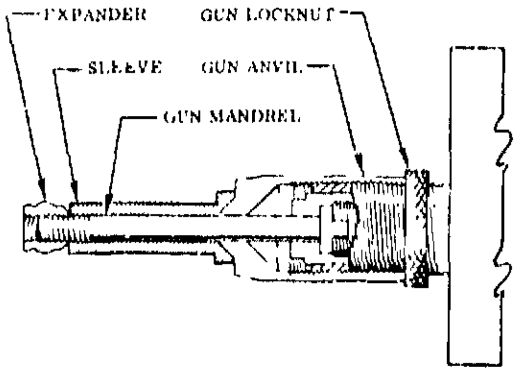
The following procedure uses trichloroethylene or trichloroethane, which are toxic solvents. Inhalation of their vapors or prolonged contact with the liquids can cause serious injury or death.

- 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.

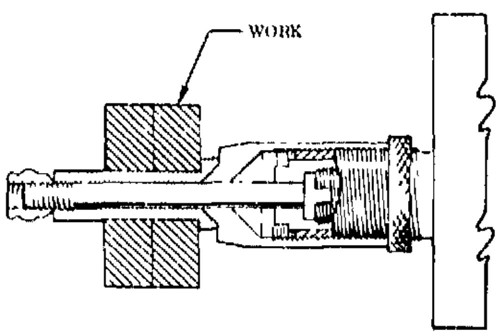
1-137. CLEANING ORIFICES. Clean all metal orifice plates by vapor degreasing. Hand-clean orifice plates with molded rubber seals (except RD251-5001) using a clean, lint-free cloth dampened with trichloroethylene (MIL-T-27602) or trichloroethane (Federal Specification O-T-620). Hand-clean orifice plate RD251-5001 with isopropyl alcohol (Federal Specification TT-I-735).

Blind Nut First Dash No.	Anvil Number	Chuck Number	Mandrel Number 0-1 Inch Grip	Mandrel Number 1-2 Inch Grip	Mandrel Number 2-3 Inch Grip
BLIND NUTS BN359 AND BN514					
-832	A25-832	C2-8	M1-8	M2-8	M3-8
-1032	A25-1032	C2-1032	M1-1032	M2-1032	M3-1032
-428	A25-428	C2-12	M1-12	M2-12	M3-12
-524	A25-524	C2-14	M1-14	M2-14	M3-14
-624	A25-624	C2-16	M1-16	M2-16	M3-16
BLIND NUTS BN372					
-440	A27-440	C2-5	M1-5	M2-5	--
-632	A27-632	C2-632	M1-632	M2-632	--
-832	A27-832	C2-8	M1-8	M2-8	M3-8
-1032	A27-1032	C2-1032	M1-1032	M2-1032	M3-1032
-428	A27-428	C2-12	M1-12	M2-12	M3-12
-524	A27-524	C2-14	M1-14	M2-14	M3-14
-624	A27-624	C2-16	M1-16	M2-16	M3-16
BLIND NUTS BN523 AND BN360					
-440	A27-440	C2-5	M1-5	M2-5	--
-632	A27-632	C2-632	M1-632	M2-632	--
-832	A27-832	C2-8	M1-8	M2-8	M3-8
-1032	A27-1032	C2-1032	M1-1032	M2-1032	M3-1032
-428	A27-428	C2-12	M1-12	M2-12	M3-428
-420	A27-428	C2-12	M1-420	M2-420	M3-420
-524	A27-524	C2-14	M1-14	M2-14	M3-14
-518	A27-524	C2-14	M1-518	M2-518	M3-518
-624	A27-624	C2-16	M1-16	M2-16	M3-16
-616	A27-624	C2-16	M1-616	M2-616	M3-616
-720	A27-720	C3	M1-720	M2-720	M3-720
-714	A27-720	C3	M1-714	M2-714	M3-714
-820	A27-820	C3	M1-820	M2-820	M3-820
-813	A27-820	C3	M1-813	M2-813	M3-813

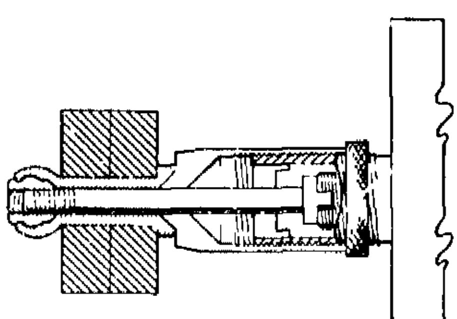
Figure 1-21. Power Unit Driving Tools for Gun BG2500



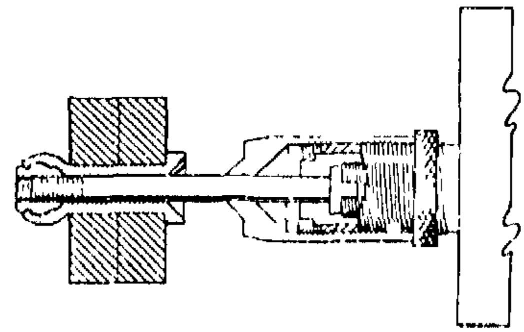
1. INSERT MANDREL THROUGH SLEEVE. THEN BY PRESSING GUN RIGHT HAND CONTROL BUTTON, SCREW EXPANDER ONTO MANDREL. TO ADJUST ANVIL TO CORRECT SLEEVE LENGTH, SPIN ANVIL TO SEAT AGAINST SLEEVE HEAD AND TIGHTEN LOCKNUT.



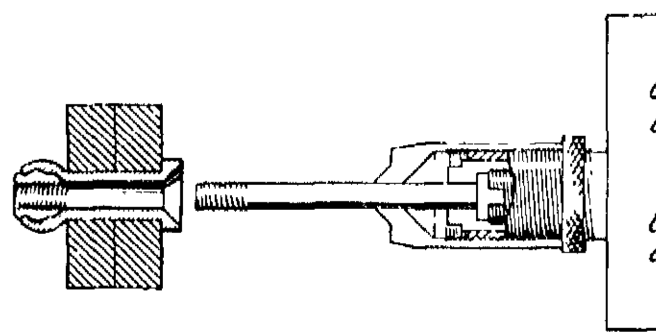
2. INSERT ASSEMBLED EXPANDER AND SLEEVE THROUGH HOLE. HOLE PREPARATION REQUIRES ONLY STANDARD DRILL TOLERANCES. NO REAMING IS REQUIRED



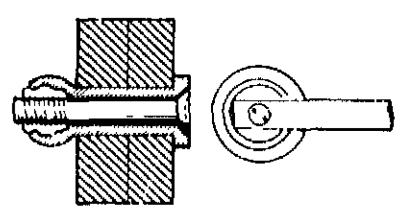
3 PRESS GUN LEFT-HAND CONTROL BUTTON TO PULL EXPANDER INTO SLEEVE. THIS PULL-UP ACTION LOCKS SLEEVE AND SWELLS SLEEVE WALLS TO TIGHTLY FILL HOLE.



4 GUN AUTOMATICALLY BACKS OFF SLEEVE HEAD AFTER PULL-UP IS COMPLETE.



5. PRESS GUN CENTER CONTROL BUTTON TO SPIN MANDREL OUT OF INSTALLED SLEEVE AND EXPANDER.



6 INSERT CORE BOLT INTO SLEEVE AND EXPANDER AND TIGHTEN WITH CORE BOLT DRIVER.

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Figure 1-22. Blind Nut Installation With Power Tools

CODING

1. IDENTIFY BY ELECTROCHEMICAL- OR ACID-ETCH ONLY.
2. THIS ORIFICE IS THE SMALLEST ALLOWABLE FOR THIS PLATE.
3. ORIFICE MUST HAVE SHARP EDGES.
4. ORIFICE EDGES MUST BE DEBURRED AND MAY BE BROKEN 0.005-INCH MAXIMUM RADIUS ON MINIMUM DIAMETER ORIFICE, AND 0.0005-INCH MAXIMUM RADIUS ON ALL OTHER SIZES.
5. ORIFICE EDGES MUST BE DEBURRED AND MAY BE BROKEN 0.005-INCH MAXIMUM RADIUS ON MINIMUM AND MAXIMUM DIAMETER ORIFICES, AND 0.0005-INCH MAXIMUM RADIUS ON ALL OTHER SIZES.
6. SEALING SURFACES MUST BE FREE OF NICKS, SCRATCHES, AND OTHER IMPERFECTIONS THAT CAN IMPAIR SEALING CAPABILITY.
7. SURFACE MUST BE FLAT WITHIN 0.002 INCH TOTAL.
8. DETAIL B DIMENSIONS DO NOT APPLY BEYOND POINT OF TANGENCY OF 45-DEGREE CHAMFER AND 0.09-INCH FILLET, EXCEPT AS NOTED.
9. COUNTERBORE MUST BE OMITTED WHEN ORIFICE DIAMETER EXCEEDS B DIAMETER.
10. VAPOR-DEGREASE.
11. HANDWIPE WITH TRICHLOROETHYLENE.
12. HANDWIPE WITH ISOPROPYL ALCOHOL.

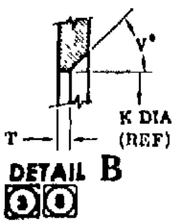
NOTE

ALL DIMENSIONS ARE IN INCHES EXCEPT AS NOTED.

RD251-4071-XXXX

NOTE

THE SECOND DASH NUMBER INDICATES DIAMETER OF ORIFICE IN THOUSANDTHS OF AN INCH ±0.001.



8

K DIA ±0.001	T +0.000 -0.010	V°
0.900 THRU 1.008	0.040	45°
1.009 THRU 1.088	0.080	
1.089 THRU 1.188	0.110	OMIT CSK
1.189 THRU 1.312	-----	

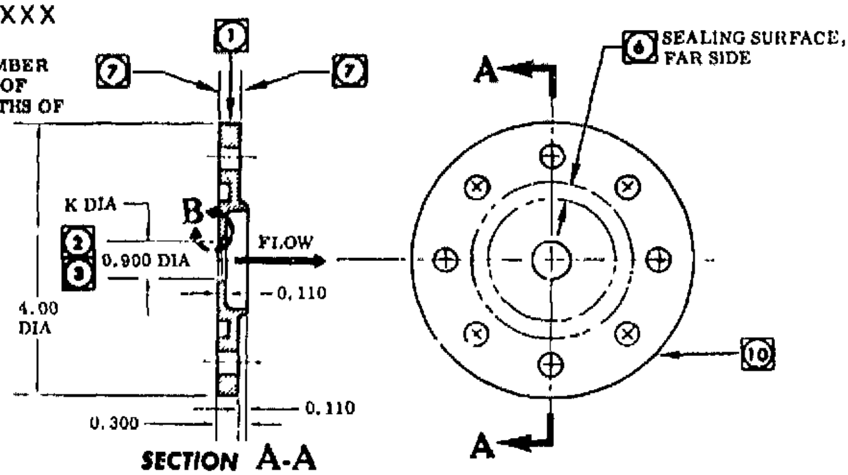


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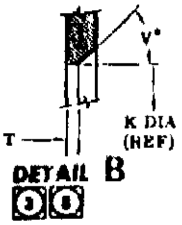
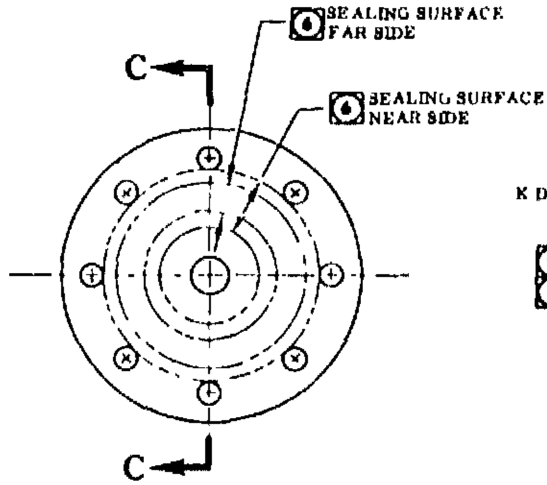
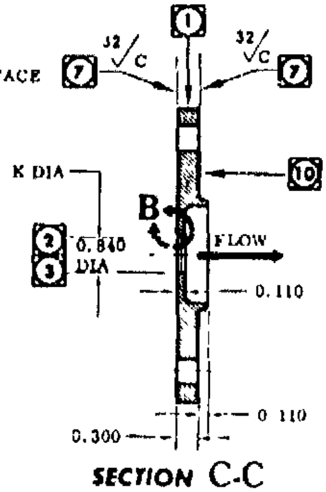
Figure 1-23. Engine Variable O...ces (Sheet 1 of 6)





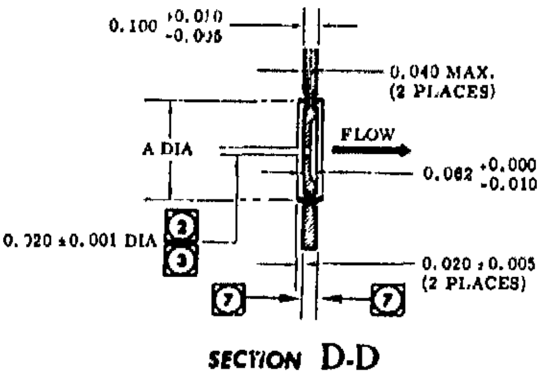
RD251-4072-XXXX

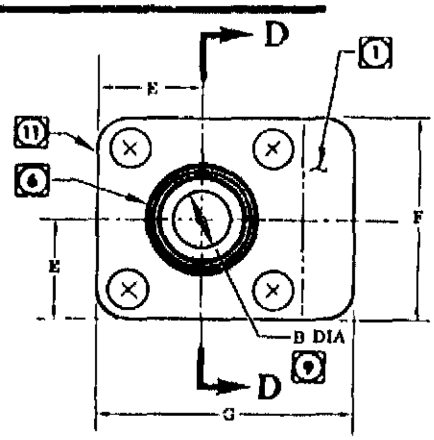


K DIA ±0.001	T +0.000 -0.010 [8]	V°
0.840 THRU 1.008	0.040	45°
1.009 THRU 1.088	0.080	
1.089 THRU 1.188	0.110	OMIT CSK
1.189 THRU 1.416	- - -	

NOTE

THE SECOND DASH NUMBER IS DIAMETER OF ORIFICE IN THOUSANDTHS OF AN INCH ±0.001.





RD251-4080-XXXX
RD251-4082-XXXX
RD251-4083-XXXX
RD251-4084-XXXX
RD251-4085-XXXX
RD251-4087-XXXX

BASIC PART NUMBER	A DIA	[9] B DIA	E ±0.005	F	G
RD251-4080	0.570	0.307	0.750	1.500	1.88
RD251-4082	0.735	0.406	0.750	1.500	1.88
RD251-4083	0.735	0.406	0.750	1.500	1.88
RD251-4084	0.735	0.406	0.750	1.500	1.88
RD251-4085	0.870	0.500	0.810	1.620	2.00
RD251-4087	1.125	0.625	1.000	2.000	2.38

NOTE

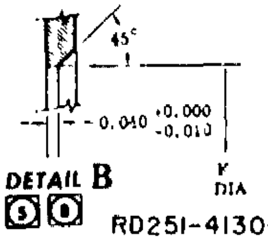
THE SECOND DASH NUMBER IS DIAMETER OF ORIFICE IN THOUSANDTHS OF AN INCH ±0 001.

- ALL DIMENSIONS ARE IN INCHES.

(SEE CODES ON SHEET 1.)

F1-3-1-114A

Figure 1-23. Engine Variable Orifices (Sheet 2 of 6)

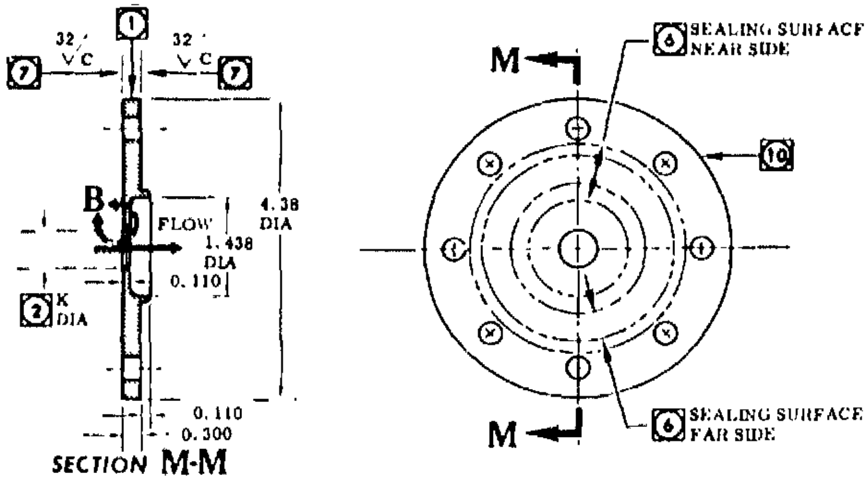


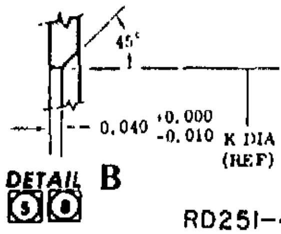
RD251-4130-XXXX

NOTE

THE SECOND DASH NUMBER IS DIAMETER OF ORIFICE IN THOUSANDTHS OF AN INCH. SEE TABLE FOR ACTUAL ORIFICE SIZES AND TOLERANCES.

K DIA	TOLERANCE
0.830	±0.011
0.8500 THRU 1.4150	±0.0005
1.416	±0.001



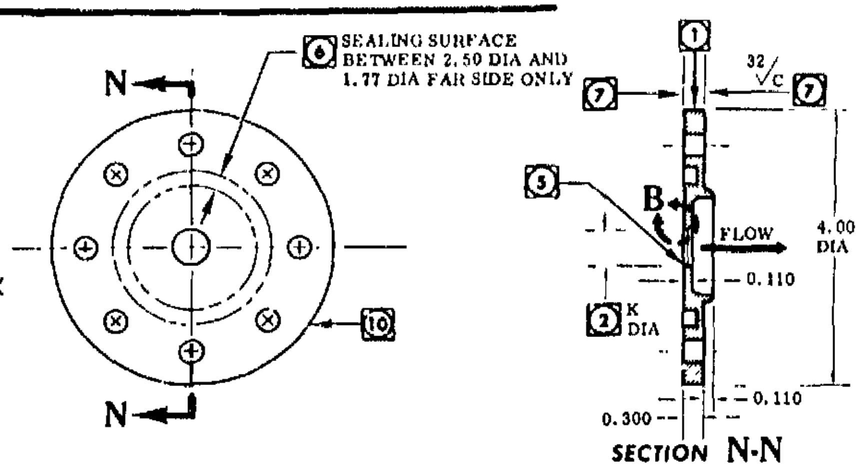


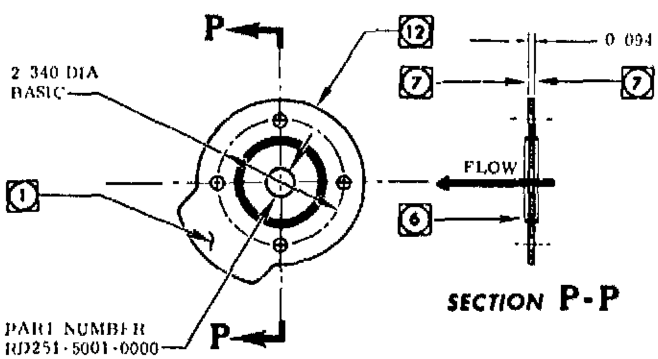
RD251-4131-XXXX

NOTE

THE SECOND DASH NUMBER IS DIAMETER OF ORIFICE IN THOUSANDTHS OF AN INCH. SEE TABLE FOR ACTUAL ORIFICE SIZES AND TOLERANCES.

K DIA	TOLERANCE
0.890	±0.011
0.9100 THRU 1.3110	±0.0005
1.312	±0.001





NOTE

THE SECOND DASH NUMBER IS DIAMETER OF ORIFICE IN THOUSANDTHS OF AN INCH 0.001.

- ALL DIMENSIONS ARE IN INCHES.

RD251-5001-XXXX

(SEE CODES ON SHEET 1.)

F1-3-1-115

Figure 1-23. Engine Variable Orifices (Sheet 3 of 6)

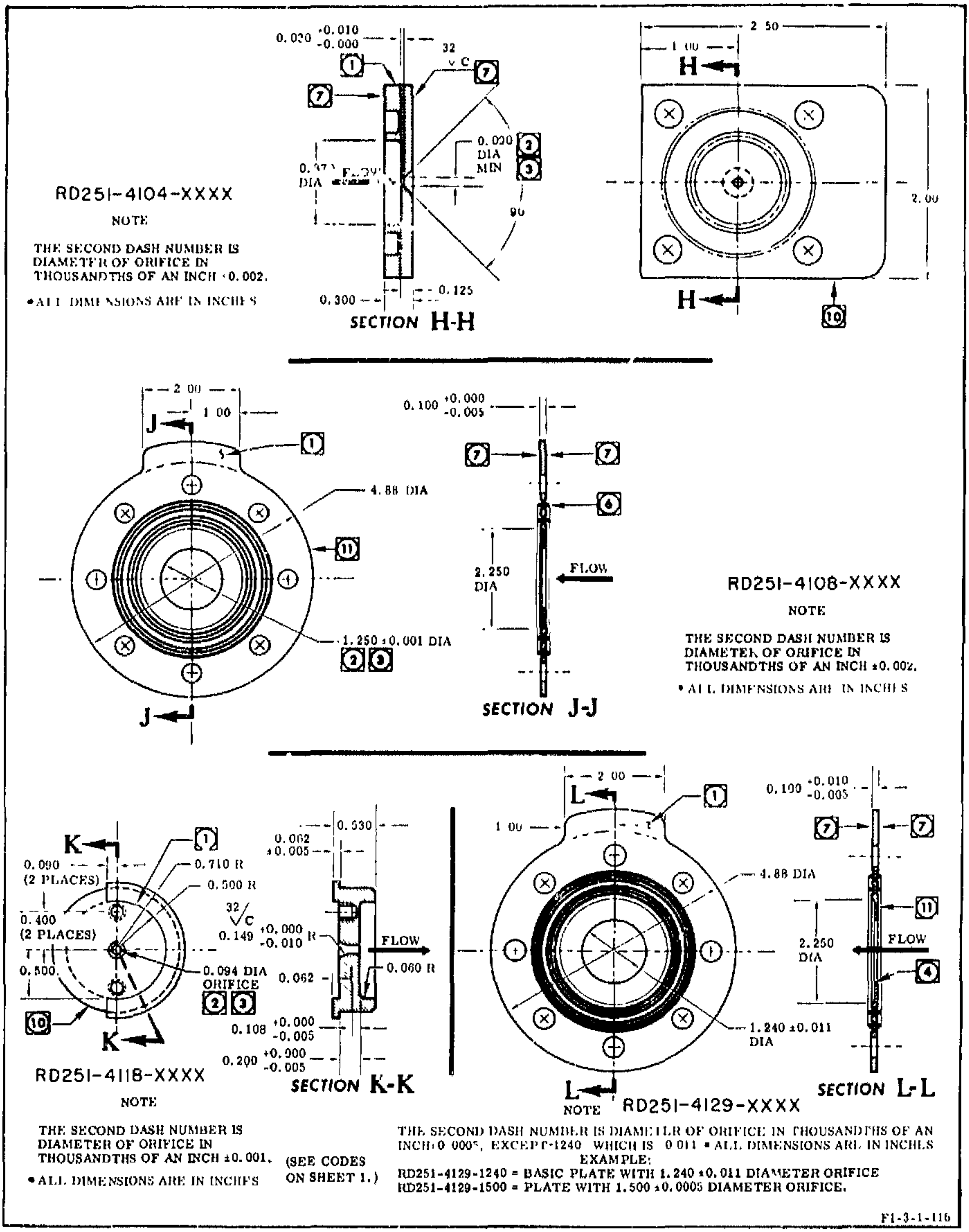


Figure 1-23. Engine Variable Orifices (Sheet 4 of 6)

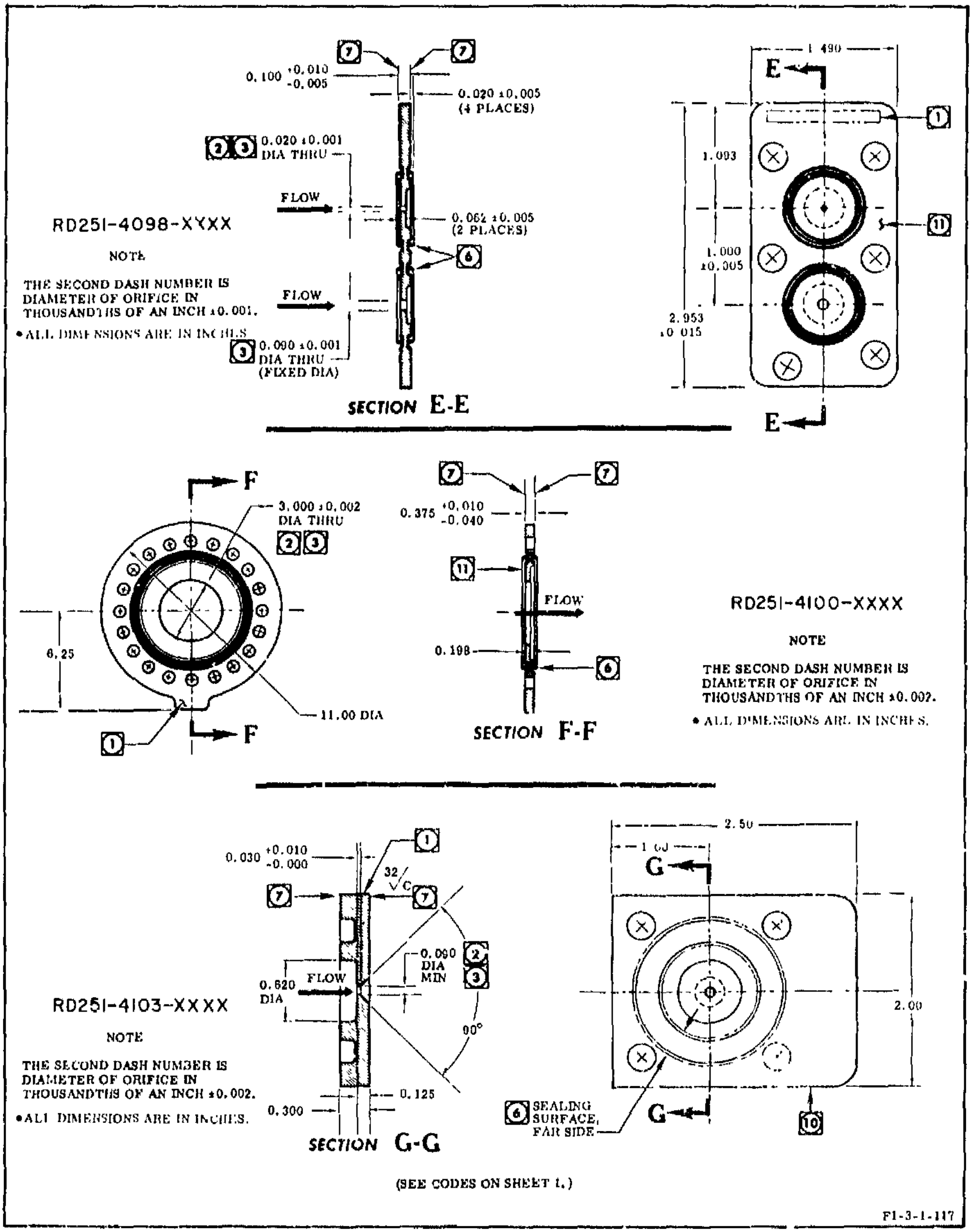


Figure 1-23. Engine Variable Orifices (Sheet 5 of 6)

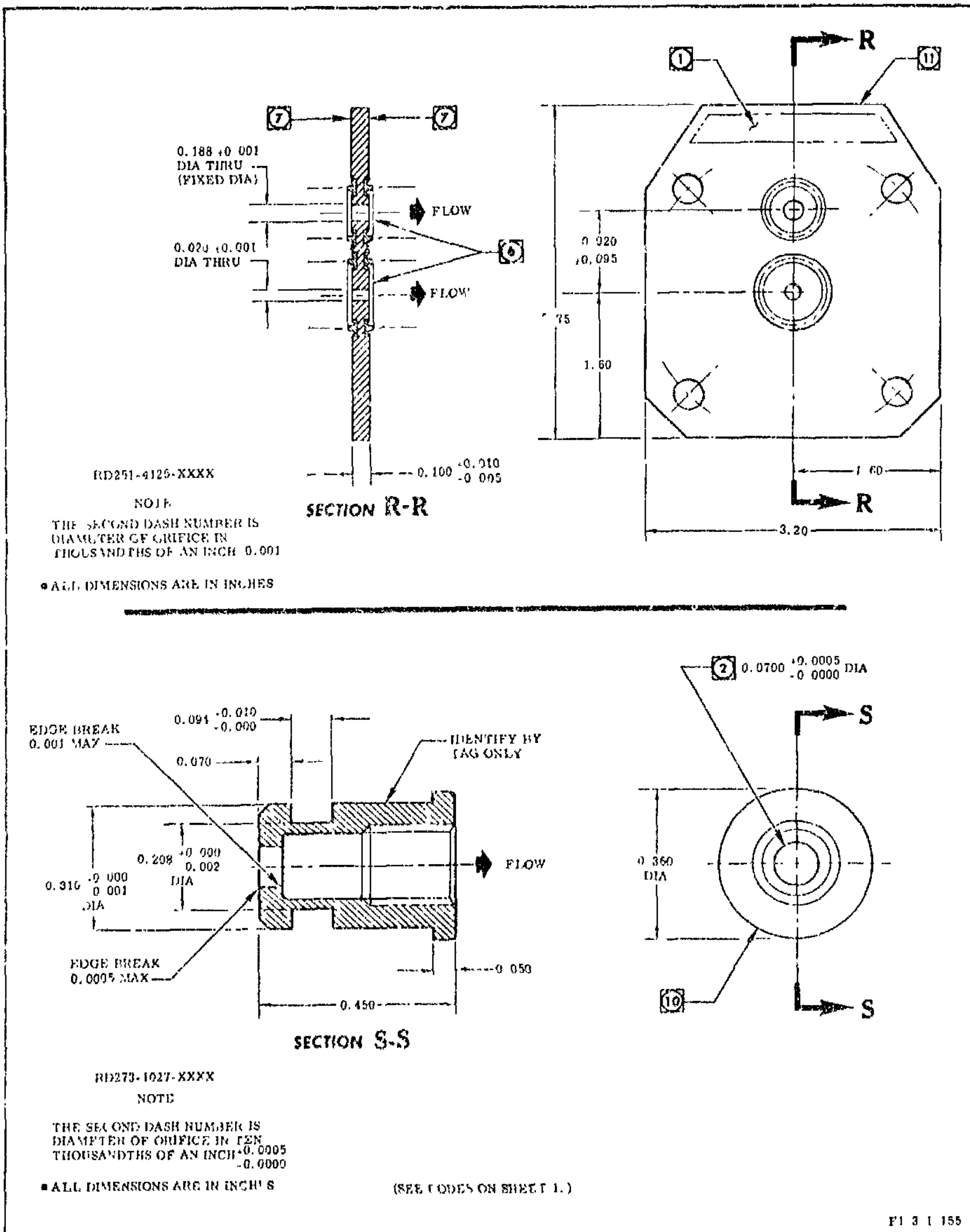


Figure 1-23. Engine Variable Orifices (Sheet 6 of 6)

Part Number[a]	Nomenclature	Location
RD251-4071-XXXX	Gas generator oxidizer feed (upstream)	Gas generator oxidizer supply duct.
RD251-4072-XXXX	Gas generator oxidizer feed (downstream)	Gas generator oxidizer supply duct.
RD251-4080-XXXX	No. 2 fuel bleed	No. 2 fuel inlet elbow.
RD251-4082-XXXX	No. 1 oxidizer valve dome purge	No. 1 oxidizer valve.
RD251-4082-XXXX	No. 2 oxidizer valve dome purge	No. 2 oxidizer valve.
RD251-4083-XXXX	No. 1 fuel valve open control	No. 1 fuel valve.
RD251-4083-XXXX	No. 2 fuel valve open control	No. 2 fuel valve.
RD251-4084-XXXX	No. 1 fuel inlet pressure	No. 1 fuel inlet elbow.
RD251-4085-XXXX	No. 1 oxidizer valve open control	No. 1 oxidizer valve.
RD251-4085-XXXX	No. 2 oxidizer valve open control	No. 2 oxidizer valve.

Part Number[a]	Nomenclature	Location
RD251-4087-XXXX	Fuel impeller balance cavity supply	No. 1 turbopump volute.
RD251-4088-XXXX	Gas generator ball valve open control	Gas generator ball valve.
RD251-4100-XXXX	No. 1 main fuel	No. 1 fuel valve inlet.
RD251-4100-XXXX	No. 2 main fuel	No. 2 fuel valve inlet.
RD251-4103-XXXX	Heat exchanger oxidizer bypass	Oxidizer bypass hose.
RD251-4104-XXXX	Heat exchanger helium bypass	Helium bypass hose.
RD251-4108-XXXX	Gas generator fuel supply	Gas generator fuel supply duct.
RD251-4118-XXXX	Heat exchanger oxidizer inlet[b]	Oxidizer supply hose.

(a) Refer to Engine Log Book for recorded number.
(b) Four each required.

Figure 1-23A. Engine Orifices (Sheet 1 of 2)

Part Number[a]	Nomenclature	Location	Part Number[a]	Nomenclature	Location
RD251-4118-XXXX	Heat exchanger helium inlet[c]	Helium supply duct.	RD251-4131-XXXX	Gas generator oxidizer feed (upstream)	Gas generator oxidizer supply duct.
RD251-4125-XXXX	Pressure switch	Pressure switch manifold.	RD251-5001-XXXX	Fuel impeller balance cavity return	No. 2 turbopump inlet.
RD251-4129-XXXX	Gas generator fuel supply	Gas generator fuel supply duct.	RD273-1027-XXXX	Bearing coolant control valve	Bearing coolant control valve supply.
RD251-4130-XXXX	Gas generator oxidizer feed (downstream)	Gas generator oxidizer supply duct.			

(a) Refer to Engine Log Book for recorded number.
(c) Two each required.

Figure 1-23A. Engine Orifices (Sheet 2 of 2)

Part Number[(a)]	Nomenclature	Location	Part Number[(a)]	Nomenclature	Location
RD251-4118-XXXX	Heat exchanger helium inlet[(c)]	Helium supply duct.	RD251-4131-XXXX	Gas generator oxidizer feed (upstream)	Gas generator oxidizer supply duct.
RD251-4125-XXXX	Pressure switch	Pressure switch manifold.	RD251-5001-XXXX	Fuel impeller balance cavity return	No. 2 turbopump inlet.
RD251-4129-XXXX	Gas generator fuel supply	Gas generator fuel supply duct.	RD273-1027-XXXX	Bearing coolant control valve	Bearing coolant control valve supply.
RD251-4130-XXXX	Gas generator oxidizer feed (downstream)	Gas generator oxidizer supply duct.			

(a) Refer to Engine Log Book for recorded number.
(c) Two each required.

Figure 1-23A. Engine Orifices (Sheet 2 of 2)

1-138. IDENTIFICATION PLATES.

1-139. Whenever an engine modification is performed or an identification plate is replaced for other reasons, engine identification plate RD171-1025-0001 or modification (MD) identification plate RD171-1052-0001, RD171-1052-0002, or RD171-1052-0003 is to be located and installed as specified in this procedure. Satisfactory adhesion of plates will be obtained only if the surface area to which the plate will be applied is properly cleaned of dirt, grease, or other contamination and the prepared area is not touched with the fingers at any time.

1-140. INSTALLING IDENTIFICATION PLATES. (See figure 1-24.)

WARNING

The following procedure uses trichloroethylene or trichloroethane, which are toxic solvents. Inhalation of their vapors or prolonged contact with the liquids can cause serious injury or death.

- The following procedure uses naphtha 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.

a. Using a clean cloth dampened with trichloroethylene (MIL-T-27602), trichloroethane (Federal Specification O-T-620), or naphtha (Federal Specification TT-N-95, Type I) thoroughly clean area that identification plate will contact. Do not allow solvent to dry on the area; wipe area, while still wet, with a clean, dry cloth.

b. Remove existing engine identification plate RD171-1025-0001 from engine. Using stencil-cutting setting of a typewriter, transfer all information from removed plate to new plate RD171-1025-0001.

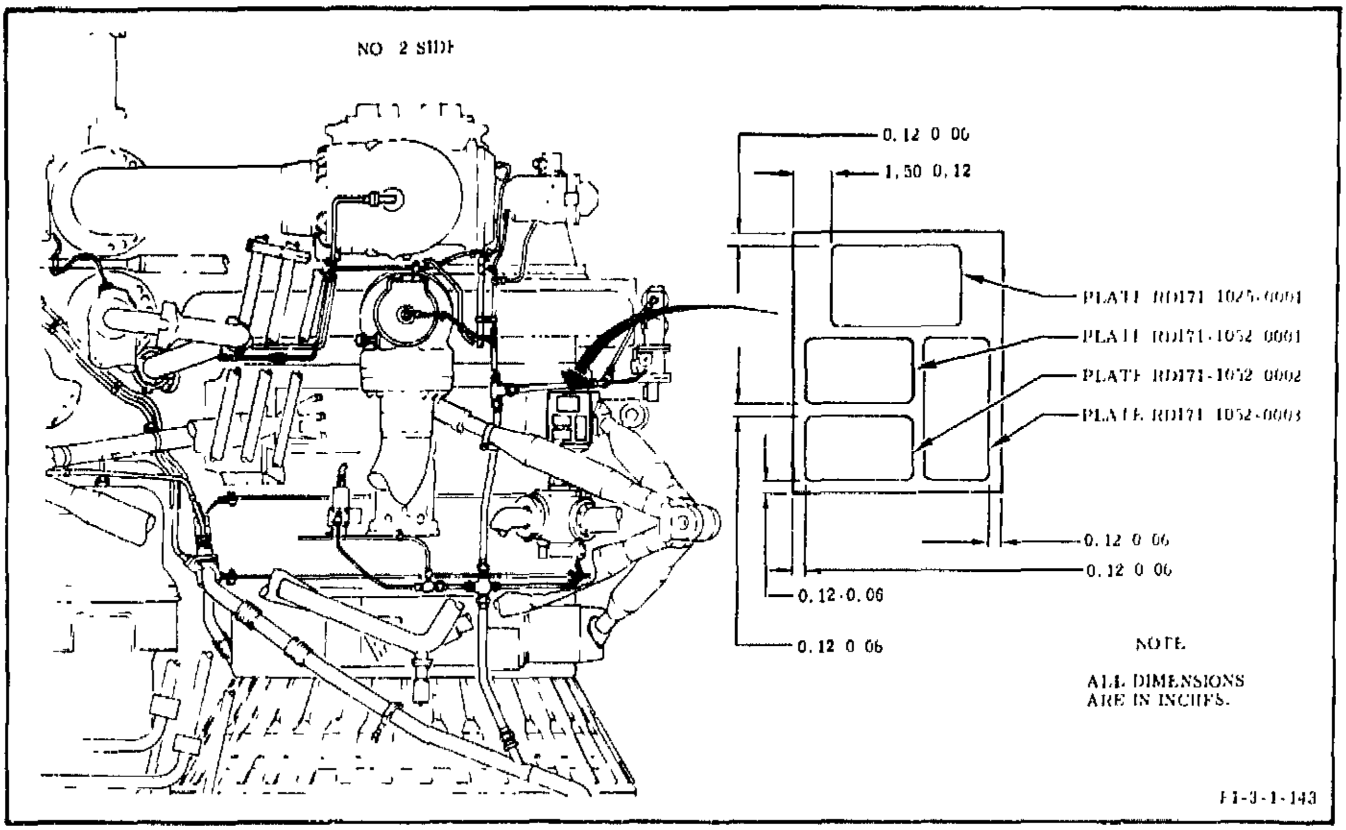


Figure 1-24. Engine and Modification (MD) Identification Plates

c. Remove existing modification (MD) identification plate RD171-1022-0001 from engine. Using stencil-cutting setting of a typewriter, enter a K (kit) or P (production) in applicable blocks of new identification plate RD171-1052-0001, RD171-1052-0002, or RD171-1052-0003 (information to be obtained from Engine Log Book).

d. Remove protective backing from new identification plate by bending plate along split with backing facing out while gently pressing against split with thumbs. Carefully pull backing from plate. Do not touch adhesive on plate or allow adhesive to become contaminated with dirt, moisture, or other foreign matter.

e. Immediately after removal of protective backing, place one edge of identification plate on previously prepared surface area. Press down remainder of plate, being careful to avoid formation of wrinkles or bubbles. Make certain that edges and corners are firmly pressed down. A rubber or plastic roller may be used to press down plate. If plate is applied in the wrong position, is damaged, or is not firmly adhered, it must be removed, discarded, and a new plate installed.

1-141. AGE-CONTROLLED COMPOUNDS.

1-142. The shelf-life requirements of a compound provide the warranty limits of the compound; not the useful life limits. A compound can exceed its maximum usable life before its shelf-life expiration date if the aging process of the compound has somehow been accelerated. Conversely, often compounds under proper storage conditions can be used over a much longer period than their shelf life limits indicate.

1-143. TESTING COMPOUNDS FOR USABILITY.

1-144. Simple and inexpensive tests have been devised to determine the usability of age-controlled compounds in the field. These tests are designed to be used when it is imperative to use a compound without delay when recertification cannot be immediately confirmed. There is no limit to the number of times a material may be tested to determine its usability, unless stated otherwise. Accepting a compound for use under the usability test criteria does not, however, recertify the compound to the original specification standards. Recertification of certain compounds, as deemed necessary by the local Quality Representative, must be returned to Rocketdyne for analysis and recertification.

1-145. USABILITY OF COMPOUNDS.

1-146. Shelf life of a compound is normally specified for a period of time (6 months, 12 months, etc) that starts from the date the compound was manufactured. If in the judgment of the local Quality Representative the tested compounds exhibit favorable properties, as described in the usability tests, the compound should be considered to be usable and the shelf life extended to one-half the original shelf life, unless stated otherwise. For example: if the original shelf life was 12 months, the shelf life can be extended an additional six months. Subsequent successful tests also extend the shelf life six months (one-half the original shelf life). After a compound has passed the usability test, the Quality Representative fills out a Serviceable Label-Material tag, DD Form 1574, with the required data and attaches it to the compound container. The completed tag, which includes the new shelf life extended time period, serves as the official age control document.

1-147. STORAGE ENVIRONMENT AND CONTAINER CONDITION.

1-148. The storage area and the condition of the compound containers should be examined before agitating or opening the container to determine if the immediate environment has a possible effect on the usability of the compound.

1-149. STORAGE ENVIRONMENT. Proper storage is imperative. For example, the aging of many compounds may be minimized by storing the compound in a $<32^\circ$ F environment. However, literature accompanying the compound may warn against such storage and it must be determined what storage conditions are recommended for each compound, and whether the compounds meet these conditions. Usually, storage in direct sunlight, in areas of high heat, or in an area of fluctuating temperature will cause detrimental effects on a compound's usability.

1-150. CONDITION OF CONTAINER. Containers should be kept tightly closed. Loss of volatile constituents or absorption of moisture due to incorrectly closed or sealed containers will generally accelerate or inhibit cure properties, decreasing the maximum usable life of the compound. Use caution with questionable containers.

1-151. CONDITION OF COMPOUND.

1-152. Before agitating or stirring the contents of a container, open the container and determine the general condition of the compound. Following are a few typical examples of what can be encountered during inspection of the general condition of compounds. The user must determine which properties may or may not affect the useful life of a compound:

a. Skinning. Some liquids develop a partially cured skin or thin crystallized shell over the exposed top portion of the liquid in the container. Sometimes, removing this skin will expose usable material; other times this skin is cause for disposing of the compound. Where literature or usability criteria allow formation of surface skinning, it must be removed before stirring or agitating the container, as follows:

(1) Using a spatula, carefully free edge of skin from side of container.

(2) Carefully lift skin out of container in as large of piece as possible.

(3) Remove as many remaining small pieces as possible.

b. Wet Caking. Fillers in certain compounds are evenly dispersed during the manufacturing process and upon storage settle to form a thick mass at the bottom of the container. The following steps should be followed to determine whether the material is usable when caking exists. If literature notes that caking or settling is a cause for disposal, discard material.

(1) Lower a spatula to bottom of container and note viscosity of material in upper half of container. Any caking will show up as increased viscosity when spatula is stirred at bottom of container and compared to viscosity of material in upper half of container. Remove spatula and inspect it for evidence of caking.

(2) If caking in container is hard and cannot be stirred or penetrated with spatula, the material has exceeded its maximum usability life.

(3) If caking is firm, but can be stirred, remix caking with liquid media (supernate) as outlined in substeps 4 through 8.

(4) Pour supernate into suitable clean container, to expose caking in original container.

(5) Stir and break up caking as much as possible and pour back a small amount of supernate into original container.

(6) Try to form a homogeneous paste by mixing small amount of supernate with caking.

(7) Pour another small amount of supernate into original container and again form a homogeneous paste. Continue this operation until all supernate has been added back as completely as possible and a homogeneous mixture is formed.

(8) If a homogeneous mixture containing few gelled bodies, few undispersed conglomerates, or few coarse particles cannot be formed, dispose of material.

c. Dry Caking. Some fillers may be shipped separately or in the dry state and are to be mixed with the compound when it is ready for use. Dry caking of the filler can be determined as follows:

(1) Remove a small amount of filler from container to be examined and note condition of sample as to uniformity, particle size, and apparent moisture content.

(2) If filler has not absorbed much moisture, break lumps into fairly uniform size with blunt instrument or mortar and pestle.

(3) If filler has absorbed moisture, moisture can be safely removed from most fillers by placing filler in dessicator or vacuum drying filler at approximately 75° F for 24 hours.

(4) If caking cannot be reduced to a usable material, discard filler.

d. Gelling. Ordinarily, materials that gel are pourable rubber-based materials that gradually change in properties over an extended period of time. Determine if material has gelled as follows:

(1) Lower a spatula into material and observe its qualities to determine if it is abnormally thick or gellatinous.

(2) If material has not fully gelled, gelled particles may be noted by inserting and removing spatula and allowing a stream of material to flow from it. If gelling is detected, discard material, since it will generally be a short time before the maximum usability time is exceeded.

e. Separation. Two or more liquids in a homogeneous system may separate upon standing (similar to caking). Depending on the material, separation may or may not be cause for disposal. If separation has occurred, try to reblend material by careful stirring or mechanical agitation. If a homogeneous blend cannot be obtained, dispose of material.

f. Solidification. Some liquid materials will eventually cure, crystallize, or solidify in their containers over an extended period as evidenced by the presence of a hard solid mass. The material can generally be considered useless if found in this condition.

g. Contamination. Contamination or adulteration of a frequently used material can easily occur and can be recognized by discoloration, dirt, or partial cure. Simple contamination can be prevented as follows:

(1) Keep containers tightly closed.

(2) Keep pouring spouts and openings clean.

(3) Take samplings with clean utensils.

(4) Do not pour unused material back into original container.

1-153. PREWEIGHED COMPOUNDS.

1-154. Components of some compounds (generally in kit form) are preweighed for convenience and are to be mixed and used for one application. Test samples of these preweighed compounds can be made if the following conditions exist:

a. Mixing ratios are known.

b. Enough of the component exists for accurate weighing.

c. Care is taken not to leave containers open longer than necessary.

d. Material loss is minimized.

Any container that cannot be resealed, should be placed in a container that is sealable. If the above steps cannot be met or when a kit is small enough to be expendable, use the whole kit rather than trying to reseal containers.

1-155. CPR 2028 ISONATE FOAM (THE UPJOHN CO).

1-156. LEADING PARTICULARS.

a. Shelf Life. 3 months.

b. Description. Two-part flexible polyether based polyurethane foam.

c. Type Container. Part A: can; Part B: can.

d. Color. Part A: water white; Part B: water white.

e. Consistency. Part A: pourable; Part B: easily pourable.

1-157. USABILITY TEST.

WARNING

The following procedure specifies polyurethane foam, the components of which, must not be allowed to contact any part of the body. Face shield and gloves must be worn by personnel handling polyurethane foam. Polyurethane foam must be mixed and applied in a well-ventilated area since the vapors are extremely hazardous. Part A in the uncured condition can react as soon as the container is opened. In case of contact,the skin or eyes must be immediately flushed with water for at least 15 minutes and given medical attention.

a. Test I. This test determines usability of uncured foam.

(1) Precondition at 77° ±5° F, curing agent from a batch known to have demonstrated curing ability.

(2) Weigh out a 50-100 gram sample of uncured foam, and precondition foam at 77° ±5° F.

(3) Add appropriate amount of preconditioned curing agent to preconditioned uncured foam sample. Mix thoroughly for one minute.

(4) Allow the mixture to set for 2 hours at 77° ±5° F; then attempt to mix the catalyzed foam.

(5) If mixture cannot be easily mixed, uncured foam is usable.

(6) If mixture can be easily mixed, uncured foam has exceeded its maximum usability life. Discard each tested container and additional containers from same lot number stored under the same conditions.

b. Test II. This test determines usability of curing agent.

(1) Precondition at 77° ±5° F, uncured foam from a batch known to have demonstrated curing ability.

(2) Weigh out a 50-100 gram sample of curing agent and precondition at 77° ±5° F.

(3) Add appropriate amount of preconditoned uncured foam to preconditioned curing agent sample. Mix thoroughly for one minute.

(4) Allow the mixture to set for 2 hours at 77° ±5° F; then attempt to mix the catalyzed foam.

(5) If mixture cannot be easily mixed, curing agent is usable.

(6) If mixture can be easily mixed, curing agent has exceeded its maximum usability life. Discard each tested container, and additional containers from same lot number stored under the same conditions.

1-158. CPR 302-1.5 ISONATE FOAM (THE UPJOHN CO).

1-159. LEADING PARTICULARS.

a. Shelf Life. 6 months at 70° to 90° F.

b. Description. Two-part polyether rigid urethane foam.

c. Type Container. Part A: can; Part B: can.

d. Color. Part A: clear; Part B: brown.

e. Consistency. Part A: syrup; Part B: thick, pourable.

1-160. USABILITY TEST.

WARNING

The following procedure specifies urethane foam, the components of which, must not be allowed to contact any part of the body. Face shield and gloves must be worn by personnel handling urethane foam. Urethane foam must be mixed and applied in a well-ventilated area since the vapors are extremely hazardous. Part A in the uncured condition can react as soon as the container is opened. In case of contact, the skin or eyes must be immediately flushed with water for at least 15 minutes and given medical attention.

a. Test I. This test determines usability of uncured foam.

(1) Precondition at 77° ±5° F, curing agent from a batch known to have demonstrated curing ability.

(2) Weigh out a 50-100 gram sample of uncured foam, and precondition foam at 77° ±5° F.

(3) Add appropriate amount of preconditioned curing agent to preconditioned uncured foam sample. Mix thoroughly for one minute.

(4) Allow the mixture to set for 2 hours at 77° ±5° F; then attempt to mix the catalyzed foam.

(5) If mixture cannot be easily mixed, uncured foam is usable.

(6) If mixture can be easily mixed, uncured foam has exceeded its maximum usability life. Discard each tested container and additional containers from same lot number stored under same conditions.

b. Test II. This test determines the usability of curing agent.

(1) Precondition at 77° ±5° F, uncured foam from a batch known to have demonstrated curing ability.

(2) Weigh out a 50-100 gram sample of curing agent, and precondition curing agent at 77° ±5° F.

(3) Add appropriate amount of preconditioned uncured foam to preconditioned curing agent sample. Mix thoroughly for one minute.

(4) Allow the mixture to set for 2 hours at 77° ±5° F; then attempt to mix the catalyzed foam.

(5) If mixture cannot be easily mixed, curing agent is usable.

(6) If mixture can be easily mixed, curing agent has exceeded its maximum usability life. Discard each tested container, and additional containers from same lot number stored under same conditions.

1-161. CPR 9811 POLYURETHANE FOAM (THE UPJOHN CO).

1-162. LEADING PARTICULARS.

a. Shelf Life. Indefinite.

b. Description. Polyester-based flexible polyurethane foam.

c. Type Container. Buns; none; Sheets: boxes.

d. Color. Charcoal.

e. Consistency. Solid bun or sheet stock.

1-163. USABILITY TEST.

a. Remove foam from box (if applicable) and examine for damage.

b. If foam shows evidence of damage or contamination, discard material.

c. If foam is not flexible, discard material.

d. If foam crumbles when handled, discard material.

e. If foam shows evidence of moisture absorption, attempt to dry it by squeezing and placing in an oven at 200° F for 2 hours (longer if necessary to completely dry material).

f. If foam retains moisture, discard material.

g. Retain material not rejected in steps b through f.

1-164. C-328 RTV VITON ELASTOMER (CONNECTICUT HARD RUBBER CO).

1-165. LEADING PARTICULARS.

a. Shelf Life. 6 months.

b. Description. Two-part high temperature, fuel, and chemical resistant cement.

c. Type Container. Base: can; Curing agent: can.

d. Color. Base: black; Curing agent: transparent.

e. Consistency. Base: spreadable paste; Curing agent: pourable.

1-166. USABILITY TEST.

WARNING

Viton elastomer C-328 RTV is flammable and must not be used near heat, sparks, or open flame. It is toxic. Inhalation of its vapors or prolonged contact with the curing agent (catalyst) can cause serious bodily harm. In case of prolonged exposure, immediately obtain fresh air and wash skin with soap and water.

a. Test I.

(1) Remove lids and check each component. Each component must be free of skins, lumps, and coagulation.

(2) Mix appropriate amounts of components together. Both components must be capable of being mixed together to form a smooth, uniform compound.

b. Test II.

(1) If components are not rejected in Test I, thoroughly condition enough of both components at 77° ±5° F for a 50-100 gram sample.

(2) Mix the appropriate amount of curing agent with sample of the base compound.

(3) Apply a thin uniform coating of the mixture to one surface of a flat, smooth clean, metal sample of convenient size.

(4) Allow the coated metal sample to cure at 77° ±5° F for 4 hours.

(5) Touch the coating after curing. If the coating is tacky, discard the base resin and the catalyst. If the coating is not tacky, the base and catalyst have not exceeded their maximum usability life, and are usable.

1-167. EC1099 ADHESIVE (MINNESOTA MINING AND MFG).

1-168. LEADING PARTICULARS.

a. Shelf Life. 6 months.

b. Description. One-part adhesive.

c. Type Container. Can.

d. Color. Light tan.

e. Consistency. Thin syrup.

1-169. USABILITY TEST.

WARNING

Adhesive EC1099 is flammable and must not be used near heat, sparks, or open flame. It is toxic. Inhalation of its vapors or prolonged contact with the adhesive can cause serious bodily harm. In case of prolonged exposure, immediately obtain fresh air and wash skin with soap and water.

a. Test I.

(1) Remove lid and check adhesive. Adhesive must be free of skins, lumps, and coagulations.

(2) Apply adhesive to a smooth surface. Adhesive must flow in a thin, even coat.

b. Test II.

(1) If adhesive is not rejected in Test I, apply a thin, even coat of adhesive to each surface of flat smooth samples to be bonded together. (The samples should be of materials recommended to be bonded by this adhesive and be flat and smooth.)

(2) Allow adhesive to dry to an aggressively tacky stage (evidenced by adhering but not transferring to the finger when touched); then join surfaces and roll or press firmly to ensure contact.

(3) If an agressively tacky stage cannot be attained or if an effective bond cannot be achieved from two samples joined together, the adhesive has exceeded its maximum usability life and must be discarded.

1-170. EC1300 ADHESIVE (MINNESOTA MINING AND MFG).

1-171. LEADING PARTICULARS.

a. Shelf Life. 5 months.

b. Description. One-part adhesive.

c. Type Container. Can.

d. Color. Yellow.

e. Consistency. Thin syrup.

1-172. USABILITY TEST.

WARNING

Adhesive EC1300 is flammable and must not be used near heat, sparks, or open flame. It is toxic. Inhalation of its vapors or prolonged contact with the adhesive can cause serious bodily harm. In case of prolonged exposure, immediately obtain fresh air and wash skin with soap and water.

a. Test I.

(1) Remove lid and check adhesive. Adhesive must be free of skins, lumps, and coagulations.

(2) Apply adhesive to a smooth surface. Adhesive must flow in a thin, even coat.

b. Test II.

(1) If adhesive is not rejected in Test I, apply a thin, even coat of adhesive to sample surfaces to be bonded together. (The samples should be of materials recommended to be bonded by this adhesive and be flat and smooth.)

(2) Allow adhesive to dry to an aggressively tacky stage (evidenced by adhering but not transferring to the finger when touched); then join surfaces and roll or press firmly to ensure contact.

(3) If an aggressively tacky stage cannot be attained or if an effective bond cannot be achieved from two samples joined together, the adhesive has exceeded its maximum usability life and must be discarded.

1-173. MIL-P-8585 PRIMER.

1-174. LEADING PARTICULARS.

a. Shelf Life. 12 months.

b. Description. Zinc chromate primer.

c. Type Container. Can.

d. Color. Yellow.

e. Consistency. Syrup.

1-175. USABILITY TEST.

WARNING

Primer (MIL-P-8585) is flammable and must not be used near heat, sparks, or open flame. It is toxic. Inhalation of its vapors or prolonged contact with the primer can cause serious bodily harm. In case of prolonged exposure, immediately obtain fresh air and wash skin with soap and water.

a. Remove lid and check primer for separation of components. Separation of components generally indicates the primer has exceeded its usability life.

b. If separation has occurred, try to reblend mixture by carefully stirring or mechanically agitating the contents.

c. If the primer can be blended into a homogeneous mixture with little evidence of coarse particles dispersed throughout, it has not yet reached its maximum usability life and is usable.

d. If a homogeneous blend cannot be obtained, the primer has exceeded its maximum usability life and must be discarded.

1-176. PR-1532 POTTING COMPOUND (PRODUCTS RESEARCH AND CHEMICAL, SEMCO).

1-177. LEADING PARTICULARS.

a. Shelf Life. 6 months.

b. Description. Two-part urethane sealant.

c. Type Container. Part A; can; Part B: can.

d. Color. Part A: gray; Part B: white.

e. Consistency. Part A: paste; Part B: spreadable thick paste.

1-178. USABILITY TEST.

WARNING

Potting compound PR-1532 is toxic. Inhalation of its vapors or contact with the material can cause serious bodily harm. It must be used in a well-ventilated area. In case of contact, wash skin with soap and water.

a. Test I.

(1) Remove lids and check each component. Each component must be free of skins, lumps, and coagulations.

(2) Mix appropriate amounts of components together. Both components must be capable of being mixed together to form a smooth, uniform compound.

b. Test II.

(1) If components are not rejected in Test I, thoroughly condition enough of both components at 77° ±5° F for a 50-100 gram sample.

(2) Mix the appropriate amount of curing agent with sample of base compound.

(3) Allow the mixture to cure at 77° ±5° F for 4 hours.

(4) If the catalyzed compound cannot be easily mixed after curing both components are usable.

(5) If the catalyzed compound can be easily mixed, either the curing agent or the base material has exceeded its usability limit, and each component must be discarded.

1-179. PR-1553 POTTING COMPOUND (PRODUCTS RESEARCH AND CHEMICAL, SEMCO).

1-180. LEADING PARTICULARS.

a. Shelf Life. 6 months.

b. Description. Two-part urethane molding and potting compound.

c. Type Container. Part A: can; Part B: can.

d. Color. Part A: black; Part B: light amber.

e. Consistency. Part A: thick pourable; Part B: thick pourable.

1-181. USABILITY TEST.

WARNING

Potting compound PR-1553 is toxic. Inhalation of its vapors or contact with the material can cause serious bodily harm. It must be used in a well-ventilated area. In case of contact, wash skin with soap and water.

a. Test I.

(1) Remove lids and check each component. Each component must be free of skins, lumps, and coagulations.

(2) Mix appropriate amounts of components together. Both components must be capable of being mixed together to form a smooth, uniform compound.

b. Test II.

(1) If components pass Test I, thoroughly condition enough of both components at 77° ±5° F for a 50-100 gram sample.

(2) Mix the appropriate amount of curing agent with sample of the base compound.

(3) Allow the mixture to cure at 77° ±5° F for 1/2 hour.

(4) If the catalyzed compound cannot be easily mixed after curing both components are usable.

(5) If the catalyzed compound can be easily mixed, either the curing agent or the base material has exceeded its usability life, and each component must be discarded.

1-182. RB0120-017 SEALANT AND ANTISEIZE DISPERSION (ROCKETDYNE).

1-183. LEADING PARTICULARS.

a. Shelf Life. 2 months.

b. Description. Special sealing and antiseize dispersion material.

c. Type Container. Dispersion, plastic bottle; buffer solution, vial.

d. Color. Dispersion, milky white; buffer, clear.

e. Consistency. Dispersion, thin, easily pourable; buffer, thin, easily pourable.

1-184. USABILITY TEST.

a. Mix a sample of dispersion and buffer solution per instructions supplied with the kit; then check solution. If there are any signs of coagulation or solidification, the dispersion and buffer solution have exceeded their maximum usability life and must be discarded.

b. If contents cannot be thoroughly dispersed by shaking, dispose of solution.

NOTE

This solution has a limited life after buffer is added and the 2-month usability life imposed by the specification must be adhered to.

1-184A. RB0120-034 GASKET SEALANT (ROCKETDYNE).

1-184B. LEADING PARTICULARS.

a. Shelf Life. 6 months.

b. Description. One-part gasket sealing compound.

c. Type Container. Can or bottle.

d. Color. Aluminum.

e. Consistency. Paste.

1-184C. USABILITY TEST.

a. Remove lid and check compound for signs of gelling, lumps, or hard settling.

b. If compound shows signs of gelling, lumps, or hard settling, try to reblend compound by carefully stirring or mechanically agitating contents.

c. If compound can be blended into a homogeneous mixture with little evidence of coarse particles throughout, it has not yet reached its maximum usability life and is usable.

d. If a homogeneous mixture cannot be obtained, the compound has exceeded its maximum usability life and must be discarded.

1-185. RTV-102 WHITE SEALANT (GENERAL ELECTRIC).

1-186. LEADING PARTICULARS.

a. Shelf Life. 6 months for AB0120-057.
12 months for AB0120-013.

b. Specification Ref. AB0120-057 and AB0120-013.

AB0120-057 supersedes AB0120-013 for future procurement. RTV-102 white sealant conforming to specification AB0120-013 may be used until the supply is exhausted.

c. Description. One-part silicone adhesive.

d. Type Container. Tube.

e. Color. White.

f. Consistency. Soft, spreadable, thick paste.

1-187. USABILITY TEST.

a. Remove cap and remove any cured or partially cured adhesive blocking or present at tube opening.

WARNING

White sealant RTV-102 is flammable and must not be used near heat, sparks, or open flame. It is toxic. Inhalation of its vapors or prolonged contact with the sealant can cause serious bodily harm. In case of prolonged exposure, immediately obtain fresh air and wash skin with soap and water.

b. Squeeze tube. If the adhesive cannot be squeezed out after freeing plugged opening, discard adhesive.

c. If, when attempting to squeeze out adhesive, the tube is punctured or ruptures, discard adhesive.

d. If the adhesive can be squeezed out and lumps can be detected other than lumps from the plugged or partially plugged opening, discard adhesive.

e. If the adhesive is not rejected by one of the above steps, the adhesive is usable.

1-188. RTV-106 RED SEALANT (GENERAL ELECTRIC).

1-189. LEADING PARTICULARS.

a. Shelf Life. 12 months.

b. Description. One-part silicone adhesive.

c. Type Container. Tube.

d. Color. Red.

e. Consistency. Soft, spreadable, thick paste.

1-190. USABILITY TEST.

WARNING

Red sealant RTV-106 is flammable and must not be used near heat, sparks, or open flame. It is toxic. Inhalation of its vapors or prolonged contact with the sealant can cause serious bodily harm. In case of prolonged exposure, immediately obtain fresh air and wash skin with soap and water.

a. Remove cap and remove any cured or partially cured adhesive blocking or present at tube opening.

b. Squeeze tube. If the adhesive cannot be squeezed out after freeing plugged opening, discard adhesive.

c. If, when attempting to squeeze out adhesive, the tube is punctured or ruptures, discard adhesive.

d. If the adhesive can be squeezed out and lumps can be detected other than lumps from the plugged or partially plugged opening, discard adhesive.

e. If the adhesive is not rejected by one of the above steps, the adhesive is usable.

1-191. RTV-108 ADHESIVE SEALANT (GENERAL ELECTRIC).

1-192. LEADING PARTICULARS.

a. Shelf Life. 12 months.

b. Description. One-part silicone adhesive.

c. Type Container. Tube.

d. Color. Transparent.

e. Consistency. Soft, spreadable, thick paste.

1-193. USABILITY TEST.

WARNING

Adhesive sealant RTV-108 is flammable and must not be used near heat, sparks, or open flame. It is toxic. Inhalation of its vapors or prolonged contact with the sealant can cause serious bodily harm. In case of prolonged exposure, immediately obtain fresh air and wash skin with soap and water.

a. Remove cap and remove any cured or partially cured adhesive blocking or present at tube opening.

b. Squeeze tube. If the adhesive cannot be squeezed out after freeing plugged opening, discard adhesive.

c. If, when attempting to squeeze out adhesive, the tube is punctured or ruptures, discard adhesive.

d. If the adhesive can be squeezed out and lumps can be detected other than lumps from the plugged or partially plugged opening, discard adhesive.

e. If the adhesive is not rejected by one of the above steps, the adhesive is usable.

1-194. RTV-615 SILICONE RESIN (GENERAL ELECTRIC).

1-195. LEADING PARTICULARS.

a. Shelf Life. 6 months.

b. Description. Two-part silicone potting and encapsulating compound.

c. Type Container. Part A: can; Part B: can.

d. Color. Part A: clear; Part B: clear.

e. Consistency. Part A: easily pourable; Part B: pourable.

1-196. USABILITY TEST.

WARNING

Silicone resin RTV-615 contains an alkaline catalyst that may cause burns. It must not be allowed to contact skin or clothes. In case of contact, wash skin with soap and water and treat injured area as a burn.

a. Test I. This test determines usability of uncured silicone rubber.

(1) Precondition at 77° ±5° F curing agent from a batch known to have demonstrated curing ability.

(2) Weigh out a 50-100 gram sample of uncured silicone and precondition at 77° ±5° F.

(3) Add appropriate amount of conditioned curing agent to conditioned uncured silicone sample. Mix thoroughly for one minute.

(4) Allow the mixture to set for 4 hours at 77° ±5° F; then attempt to mix the catalyzed silicone.

(5) If mixture cannot be easily mixed, uncured silicone is usable.

(6) If mixture can be easily mixed, uncured silicone has exceeded its maximum usability life. Discard each tested container and additional containers from same lot number stored under the same conditions.

b. Test II. This test determines usability of curing agent.

(1) Precondition at 77° ±5° F uncured silicone from a batch known to have demonstrated curing ability.

(2) Weigh out a 50-100 gram sample of curing agent and precondition at 77° ±5° F.

(3) Add appropriate amount of conditioned uncured silicone to conditioned curing agent sample. Mix thoroughly for one minute.

(4) Allow the mixture to set for 4 hours at 77° ±5° F; then attempt to mix the catalyzed silicone.

(5) If mixture cannot be easily mixed, curing agent is usable.

(6) If mixture can be easily mixed, curing agent has exceeded its maximum usability life. Discard tested container and additional containers from the same lot number stored under the same conditions.

1-197. SS-4120 SILICONE PRIMER (GENERAL ELECTRIC).

1-198. LEADING PARTICULARS.

a. Shelf Life. 6 months. Primer must be kept sealed and placed in a cool, dark area during storage.

b. Description. Silicone primer.

c. Type Container. Bottle.

d. Color. Clear.

e. Consistency. Thin, easily pourable.

1-199. USABILITY TEST.

WARNING

Silicone primer SS-4120 is flammable and must not be used near heat, sparks, or open flame. It is toxic. Inhalation of its vapors or prolonged contact with the primer can cause serious bodily harm. In case of prolonged exposure, immediately obtain fresh air and wash skin with soap and water.

a. Without shaking original container, carefully pour a small amount of the liquid from the top of bottle into a clear, clean inspection container.

b. If the primer appears to be a clear liquid, it can generally be considered not to have exceeded its maximum usability life.

c. If the primer appears to be a cloudy liquid, or if it appears to be clear but has precipitate suspended or settling out, the primer has exceeded its maximum usability life and must be discarded.

1-200. 1200 RTV PRIMER (DOW CORNING CORP).

1-201. LEADING PARTICULARS.

a. Shelf Life. 6 months.

b. Specification Ref. ST0120RB0043.

c. Description. Silicone primer.

d. Type Container. Bottle.

e. Color. Red.

f. Consistency. Thin, easily pourable.

1-202. USABILITY TEST.

WARNING

Primer 1200 RTV is flammable and must not be used near heat, sparks, or open flame. It is toxic. Inhalation of its vapors or prolonged contact with primer can cause serious injury. In case of prolonged exposure, immediately obtain fresh air and wash skin with soap and water.

a. Without shaking original container, carefully pour a small amount of the liquid from top of bottle into a clear, clean inspection container.

b. Visually inspect container. If primer appears to be a clear or slightly cloudy liquid, it can generally be considered not to have exceeded its maximum usability life.

c. If primer in original container or inspection container has a milky appearance or any signs of precipitation or precipitant (other than slightly cloudy), the primer has exceeded its maximum usability life and must be discarded.

1-203. 584 ADHESIVE (COAST PRO-SEAL).

1-204. LEADING PARTICULARS.

a. Shelf Life. 12 months.

b. Description. One-part adhesive.

c. Type Container. Can.

d. Color. Tan.

e. Consistency. Thin syrup.

1-205. USABILITY TEST.

WARNING

Adhesive 584 is flammable and must not be used near heat, sparks, or open flame. It is toxic. Inhalation of its vapors or prolonged contact with the adhesive can cause serious bodily harm. In case of prolonged exposure, immediately obtain fresh air and wash skin with soap and water.

a. Test I.

(1) Remove lid and check adhesive. Adhesive must be free of skins, lumps, and coagulations.

(2) Apply adhesive to a smooth surface. Adhesive must flow in a thin, even coat.

b. Test II.

(1) If adhesive is not rejected in Test I, apply a thin, even coat of the adhesive to sample surfaces to be bonded together. (The samples should be of materials recommended to be bonded by this adhesive and be flat and smooth.)

(2) Allow adhesive to dry to an aggressively tacky stage (evidenced by adhering but not transferring to the finger when touched); then join surfaces and roll or press firmly to ensure contact.

(3) If an aggressively tacky stage cannot be attained or if an effective bond cannot be achieved from two samples joined together, the adhesive has exceeded its maximum usability life and must be discarded.

1-206. 92-018 AEROSPACE SEALANT (DOW CORNING CORP).

1-207. LEADING PARTICULARS.

a. Shelf Life. 12 months.

b. Specification Ref. AB0120-013.

c. Description. One-part silicone adhesive.

d. Type Container. Tube or cartridge.

e. Color. Black.

f. Consistency. Soft, spreadable, thick paste.

1-208. USABILITY TEST.

a. Remove cap and remove any cured or partially cured adhesive blocking or present at container opening.

b. Squeeze container. If adhesive cannot be squeezed out after freeing plugged opening, discard adhesive.

c. If, when attempting to squeeze out adhesive, the container is punctured or ruptures, discard adhesive.

d. If the adhesive can be squeezed out and lumps can be detected other than lumps from the plugged or partially plugged opening, discard adhesive.

e. If the adhesive is not rejected by one of the above steps, the adhesive is usable.

SECTION II

HANDLING

WARNING

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

G4044, Air Transport Engine Handler
G4047, Engine Cover
G4048, Thrust Chamber Protective Cover
G4049, Engine Vertical Installer
G4050, Engine Rotating Sling
G4051, Roadable Vertical Engine Dolly
G4052, Engine Handler Sling
G4054, Engine Vertical Sling
G4C58, Engine Handling Dolly
G4069, Engine Handler
G4080, Nozzle Extension Handling Fixture
G4081, Nozzle Extension Handling Adapter

2-1. SCOPE. This section describes the use of engine, thrust chamber, and nozzle extension handling equipment and the preparation of the engine and thrust chamber for maintenance. In addition to the equipment described in this section, a 30,000-pound monorail or bridge crane facility hoist capable of lifting the handling equipment with the engine installed, is required. Only the operating personnel must be allowed in the immediate area when equipment is suspended.

2-2. ENGINE AND THRUST CHAMBER HANDLING EQUIPMENT.

2-3. ENGINE COVER G4047.

2-4. The engine cover, which encloses the engine during shipping or storage, is two-piece and weatherproof. The cover is supported by a lightweight aluminum frame on the front part of the engine and rests directly on the aft end of the engine.

2.5 REMOVING ENGINE COVER G4047. (See figure 2-1.)

WARNING

Engine Cover G4047 must be removed/installed by authorized personnel trained in the use of the equipment.

CAUTION

Adequate support of the cover must be maintained during removal, to prevent damage to the zipper.

a. Provide support for engine cover, and unfasten straps on each side and at rear of engine at gimbal outrigger and at truss plug. Unzip and remove lower half of engine cover.

b. Store lower half of engine cover in a suitable container.

c. Position facility hoist above engine.

d. Using a suitable sling, carefully insert sling under upper half of engine cover (between frame and cover).

e. Attach sling to facility hoist. Carefully lift cover from engine and store with lower half of engine cover.

NOTE

Due to differences in the manufacturer's installation of zippers on covers, the upper and lower covers must be retained as a set. For future procurement and rework of covers, the upper and lower covers have the same serial number.

f. Loosen adjustment bolt on back of top frame at thrust chamber exhaust manifold flange.

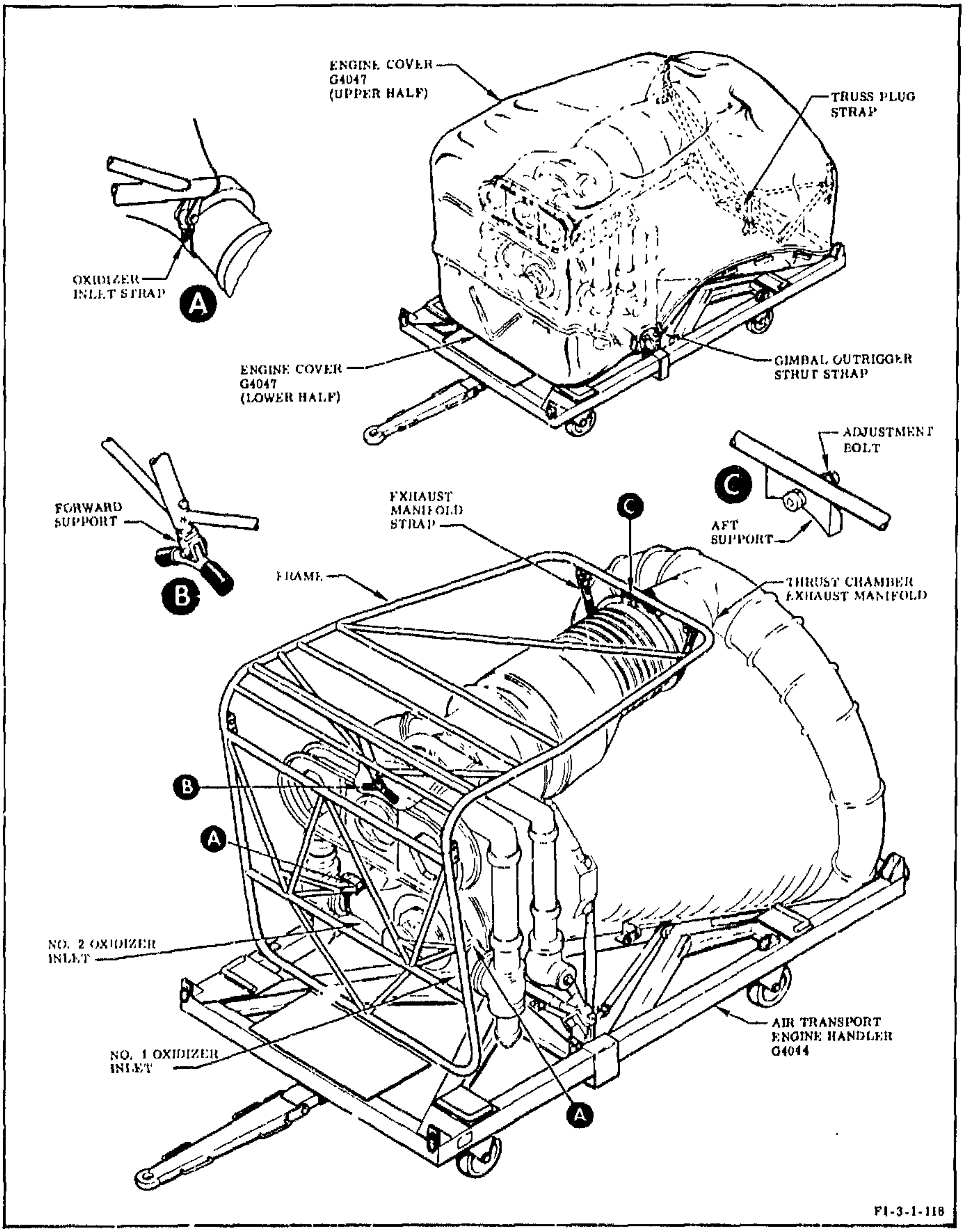


Figure 2-1. Removing and Installing Engine Cover

g. Using facility hoist, support weight of frame. Unstrap frame from engine at the following places:

(1) No. 1 oxidizer inlet

(2) No. 2 oxidizer inlet

(3) Thrust chamber exhaust manifold

h. Carefully hoist frame away from engine and lower to floor.

CAUTION

The engine cover frames must be prepared for shipping or storage as outlined in steps i through k; otherwise, damage to the frames could occur.

i. Disconnect bottom frame from top frame. Stow attaching pins.

j. Invert top frame and secure on shipping crate with metal straps. Use adequate padding between frame and crate to prevent damage.

CAUTION

- Engine cover straps must not be used to attach the frame to the crate. Damage to the straps may occur during shipment if the straps are used for this purpose.
- Padded supports on the bottom frame must be facing up to prevent damage to supports.

k. Invert bottom frame and secure to top frame. Use adequate padding between frames to prevent damage.

2-6. INSTALLING ENGINE COVER G4047. (See figure 2-1.)

a. Using facility hoist, position frame on engine and strap to engine at the following points:

(1) No. 1 oxidizer inlet

(2) No. 2 oxidizer inlet

(3) Thrust chamber exhaust manifold

b. Adjust forward support, as required, to obtain a good fit between engine and frame.

c. Tighten adjustment bolt located on aft support of top frame at thrust chamber exhaust manifold, until snug. Torque jamnut to 160-210 in-lb.

d. If engine cover has not been reinforced to prevent chafing, use pressure-sensitive tape (Federal Specification PPP-T-60) to secure a single layer of 1/4-inch-thick Ethafoam (Dow Chemical Co) around rounded corners of engine cover frame, around truss yokes, and over truss yoke attaching points at thrust chamber exit flange. Add this protection to any other engine areas that may cause chafing of engine cover.

e. Spread upper half of engine cover on floor over a suitable sling. Attach sling to a hoist.

f. Using hoist, carefully position upper half of engine cover over frame on engine.

g. Carefully remove sling from beneath cover.

h. Position lower half of engine cover beneath engine.

CAUTION

The forward zipper must be closed while the aft zippers are open, to prevent zipper damage when installing covers.

i. Support and zip lower half of engine cover to upper half of engine cover.

j. Fasten straps on each side and rear of engine at gimbal outrigger and at truss plug.

2-7. THRUST CHAMBER PROTECTIVE COVER G4048.

2-8. The thrust chamber protective cover protects the thrust chamber tubes from damage. The cover must be installed at all times except during an engine firing or when a test or maintenance procedure requires its removal.

2-9. REMOVING THRUST CHAMBER PROTECTIVE COVER G4048. Unfasten buckles and straps, and remove protective cover.

2-10. INSTALLING THRUST CHAMBER PROTECTIVE COVER G4048. Position protective covers on thrust chamber as directed by instructions stamped on cover. Secure buckles and straps.

2-11. ENGINE ROTATING SLING G4050.

2-12. The engine rotating sling is capable of lifting and rotating either the engine or the thrust chamber. The sling has six different load conditions (figure 2-2), indicated by a one-inch-wide black strip on the underside of the beam with corresponding numbers on each side of the beam. An instruction plate attached to the control cable just above the control station lists the six strip positions and briefly describes load conditions for each position. Engine rotating slings incorporating MD3 change have 600 pounds of ballast added to the forward end of the beam, a tire bumper installed at the aft end of the beam, and seven load-condition strips. Engine rotating slings incorporating MD4 change, include a number eight position on the beam for lifting a vertical engine with actuators attached. An arrow on the carriage drive bracket is alined with numbered strip positions on the beam for load conditions as follows:

a. Number 1 for lifting and lowering thrust chamber in vertical position.

b. Number 2 for lifting and lowering engine in vertical position.

c. Number 3 for attaching or removing sling from vertical thrust chamber or engine.

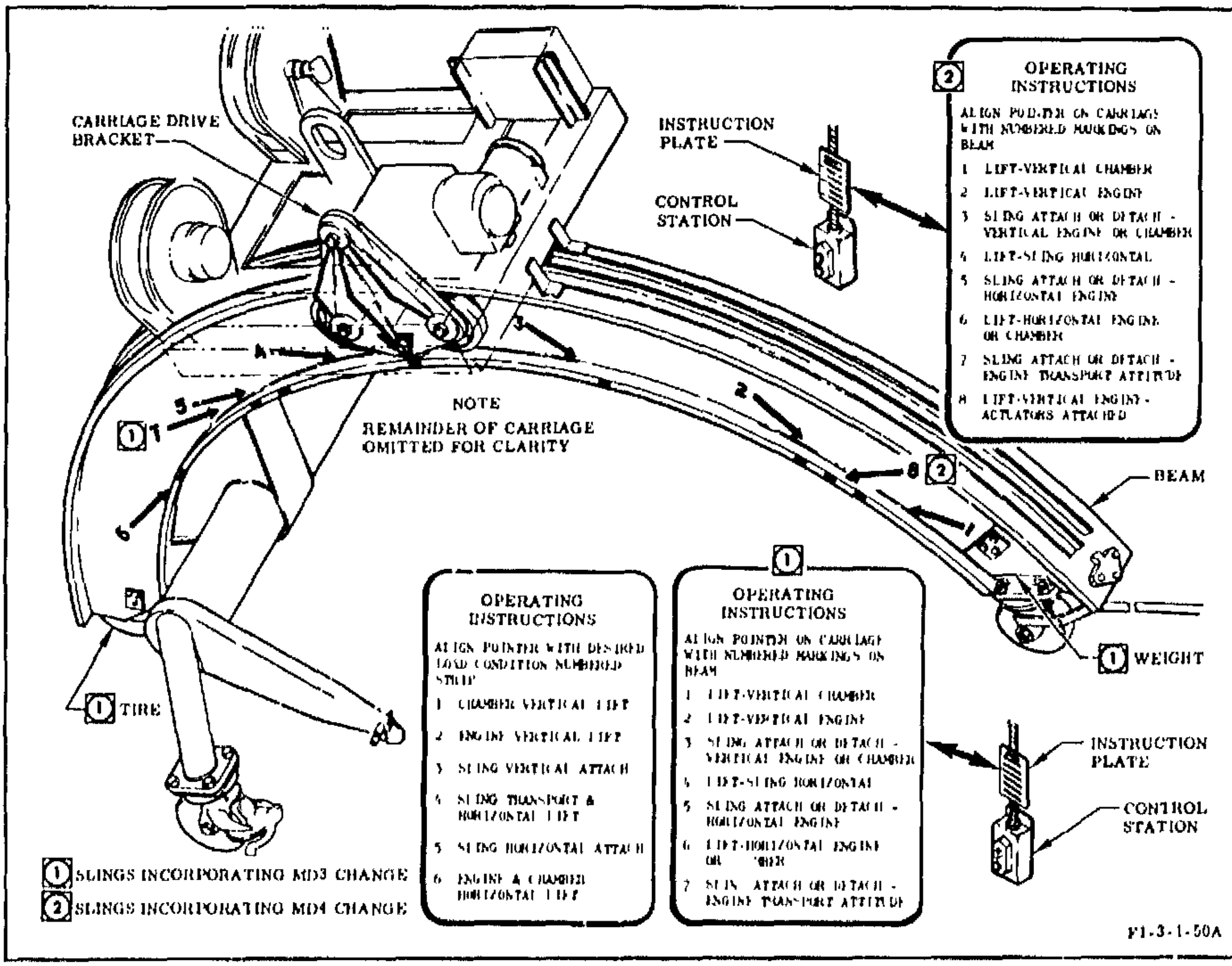


Figure 2-2. Engine Rotating Sling Load Condition Numbered Strip Positions

d. Number 4 for transporting, lifting, and lowering sling.

e. Number 5 for attaching and removing sling from a horizontal thrust chamber or engine.

f. Number 6 for lifting and lowering a thrust chamber or engine in horizontal position.

g. Number 7 for attaching and [illegible] ching sling where engine is in 7-degree [illegible] ed-down position (engine rotating slings incorporating MD3 change only).

gA. Number eight for lifting a vertical engine with actuators attached (engine rotating slings incorporating MD4 change).

2-13. REMOVING ENGINE ROTATING SLING G4050. (See figure 2-3.)

NOTE

The load condition numbered strip positions noted in this procedure are used for initial positioning of the engine rotating sling beam. Minor adjustments of the beam to either side of a strip position may be required to level the load.

a. Lower facility hoist hook to relieve tension, and position sling carriage to load condition No. 3 strip position for engine or thrust

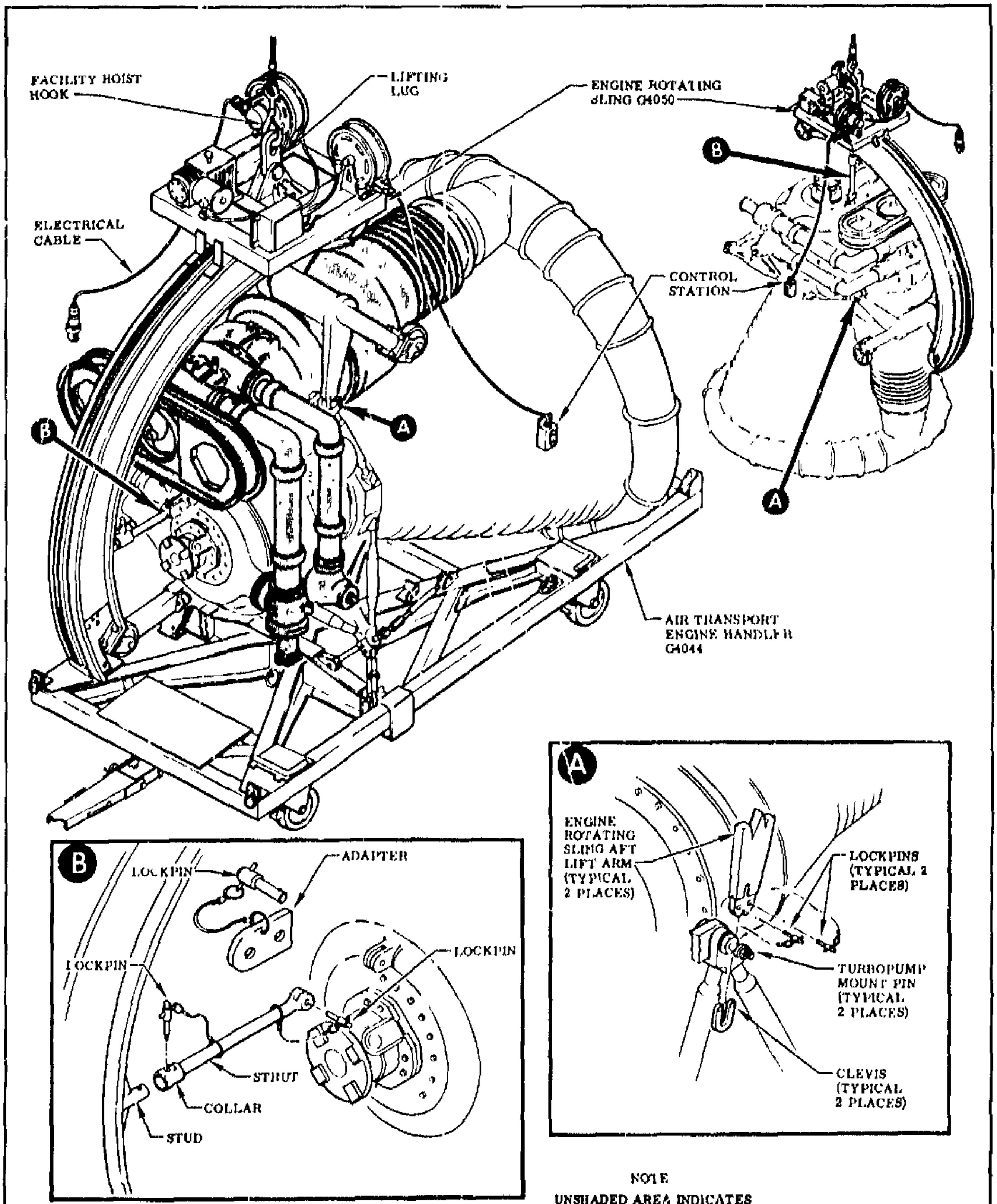


Figure 2-3. Removing and Installing Engine Rotating Sling

chamber vertical position, No. 5 strip position for engine or thrust chamber horizontal position or (on engine rotating slings incorporating MD3 change) No. 7 strip position for engine in transport attitude; then resume tension on sling.

CAUTION

Step a must be performed prior to steps b through d, since the incorrect lift point with respect to the center of gravity will cause the sling beam to swing toward the engine, possibly damaging the heat exchanger.

b. Remove lockpin that secures sling strut collar to stud at sling forward end.

c. Remove lockpin that secures sling strut to adapter 9017823. Remove lockpin that secures adapter to oxidizer dome clevis, and stow adapter on sling.

d. Remove lockpins that secure clevises to aft lift arms of sling.

e. Using facility hoist, carefully move sling away from engine or thrust chamber.

f. Make sure engine rotating sling is hoisted to a sufficient height to allow sling beam to be positioned to load condition No. 4 strip position without interference.

g. Press sling control station FORWARD or REVERSE button, as applicable, to position sling beam to load condition No. 4 strip position.

h. Using facility hoist, lower sling to floor, and lock sling wheel brakes.

i. Install clevises on aft lift arms, and stow sling strut.

NOTE

The facility hoist hook must be lowered and repositioned as step j is performed.

j. Press sling control station FORWARD button, and position sling carriage to load condition No. 6 strip position.

k. Disconnect facility hoist hook from sling lifting lug, and secure facility hoist.

l. Press sling control station REVERSE button, and position sling carriage to load condition No. 4 strip position.

m. Turn off sling facility electrical power source, and disconnect electrical cable from facility power source.

n. Reel in and secure sling electrical cable, and install tow bar on sling.

o. If thermal insulation bracketry is installed, reinstall assembled collars and brackets at turbopump trunnions. Torque nuts at bracket to 68 ±7 in-lb. Install washer and trunnion nuts. Torque trunnion nuts to 825 ±10 in-lb.

2-14. INSTALLING ENGINE ROTATING SLING G4050. (See figure 2-3.)

NOTE

The load condition numbered strip positions noted in this procedure are used for initial positioning of the engine rotating sling beam. Minor adjustments of the beam to either side of a strip position may be required to level the load.

a. Position engine rotating sling beneath facility hoist that is capable of lifting 30,000 pounds.

b. Remove tow bar from sling.

c. Connect sling electrical cable to facility electrical power source (440-volt, 3-phase, 60-cycle, 15-ampere) utilizing handle RPE417-002K069D and connector RPX317-912S04A (Crouse-Hinds). Turn facility electrical power source on.

d. Press sling control station FORWARD button, and position sling carriage to load condition No. 6 strip position.

e. Connect facility hoist hook to sling lifting lug.

NOTE

The facility hoist hook must be raised and centered over the sling beam as step f is performed.

f. Press sling control station REVERSE button, and position sling carriage to load condition No. 4 strip position.

g. Remove sling strut from stowed position on sling.

h. Remove clevises from sling aft lift arms.

i. Using facility hoist, raise sling until sling beam can be rotated to all positions without interference.

j. If thermal insulation bracket assemblies are installed on engine, remove outboard trunnion nuts and washers. Remove serrated collars and brackets as assemblies. Retain for reinstallation.

k. If attaching sling to a horizontal engine or thrust chamber, press sling control station FORWARD button and position sling beam to load condition No. 5 strip position.

l. If attaching sling to engine in engine lowered position on slings incorporating MD3 change, press sling control station FORWARD button and position sling beam to load condition No. 7 strip position.

m. If attaching sling to a vertical engine or thrust chamber, press sling control station REVERSE button, and position sling beam to load condition No. 3 strip position.

mA. If engine is to be rotated to horizontal position, purge oxidizer pump seal as outlined in paragraph 2-20C.

n. Using facility hoist, position sling on engine or thrust chamber and carefully mate aft lift arms with turbopump mount pins. Readjustment of the sling beam may be necessary.

o. Install clevises, securing aft lift arms to turbopump mount pins with attaching lockpins.

p. Attach adapter 9017823 to oxidizer dome clevis with lockpin. Secure sling strut to adapter with lockpin.

q. Reposition sling beam, as required, to mate sling strut collar with stud at sling forward end. Secure with attaching lockpin.

2-15. ENGINE VERTICAL SLING G4054.

2-16. The engine vertical sling lifts the engine or thrust chamber in the vertical position. Procedures for using the vertical sling with a thrust chamber are identical to these procedures except that the two stowed sling links are installed between the two short cables of the sling lift ring and the corners of the sling spreader bar.

2-17. REMOVING ENGINE VERTICAL SLING G4054. (See figure 2-4.)

a. Using facility hoist, take up slack on sling.

b. Remove lockpins and bushings from gimbal outrigger clevis and sling leg bracket.

c. Remove lockpin that secures lift plate to adapter 9017823. Remove lockpin that secures adapter to oxidizer dome clevis, and stow adapter to sling.

d. Slowly raise sling from engine.

e. Move sling away from engine and lower to position for removal from facility hoist.

2-18. INSTALLING ENGINE VERTICAL SLING G4054. (See figure 2-4.)

a. Attach sling lift ring to facility hoist that is capable of lifting 30,000 pounds.

b. Position sling over engine.

c. Slowly lower sling so that the 2 brackets on ends of sling legs mate with gimbal outrigger clevis.

d. Install bushings and lockpins through matched holes in gimbal outrigger clevis and sling leg bracket.

e. Position sling so that lift plate matches attach point at engine oxidizer dome.

f. Attach adapter 9017823 to oxidizer dome clevis with lockpin. Secure sling lift plate to adapter with lockpin.

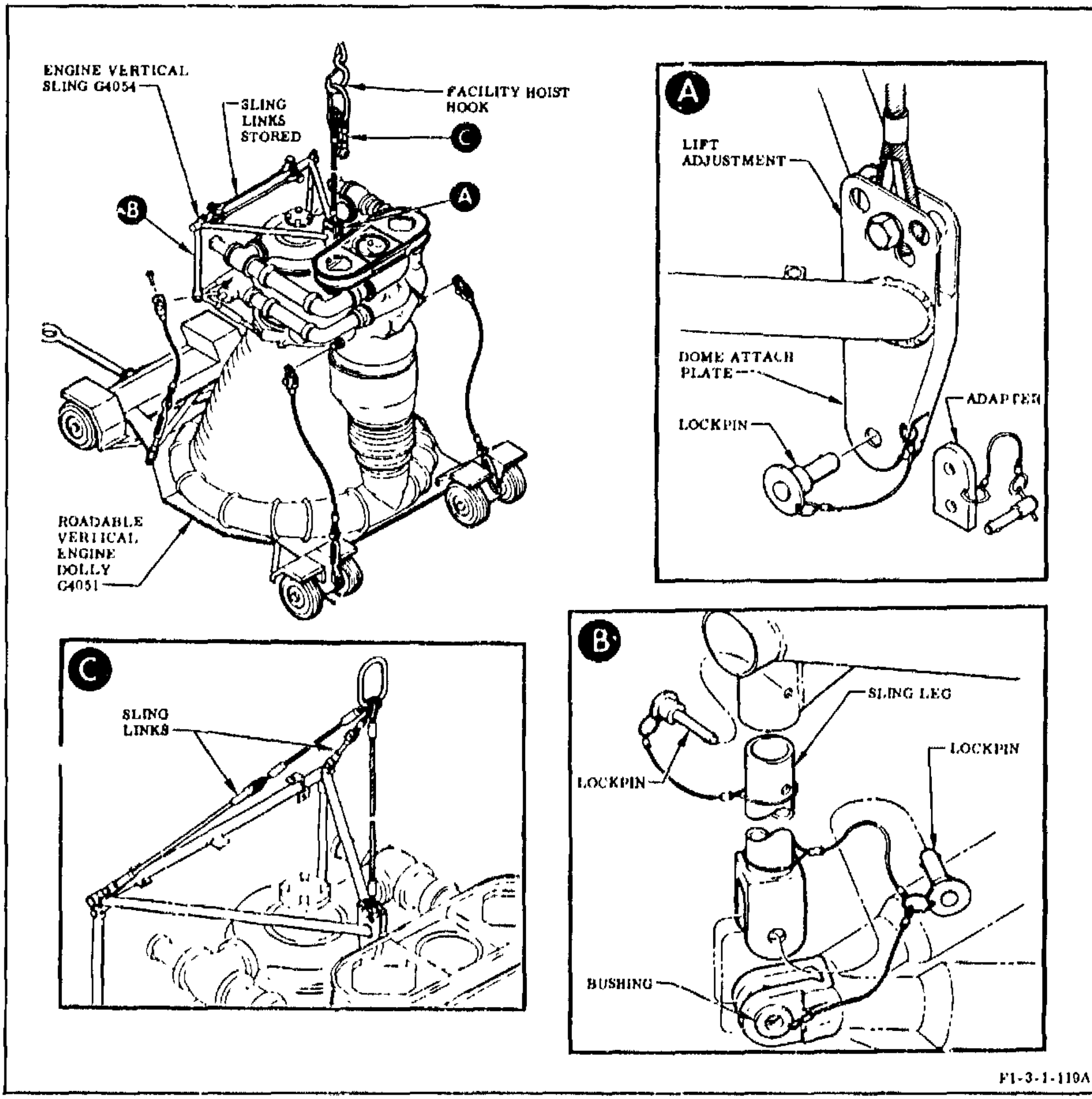


Figure 2-4. Removing and Installing Engine Vertical Sling

CAUTION

If sling links are installed between the frame and lift ring when lifting the engine, misalinement of the engine and damage to the links can result.

g. Using facility hoist, slowly raise engine or thrust chamber just enough to determine correct sling lift adjustment. Install lift cable at appropriate hole in lift plate for level lift.

2-19. HANDLING ENGINE OR THRUST CHAMBER FOR MAINTENANCE.

2-20. The engine or thrust chamber is handled from the horizontal or vertical position and rotated from or to the horizontal or vertical position. Engine Rotating Sling G4050 is used to handle the engine or thrust chamber in either the horizontal or vertical position and rotate them to either position. Engine Vertical Sling G4054 is used to handle the engine or thrust chamber in the vertical position. The engine or thrust chamber may be installed on Engine Handler G4069, on Engine Handling Dolly G4058, or on Air Transport Engine Handler G4044 when maintenance is performed. Air Transport Engine Handler G4044 supports the engine for shipping and for maintenance. The engine is installed on Roadable Vertical Engine Dolly G4051 for interfacility transport only. Remove engine covers and closures only as required to perform handling and maintenance tasks. Apply lubricating oil (Federal Specification VV-L-800 to machined areas of thrust chamber outriggers, turbopump mounts, and inside bearing surface of lower thrust chamber lug if oil was removed during handling.

2-20A. ENGINE PURGE REQUIREMENTS.

2-20B. The oxidizer pump seal must be purged any time the engine is rotated from the vertical to the horizontal position and whenever the engine is lowered from the engine horizontal to the engine lowered position. When rotating engine from vertical to horizontal position, purge oxidizer pump seal during rotation and for a minimum of 30 minutes after rotation. When lowering engine from engine horizontal to engine lowered position, maintain purge throughout lowering procedure.

2-20C. PURGING OXIDIZER PUMP SEAL.

a. Verify that closures are removed from nitrogen overboard and oxidizer overboard drain lines.

b. Remove pressure cap from oxidizer pump seal purge interface connect point, and connect a source of gaseous nitrogen (MIL-P-27401) capable of supplying 80 ±20 psig.

c. When rotating engine from vertical to horizontal position, purge oxidizer pump seal as follows:

(1) Turn on purge before rotating engine. Verify purge operation and that pressure is 80 ±20 psig.

(2) Maintain purge during engine rotation and for a minimum of 30 minutes with engine in horizontal position.

(3) Turn purge off, disconnect gaseous nitrogen supply, and install closures on overboard drain lines and interface connect point.

d. When lowering engine from engine horizontal to engine lowered position, perform steps a and b.

e. Turn on oxidizer pump seal purge before lowering engine. Verify purge operation and that pressure is 80 ±20 psig.

f. Maintain purge during lowering operation.

g. Turn purge off, disconnect gaseous nitrogen supply, and install closures on overboard drain lines and interface connect point.

2-21. AIR TRANSPORT ENGINE HANDLER G4044.

2-22. The air transport engine handler is used to support the engine when it is transported by air or truck and during maintenance.

2-23. RAISING ENGINE TO ENGINE HORIZONTAL POSITION ON AIR TRANSPORT ENGINE HANDLER G4044. (See figure 2-5.)

a. Make certain that wheels of handler are alined fore and aft and that brakes are unlocked.

b. Remove engine cover as outlined in paragraph 2-5.

c. Install engine rotating sling on engine as outlined in paragraph 2-14.

CAUTION

The engine must not be lifted at this time since damage to the engine can result.

d. Press sling control station FORWARD button, and position sling beam to load condition No. 6 strip position.

CAUTION

Drag braces must not be loosened or adjusted since damage to the load compensator spring on the truss can result.

e. Loosen turnbuckles, and remove lockpins that secure turnbuckles to lower attach point on handler.

CAUTION

The engine must not be raised higher than 15 inches while the handler truss is secured to the frame since damage to the engine and equipment can result.

f. Using facility hoist, slowly raise front end of engine. Do not exceed a maximum of 15 inches, measured at socket support block and support block.

g. Move rocket support blocks to BLOCK LOCATION ENGINE HORIZONTAL (aft position).

h. Remove struts from stored position on handler and place on socket support blocks in vertical position. Secure left strut to handler with sway bar and lockpin.

CAUTION

The full weight of the engine must not be allowed to rest on the struts until the turnbuckles are attached.

i. Using facility hoist, slowly lower engine until support blocks are in full contact with struts.

j. Attach turnbuckles to handler upper attach point with lockpins.

k. Torque turnbuckles to 60-70 ft-lb and jam nuts to 3??-460 in-lb.

l. Remove engine rotating sling as outlined in paragraph 2-13.

2-24. LOWERING ENGINE TO ENGINE LOWERED POSITION ON AIR TRANSPORT ENGINE HANDLER G4044. (See figure 2-5.)

a. Make certain that wheels of handler are alined fore and aft and that brakes are unlocked.

b. Install engine rotating sling on engine as outlined in paragraph 2-14.

bA. Purge oxidizer pump seal as outlined in paragraph 2-20C.

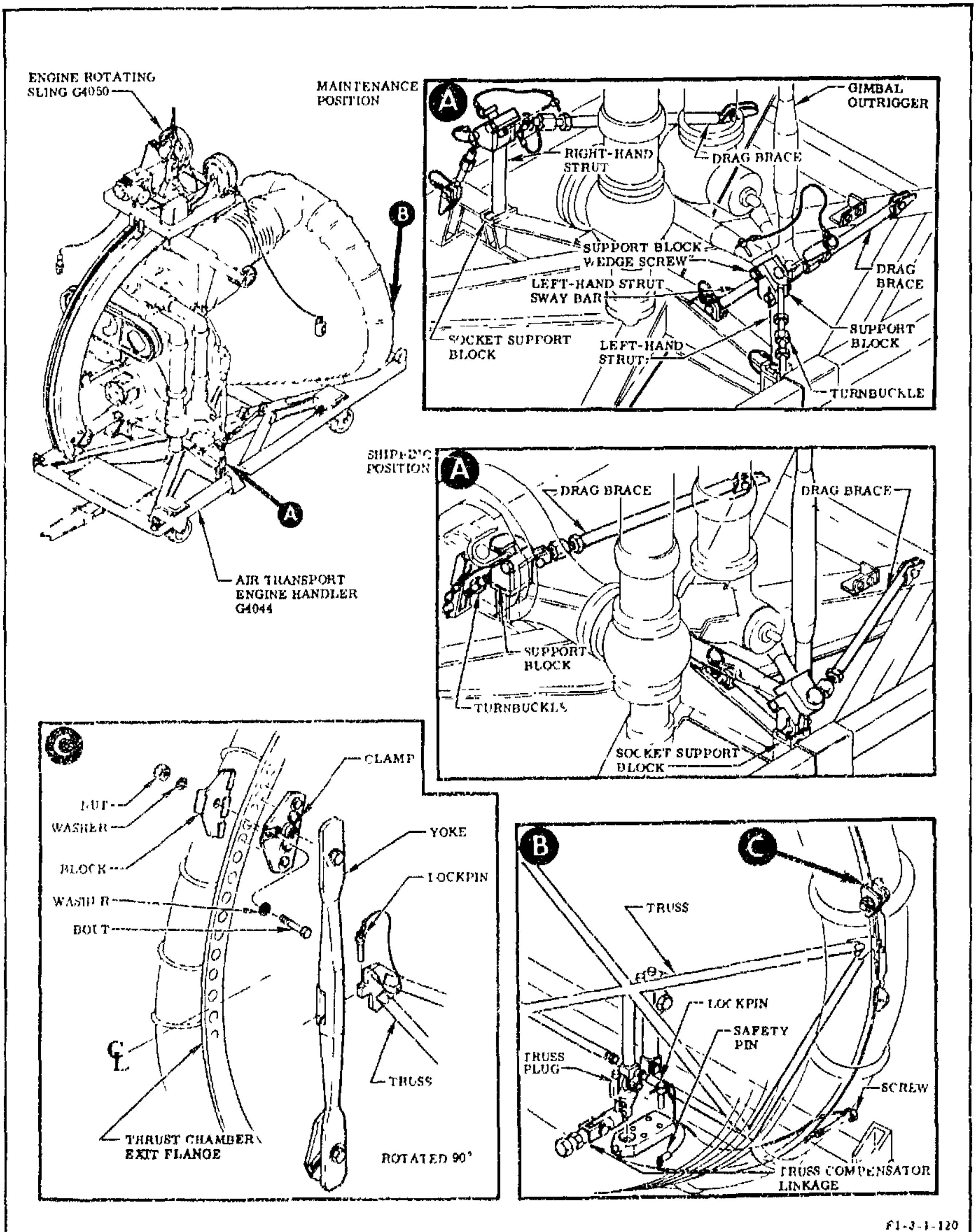


Figure 2-5. Removing and Installing Engine on Air Transport Engine Handler

c. Press sling control station FORWARD button, and position sling carriage to load condition No. 6 strip position.

CAUTION

The engine and air transport engine handler must not be lifted since damage to the engine can result.

d. Using facility hoist, support weight of engine on sling.

CAUTION

Drag braces must not be loosened or adjusted since damage to the load compensator spring on the truss can result.

e. Loosen turnbuckles and remove lockpins that secure turnbuckles to upper attach point on handler.

f. Prior to lifting engine, station a man to remove right-hand strut; then slowly raise engine to clear struts.

g. Remove and stow right-hand strut, left-hand strut, and sway bar.

h. Position socket support blocks to BLOCK LOCATION ENGINE LOWERED (forward position).

i. Using facility hoist, slowly lower engine onto support blocks.

j. Aline turnbuckles with lower attach points on handler; secure with lockpins, and torque to 60-70 ft-lb. Torque turnbuckle jamnuts to 340-460 in-lb.

k. Remove engine rotating sling as outlined in paragraph 2-13.

l. Install engine cover as outlined in paragraph 2-6.

2-25. REMOVING ENGINE FROM AIR TRANSPORT ENGINE HANDLER G4044. (See figure 2-5.)

CAUTION

The engine must not be removed from the air transport engine handler in any position other than the engine horizontal position since damage to the equipment can result.

NOTE

The load condition numbered strip positions noted in this procedure are used for initial positioning of the engine rotating sling beam. Minor adjustments of the beam to either side of a strip position may be required to level the load.

a. Make certain that wheels of handler are alined fore and aft and that brakes are unlocked.

b. Remove engine cover as outlined in paragraph 2-5.

c. Install engine rotating sling on engine as outlined in paragraph 2-14.

d. Raise engine to engine horizontal position as outlined in paragraph 2-23.

CAUTION

The engine must not be lifted at this time since damage to the engine can result.

e. Press sling control station FORWARD button, position sling carriage to load condition No. 6 strip position, and support weight of engine with sling.

f. Loosen turnbuckles, and remove lockpins that secure turnbuckles to support blocks.

g. Loosen drag braces, and remove lockpins that secure drag braces to support blocks.

h. Remove lockpin at rear support. Loosen and remove screw that secures truss to handler.

i. Remove safety pin from truss plug.

j. Prior to performing step k, station a man to remove right-hand strut when engine weight is removed.

k. Using facility hoist, carefully lift engine, and remove and stow right-hand strut. Raise engine until engine clears handler, and move engine away from handler.

l. Attach a facility hoist and sling that is capable of lifting 250 pounds, to truss. Connect sling to painted lift points on truss.

m. Using facility hoist, support weight of truss, and disconnect truss compensator linkage from bottom of thrust chamber exit ring.

n. Remove the 4 bolts that hold yokes to engine. Remove truss from engine, and remove yokes from truss.

NOTE

Steps o through y secure the handler.

o. Using facility hoist, lower truss into stowed position on handler.

p. Disconnect and secure sling and facility hoist.

q. Install clamps that secure truss to handler. Install attaching nut on truss compensator linkage.

r. Remove bolts that secure blocks and clamps on thrust chamber exit flange. Remove blocks and clamps.

s. Attach clamps to yokes. Stow yokes on handler.

t. Remove lockpin that secures left-hand strut sway bar to handler. Stow strut and sway bar.

u. Position socket support blocks to BLOCK LOCATION ENGINE LOWERED (forward position).

v. On engine, loosen support block wedge screw locknut. Back out screw, relieving tension on attaching pin.

w. Remove pins and support blocks from gimbal outriggers. Reinstall pins in support blocks.

x. Position support blocks in socket support blocks on handler.

y. Connect drag braces and turnbuckles to support blocks with attaching pins, and attach turnbuckles to lower attach points on handler.

2-26. INSTALLING ENGINE ON AIR TRANSPORT ENGINE HANDLER G4044. (See figure 2-5.)

CAUTION

The engine must not be installed on the air transport engine handler in any position other than the engine horizontal position since damage to equipment can result.

NOTE

The load condition numbered strip positions noted in this procedure are used for initial positioning of the engine rotating sling beam. Minor adjustments of the beam to either side of a strip position may be required to level the load.

a. Install engine rotating sling as outlined in paragraph 2-14.

aA. If engine is to be rotated from vertical to horizontal position, purge oxidizer pump seal as outlined in paragraph 2-20C.

b. Position air transport engine handler so that engine can be installed. Make certain that wheels of handler are alined fore and aft and that brakes are unlocked.

c. Press sling control station button as applicable, and position sling beam to load condition No. 6 strip position.

d. Using facility hoist, lower engine until truss can be installed on thrust chamber without use of special stands.

e. Remove yokes from stowage on air transport engine handler.

f. Remove clamps from yokes.

g. Place clamps on thrust chamber exit flange at the 9, 10, 12, and 13 holes located above and below centerline of engine. In each clamp installation, insert pin without cam, in hole first. Adjust cam pins to fit remaining holes.

h. Secure each clamp with a block, and torque block bolt to 300 ±25 in-lb.

i. Remove nut from truss compensator linkage. Remove lockpins that secure truss to handler.

j. Attach to truss a facility hoist and sling that is capable of lifting 250 pounds. Connect sling to painted lift points on truss.

k. Using facility hoist, remove truss from handler. Suspend truss at aft end of engine.

l. Install yokes on truss, and secure with lockpins.

m. Position truss so that upper ends of yokes can be secured to upper clamps on thrust chamber exit flange. Secure yokes to clamps with 4 bolts. Torque bolts to 300 ±25 in-lb.

n. Secure lower ends of yokes to lower clamps, adjusting yoke cams as necessary. Torque bolts to 300 ±25 in-lb.

o. Position truss in a sideways direction relative to yokes until a minimum clearance of 0.25 inch is obtained between either one of the yokes and shoulder of truss. Maintain this clearance when mating truss with handler (step x).

p. Insert truss compensator linkage through hole in thrust chamber exit ring, and install nut, securing linkage to exit ring. Torque nut to 40-50 in-lb.

q. Remove support blocks from handler and install on gimbal outriggers.

r. Torque support block wedge screws to 25-40 ft-lb and secure with nuts, and torque (wedge screw jamnuts to 100-140 in-lb.)

s. Position socket support blocks to BLOCK LOCATION ENGINE HORIZONTAL (aft position).

t. Remove left-hand strut and sway bar from stowed position and position in socket support block. Secure sway bar to handler with attached pin.

u. Remove right-hand strut from stowed position and prepare to install as engine is lowered.

v. Remove pin and screw from truss support on aft end of handler.

NOTE

Installing engine on handler requires a minimum of three men to monitor the lowering of the engine.

w. Using facility hoist, position engine over handler.

CAUTION

The drag braces on the handler must not be used for adjusting the position of the truss; otherwise, damage to the equipment may occur.

x. Make certain that minimum clearance of 0.25 inch between either one of the yokes and shoulder of truss obtained in step o is maintained; then aline plug with hole in truss support. Aline left-hand strut with support block; aline right-hand strut with support block and socket support block. Slowly lower engine until engine engages handler. Support weight of engine with sling.

y. Install screw that secures truss plug in truss support. Torque screw to 20-40 in-lb and secure with attached lockpin. Install safety pin in truss plug.

z. Using facility hoist, lower entire weight of engine on handler. Check that truss compensator linkage is in approximately neutral position.

aa. Adjust drag braces and attach to support blocks with lockpins. Torque drag brace jamnuts to 75-100 ft-lb.

ab. Install turnbuckles between support blocks and upper attach points on handler. Torque turnbuckles to 60-70 ft-lb and jamnuts to 340-460 in-lb.

ac. Lower facility hoist to relieve tension.

ad. Press sling control station REVERSE button, and position sling carriage to load condition No. 5 strip position.

CAUTION

Step ad must be performed prior to step ae; otherwise loading at the incorrect lift point (with respect to the center of gravity) would swing the sling beam toward the engine, causing possible damage to the heat exchanger.

ae. Remove engine rotating sling as outlined in paragraph 2-13.

2-27. ENGINE HANDLER G4069.

2-28. The engine handler is used to support and move the engine in a horizontal position within assembly buildings, repair shops, or hangars during engine buildup and maintenance. The handler accommodates the complete engine, including nozzle extension and gimbal actuators. The handler is not designed for transporting the engine on another vehicle. When there is considerable distance between points of use, the handler itself must be transported on another vehicle.

2-29. REMOVING ENGINE FROM ENGINE HANDLER G4069. (See figure 2-6.)

NOTE

The load condition numbered strip positions noted in this procedure are used for initial positioning of the engine rotating sling beam. Minor adjustments of the beam to either side of a strip position may be required to level the load.

a. Install engine rotating sling on engine as outlined in paragraph 2-14.

CAUTION

The engine must not be lifted at this time since damage to the engine can result.

b. Press sling control station FORWARD button, and position sling carriage to load condition No. 6 strip position. Support weight of engine with sling.

c. Loosen guy turnbuckle until tension is relieved.

d. Remove nuts that secure guy to fittings on each side of engine. Remove guy.

e. Before performing step f, station a man to remove right-hand support when engine weight is removed.

f. Using facility hoist, carefully lift engine until pin can be removed from thrust chamber lug and thrust chamber support clevis.

g. Using facility hoist, carefully move engine and sling away from handler.

h. Remove fittings from each side of thrust chamber body.

i. Store all items as placarded on handler. Tighten fitting storage bolts firmly.

j. Install closure on thrust chamber fitting pads. Lubricate bolts with lubricant grease RB0140-012 (Rocketdyne). Apply lubricant using Method A outlined in section I. Torque bolts fingertight plus 1/4 turn.

2-30. INSTALLING ENGINE ON ENGINE HANDLER G4069. (See figure 2-6.)

NOTE

The load condition numbered strip positions noted in this procedure are used for initial positioning of the engine rotating sling beam. Minor adjustments of the beam to either side of a strip position may be required to level the load.

a. Install engine rotating sling on engine as outlined in paragraph 2-14.

aA. If engine is to be rotated from vertical position to horizontal position, purge oxidizer pump seal as outlined in paragraph 2-20C.

b. Position engine handler so that engine can be installed.

c. Press sling control station FORWARD button, and position sling beam to load condition No. 6 strip position.

d. Using facility hoist, carefully lower engine until fittings can be installed.

e. Remove closures from thrust chamber mount pads and install fittings in mount pads. Cross-torque bolts to 200-270 ft-lb.

f. Loosen double nuts on thrust chamber support clevis, and install front support and brace, right-hand support, left-hand support and strut, and turnbuckle end of guy on handler.

NOTE

To improve alinement or roll of engine to handler, handler right-hand aft support may be adjusted. If additional adjustment is required, handler left-hand aft support may be adjusted simultaneously with its strut.

g. Using facility hoist, lower engine until pin can be inserted to secure thrust chamber lug to thrust chamber support clevis. Raise and aline clevis to meet lug on front of thrust chamber when engine is lowered.

h. Tighten inner nut fingertight on thrust chamber support clevis. Lock inner nut in place with outer nut.

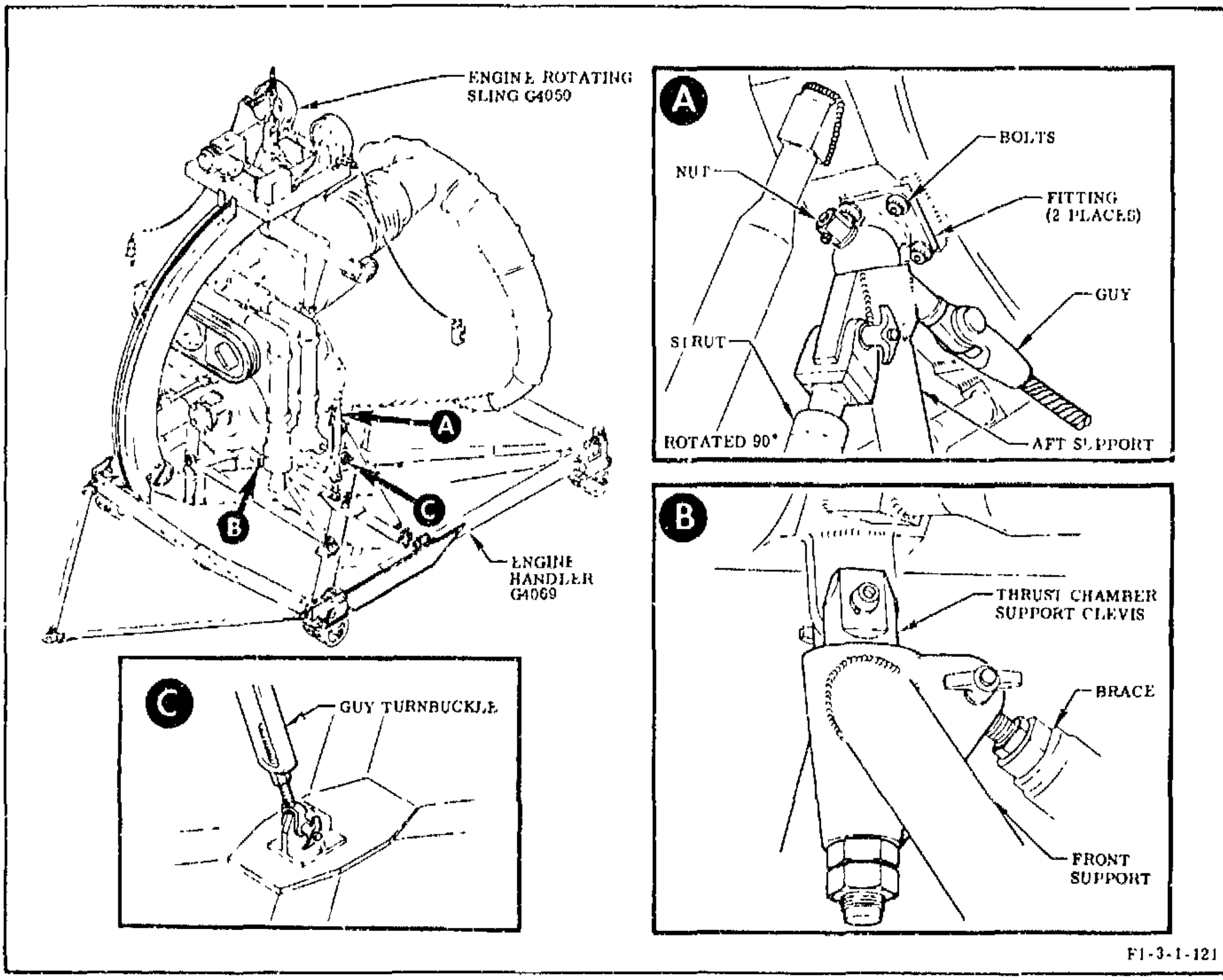


Figure 2-6. Removing and Installing Engine on Engine Handler

i. Insert guys through fittings and supports, and tighten nuts until snug.

j. Torque guy turnbuckle to 1,700-1,800 in-lb.

k. Lower facility hoist hook to relieve tension, and position sling carriage to load condition No. 5 strip position.

CAUTION

Step k must be performed prior to step l; otherwise, loading at the incorrect lift point, with respect to the center of gravity, would swing the sling beam toward the engine, causing possible damage to the heat exchanger.

l. Remove engine rotating sling as outlined in paragraph 2-13.

2-31. TOWING INSTRUCTIONS FOR ENGINE HANDLER G4069. The engine handler is designed to be moved over concrete floors and adjacent concrete aprons within assembly buildings, repair shops, or hangars. Maximum speed for the engine handler is 2-1/2 miles per hour, and maximum ramp angle with the engine installed is 2 degrees. The handler is not designed for transporting the engine on another vehicle. When there is a considerable distance between points of use, the handler itself is to be transported on another vehicle. The engine is transported on Air Transport Engine Handler G4044. The engine handler is normally pulled by the towbar with the engine installed on the handler; however, the towbar can also be used to push the handler, if necessary. If a change of direction is necessary while pushing the handler with the towbar (with the engine installed on the handler), the corners of the handler chassis at the towbar attachment end are first raised and the casters manually turned in the direction of desired movement before changing direction.

2-32. ROADABLE VERTICAL ENGINE DOLLY G4051 AND ENGINE HANDLING DOLLY G4058.

2-33. The roadable vertical engine dolly is used to support and transport the engine or the nozzle extension in a vertical position for relatively short distances, such as on site, building to building or test stand. The dolly is not designed for transporting the engine on another vehicle. The dolly accommodates the engine (without the nozzle extension installed) or the nozzle extension.

2-34. The engine handling dolly is used to support and move the engine or thrust chamber in a vertical position within assembly buildings, repair shops, or hangars during engine buildup or maintenance. The handler is not designed for transporting the engine or thrust chamber on another vehicle. When there is considerable distance between points of use, the handler must be transported by another vehicle.

2-35. REMOVING ENGINE FROM ROADABLE VERTICAL ENGINE DOLLY G4051 AND ENGINE HANDLING DOLLY G4058. The loading and tiedown requirements of the roadable vertical engine dolly and the engine handling dolly are identical. Procedures outlined in this paragraph are also applicable when removing the engine or thrust chamber from the engine dollies. The engine may be removed using either the engine rotating sling or engine vertical sling. The roadable vertical engine dolly, with an engine installed, is shown in figure 2-7.

NOTE

The load condition numbered strip positions noted in this procedure are used for initial positioning of the engine rotating sling beam. Minor adjustments of the beam to either side of a strip position may be required to level the load.

a. Position roadable vertical engine dolly beneath facility hoist that is capable of lifting 30,000 pounds.

b. Remove turbopump trunnion nuts and washers. Loosen and remove turbopump mount tiedown cables. Reinstall nuts and washers.

c. Loosen and remove gimbal strut tiedown cables that secure engine to dolly. Stow all cables.

d. Install engine rotating sling or engine vertical sling on engine as outlined in paragraph 2-14 or 2-18, as applicable.

NOTE

Procedures for using the vertical sling with a thrust chamber are identical to these procedures, except that the two stowed sling links are installed between the two short cables of the sling lift ring and the corners of the sling spreader bar.

e. If engine rotating sling is used, press sling control station REVERSE button, and position sling carriage to load condition No. 2 strip position.

eA. If engine is to be rotated to horizontal position, purge oxidizer pump seal as outlined in paragraph 2-20C.

f. If thermal insulation bracketry is installed on engine, reinstall collars and brackets as assembled at turbopump trunnions. Torque nuts at bracket to 68 ±7 in-lb. Install washer and trunnion nuts. Torque trunnion nuts to 825 ±10 in-lb.

g. Using facility hoist, carefully lift engine clear of dolly.

2-36. INSTALLING ENGINE ON ROADABLE VERTICAL ENGINE DOLLY G4051 AND ENGINE HANDLING DOLLY G4058. The loading and tiedown requirements are identical for both the roadable vertical engine dolly and the engine handling dolly. Procedures outlined in this paragraph are also applicable when installing the engine or thrust chamber on the engine dollies. The engine may be installed using either the engine rotating sling or engine vertical sling. The roadable vertical engine dolly, with an engine installed, is shown in figure 2-7.

NOTE

The load condition numbered strip positions noted in this procedure are used for initial positioning of the engine rotating sling beam. Minor adjustments of the beam to either side of a strip position may be required to level the load.

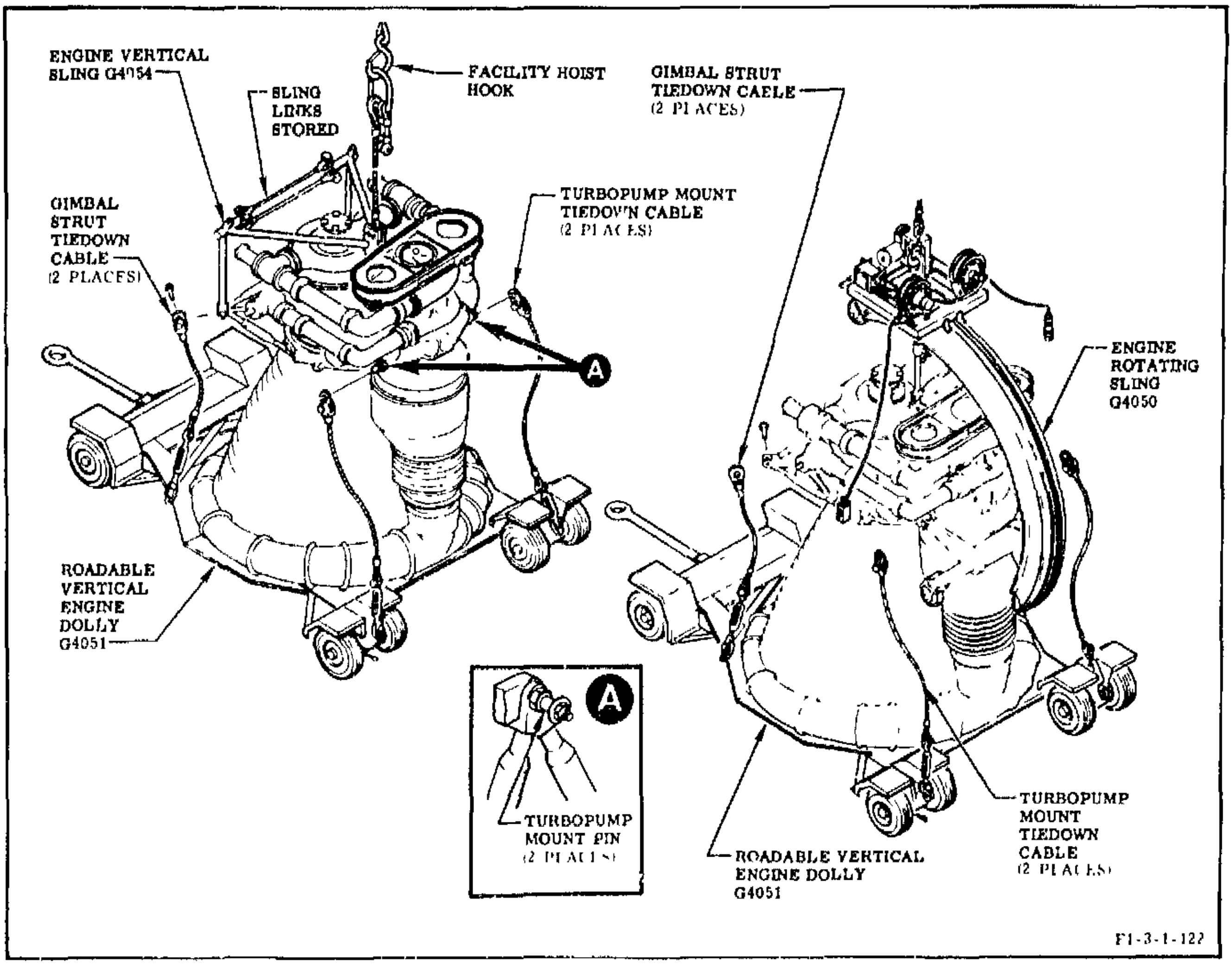


Figure 2-7. Removing and Installing Engine on Roadable Vertical Engine Dolly

a. Install engine rotating sling or engine vertical sling on engine as outlined in paragraph 2-14 or 2-18, as applicable.

NOTE

Procedures for using the vertical sling with a thrust chamber are identical to these procedures, except that the two stowed sling links are installed between the two short cables of the sling lift ring and the corners of the sling spreader bar.

b. If thermal insulation bracketry is installed on engine, remove outboard trunnion nuts and washers. Remove serrated collars and brackets as assemblies.

c. If engine rotating sling is used, raise engine until engine can be rotated to vertical position without interference. Press sling control station REVERSE button, and position sling beam to load condition No. 2 strip position.

d. Using facility hoist, position engine above roadable vertical engine dolly with turbopump facing aft end of dolly.

e. Using facility hoist, slowly lower and center engine onto dolly. Make sure thrust chamber exit ring evenly contacts dolly shock pads.

f. If engine rotating sling is used, lower facility hoist hook to relieve tension, and position sling carriage to load condition No. 3 strip position.

CAUTION

Step f must be performed prior to step g; otherwise, loading at the incorrect lift point, with respect to the center of gravity, would swing the sling beam toward the engine, causing possible damage to the heat exchanger.

g. Remove engine rotating sling as outlined in paragraph 2-13.

h. If engine vertical sling is used, remove sling as outlined in paragraph 2-17.

i. Remove turbopump trunnion nuts and washers. Install 2 turbopump mount tiedown cables between turbopump mount pins and dolly tiedown rings. Reinstall nuts and washers, and tighten cables until snug.

j. Install gimbal strut tiedown cables on gimbal outriggers. Tighten cables until snug.

2-36A. TOWING INSTRUCTIONS FOR ROADABLE VERTICAL ENGINE DOLLY G4051. The roadable vertical engine dolly is designed to move the engine or thrust chamber nozzle extension in a vertical attitude for relatively short distances over graded gravel (or better) roads. Maximum towing speed for the roadable vertical engine dolly is 10 miles per hour, maximum ramp angle with engine installed is 5 degrees, and minimum turning radius is 212 inches (17-3/4 feet).

CAUTION

The steering gear must not be forced when front wheel movement is restricted or when the tongue is against the stop bracket. Damage to the steering tie rods and tongue will result.

2-37. TOWING INSTRUCTIONS FOR ENGINE HANDLING DOLLY G4058. The engine handling dolly is designed to be moved over concrete floors and adjacent concrete aprons within assembly buildings, repair shops, or hangars. Maximum towing speed for the handling dolly when loaded is 2-1/2 miles per hour, and maximum unloaded speed is 5 miles per hour. The rear casters must be locked in the trail position when the dolly is to be towed. Maximum ramp angle with engine installed is 5 degrees. When there is considerable distance between points of use, the unloaded dolly must be transported by another vehicle. The engine handling dolly is normally pulled by the towbar with the engine installed on the dolly; however, a pair of clamp-on towing eyes may be used to tow the dolly, if necessary. When a change of direction is necessary while using towing eyes, the four dolly casters are first manually turned in the direction (trail position) of desired movement.

2-38. ENGINE VERTICAL INSTALLER G4049.

2-39. The engine vertical installer is an electrohydraulically operated, self-propelled lifting and positioning unit. The vertical installer is used to position the engine during installation in and removal from a test stand or a vertical stage. It is also used to position the thrust chamber nozzle extension during installation and removal from a vertical engine. (Refer to paragraphs 2-55 and 2-56.)

2-40. REMOVING ENGINE FROM ENGINE VERTICAL INSTALLER G4049. (See figure 2-8.)

a. Loosen and remove gimbal strut tiedown cables.

b. Install engine vertical sling on engine as outlined in paragraph 2-18.

c. Remove turbopump trunnion nuts and washers. Loosen and remove turbopump mount tiedown cables. Reinstall nuts and washers, and stow all cables.

d. If thermal insulation bracketry is installed, reinstall collars and brackets as assembled at turbopump trunnions. Torque nuts at bracket to 68 ±7 in-lb. Install washer and trunnion nuts. Torque trunnion nuts to 825 ±10 in-lb.

e. Using facility hoist, lift engine clear of engine vertical installer.

2-41. INSTALLING ENGINE ON ENGINE VERTICAL INSTALLER G4049. (See figure 2-8.)

a. Install engine vertical sling on engine as outlined in paragraph 2-18.

b. Using facility hoist, raise and position engine above 10:1 thrust chamber ring of engine vertical installer.

c. Slowly lower engine onto 10:1 thrust chamber ring. Maintain tension on sling.

d. Remove turbopump trunnion nuts and washers. Install turbopump mount tiedown cables. Reinstall nuts and washers, and torque turnbuckles of cables to 40-60 in-lb.

e. If thermal insulation bracketry is installed on engine, remove outboard trunnion nuts and

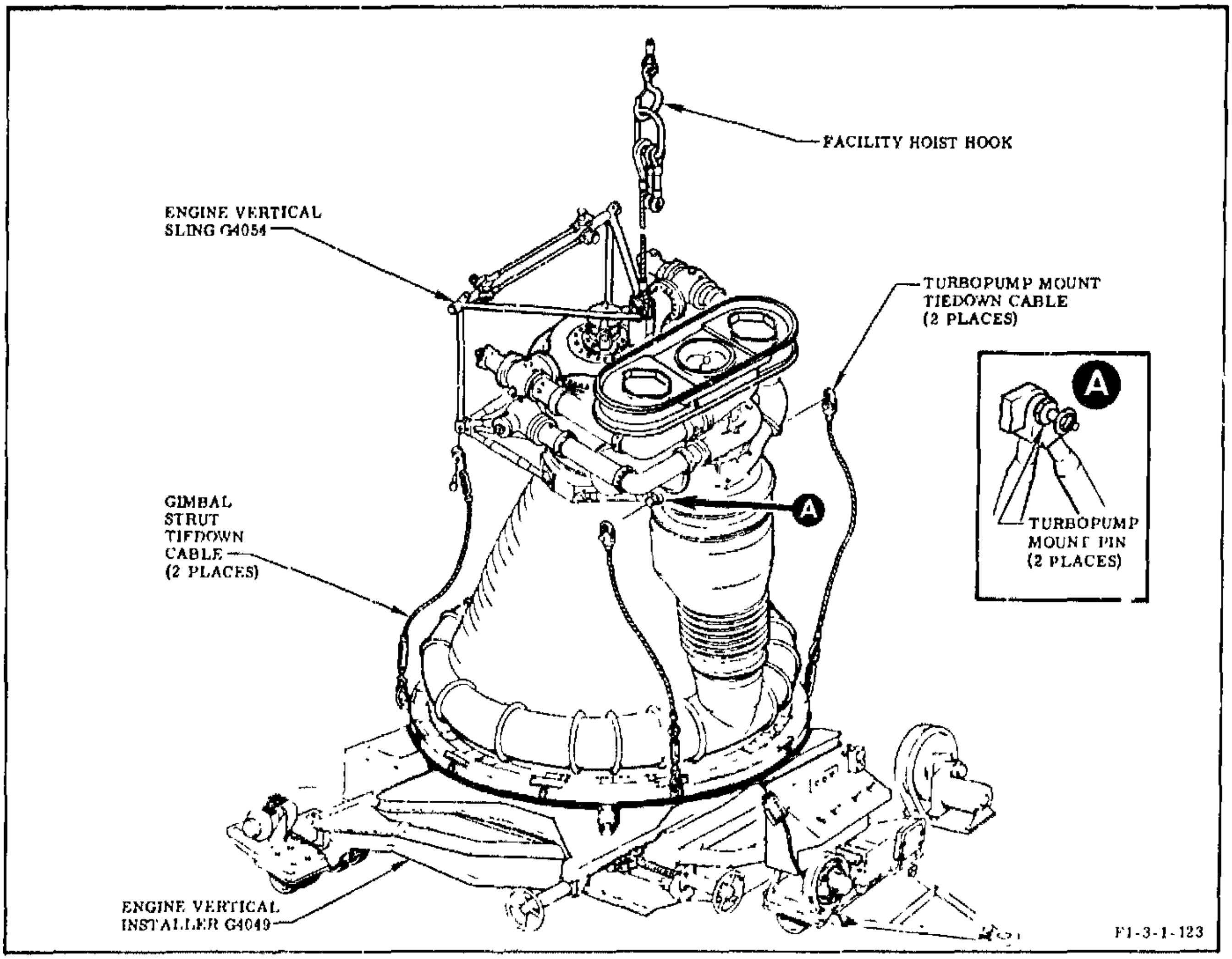


Figure 2-8. Removing and Installing Engine on Engine Vertical Installer

washers. Remove serrated collars and brackets as assemblies. Retain for reinstallation.

f. Remove engine vertical sling as outlined in paragraph 2-17.

g. Install gimbal strut tiedown cables, and torque turnbuckles to 40-60 in-lb.

2-42. NOZZLE EXTENSION HANDLING EQUIPMENT.

2-43. The nozzle extension is held in a rigid position during rotating, shipping, and storing by Nozzle Extension Handling Fixture G4080. Nozzle Extension Handling Adapter G4081 is used to support the fixture-mounted nozzle extension in a horizontal position during shipping and storing. Engine Handler Sling G4052 is used to raise or lower the nozzle extension in a vertical position. Engine Vertical Installer G4049 is used to position the nozzle extension during removal from and installation on a vertical engine.

2-44. ENGINE HANDLER SLING G4052.

2-45. The engine handler sling, adaptable at a single point to an overhead crane, is used to lift either Air Transport Engine Handler G4044, with or without the engine installed, or the thrust chamber nozzle extension. When lifting the air transport engine handler, the cables with the hooks are hooked to the lifting eyes on each front corner and on the chassis just forward of each rear wheel of the handler. When lifting the nozzle extension, the four cables stored on the bars are connected to the flange plate and the lifting eyes on the nozzle extension.

2-46. NOZZLE EXTENSION HANDLING FIXTURE G4030.

2-47. The nozzle extension handling fixture is a conical frame structure designed to hold the nozzle extension in a rigid position during rotating, shipping, and storing. The nozzle extension is lowered over the handling fixture until contact is made with shock-mounted support pads on the base ring of the fixture. Nozzle exit pads are adjusted to contact the inner surface of the nozzle extension. Adjustable nozzle flange struts are extended until the pads contact the forward flange of the nozzle extension. Cables secure the flange struts in the extended position.

2-48. REMOVING NOZZLE EXTENSION FROM NOZZLE EXTENSION HANDLING FIXTURE G4080. (See figure 2-9.)

a. Using a facility hoist capable of lifting 5,000 pounds, suspend Engine Handler Sling G4052 above nozzle extension. Make sure that nozzle handling cables (short cables) are attached to spreader bars.

b. Connect sling cables to 4 lifting lugs near upper end of extension.

c On nozzle flange struts, turn cable adjusting nut to upper end of screw

d. Remove quick-release pin from each nozzle flange strut, lift strut until flange pad clears extension flange, retract strut, and install quick-release pin.

e. Lower each flange strut until strut contacts quick-release pin at apex of strut.

f. Remove quick-release pin from each nozzle exit strut adjustment screw. Turn adjustment screw until exit strut is in retracted position. Install quick-release pin in adjustment screw.

CAUTION

To avoid damage to internal skins of the nozzle extension, the extension must be carefully guided over the fixture.

g. Slowly and carefully raise extension clear of nozzle extension handling fixture.

2-49. INSTALLING NOZZLE EXTENSION ON NOZZLE EXTENSION HANDLING FIXTURE G4080 (See figure 2-9.)

a. Place Nozzle Extension Handling Fixture G4080 on a flat, paved surface.

b. Using a facility hoist capable of lifting 5,000 pounds, suspend Engine Handler Sling G4052 until sling spreader bars clear floor.

c. Remove nozzle handling cables (short cables), which are stored on sling spreader bars.

d. Attach nozzle handling cables to spreader bars in place of engine handling cables (long cables).

e. Connect cables to 4 lifting lugs n[illegible] upper end of nozzle extension.

f. Check that nozzle flange struts on fixture are in retracted position.

g. On nozzle flange struts, turn cable-adjusting nut to upper end of screw.

h. Remove quick-release pin from apex end of each nozzle flange strut, lift strut until pin can be inserted through upper hole under strut, and then lower strut against pin.

i. Temporarily secure forward lifting cable near pad end of one nozzle flange strut.

NOTE

Securing the cable to the strut makes the cable accessible after the nozzle extension is installed on the fixture.

j. Remove quick-release pin from adjustment screw on nozzle exit strut located to left and right of fixture zero-degree index point. Turn adjustment screw until strut is in neutral position. Install quick-release pin.

k. Using procedure in step j, except for reinstallation of quick-release pin, retract all remaining nozzle exit struts.

l. Using hoist, slowly lift nozzle extension approximately 7 feet. Suspend extension over

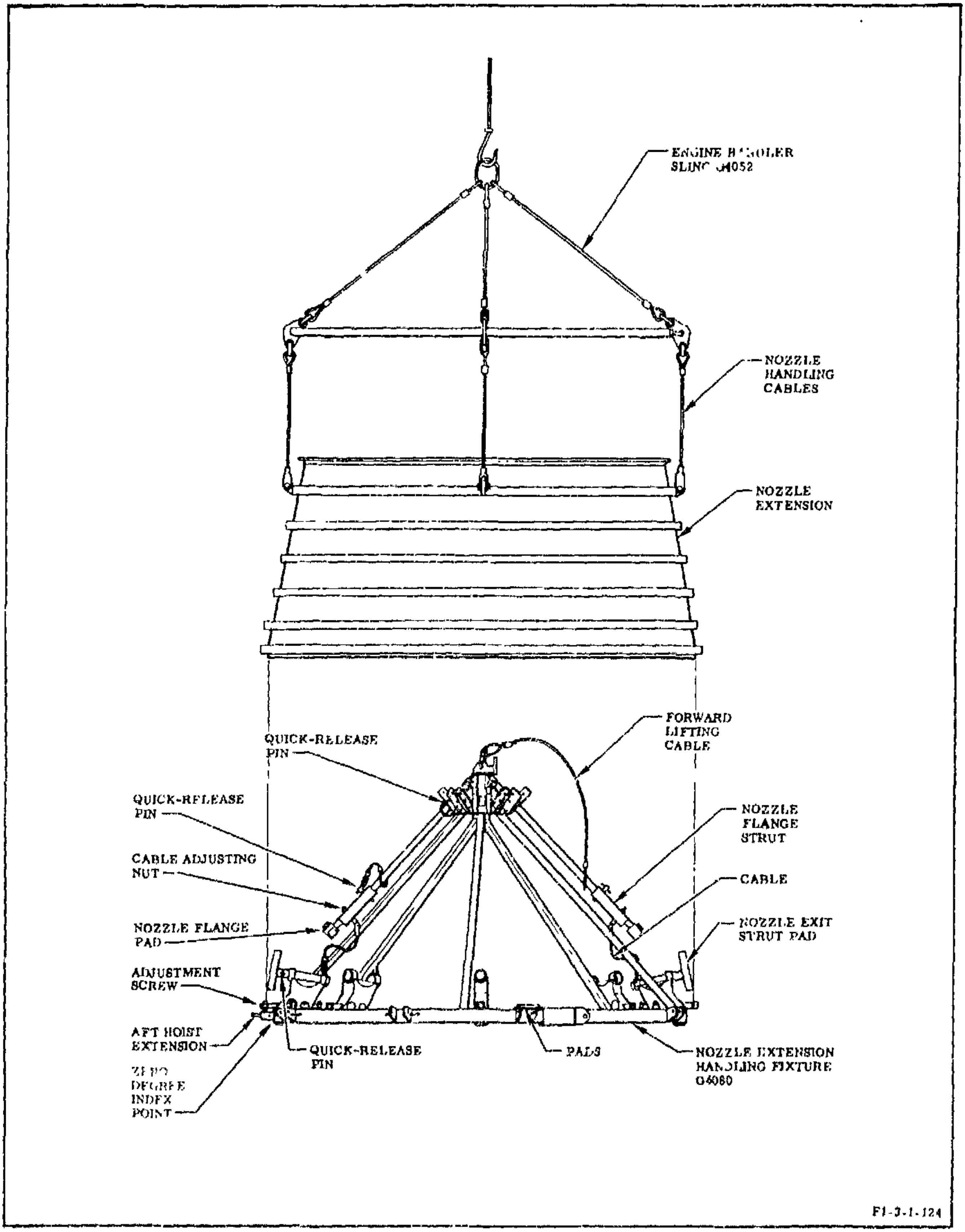


Figure 2-9. Removing and Installing Nozzle Extension on Nozzle Extension Handling Fixture

fixture, and adjust until zero-degree index points on nozzle extension and fixture are alined.

CAUTION

To avoid damaging internal skins of the nozzle extension, the extension must be carefully guided over the fixture.

m. Slowly and carefully lower nozzle extension until it simultaneously contacts the 2 neutral nozzle exit strut pads and the 8 base ring pads. Allow full weight of nozzle extension to rest on base ring pads.

n. If nozzle extension is out-of-round and gap between extension and any of the strut pads exceeds 5 inches, readjust neutral pad strut to provide a more concentric placement of extension on fixture.

o. Starting with the 2 nozzle exit struts opposite the 2 neutral struts, turn adjustment screws until all strut pads lightly contact nozzle extension.

p. Torque adjustment screws on 3 nozzle exit struts, located between and opposite the 2 neutral struts, to 300-450 in-lb. Torque adjustment screws on remaining 3 struts to 300-450 in-lb. Install quick-release pins in adjustment screws.

q. Remove quick-release pin from adjustment screw on the 2 neutral nozzle exit struts. Torque adjustment screw to 300-450 in-lb. Install quick-release pin.

NOTE

To find the appropriate flange hole, the flange strut must be moved sideways in each direction until it stops. The appropriate flange hole is the hole nearest the center of full travel.

r. Lift each nozzle flange strut, and remove quick-release pin. Extend strut until flange pad engages extension flange with alinement pin of pad in appropriate hole in flange, and insert quick-release pin in hole in strut.

s. Torque each nozzle flange strut cable preload nut to 35-40 in-lb. Torque each jamnut to 170-230 in-lb.

t. Disconnect cables from lifting lugs, and remove sling.

2-50. NOZZLE EXTENSION HANDLING ADAPTER G4081.

2-51. The nozzle extension handling adapter is used to support the fixture-mounted nozzle extension in a horizontal position during shipping and storing. Two facility hoists capable of lifting a minimum of 5,000 pounds are required to remove the fixture-mounted nozzle extension from the handling adapter and to rotate it to the vertical position.

2-52. REMOVING FIXTURE-MOUNTED NOZZLE EXTENSION FROM NOZZLE EXTENSION HANDLING ADAPTER G4081. (See figure 2-10.)

a. Attach forward lifting cable on nozzle extension handling fixture to a facility hoist that is capable of lifting 5,000 pounds.

b. Make sure that aft hoist extension on handling fixture is in extended position and is secured with quick-release pin.

c. Attach a 3/4-inch shackle to aft hoist extension.

d. Connect hook from second facility hoist to shackle.

e. Using facility hoists, remove slack from forward and aft cables.

f. Back out base ring stop bolt.

CAUTION

The loaded fixture must not be allowed to rotate from the horizontal position since damage to the equipment can result.

g. Remove quick-release pins of each turnbuckle at fixture ball-joint bracket. Stow turnbuckle on bracket of nozzle extension handling adapter.

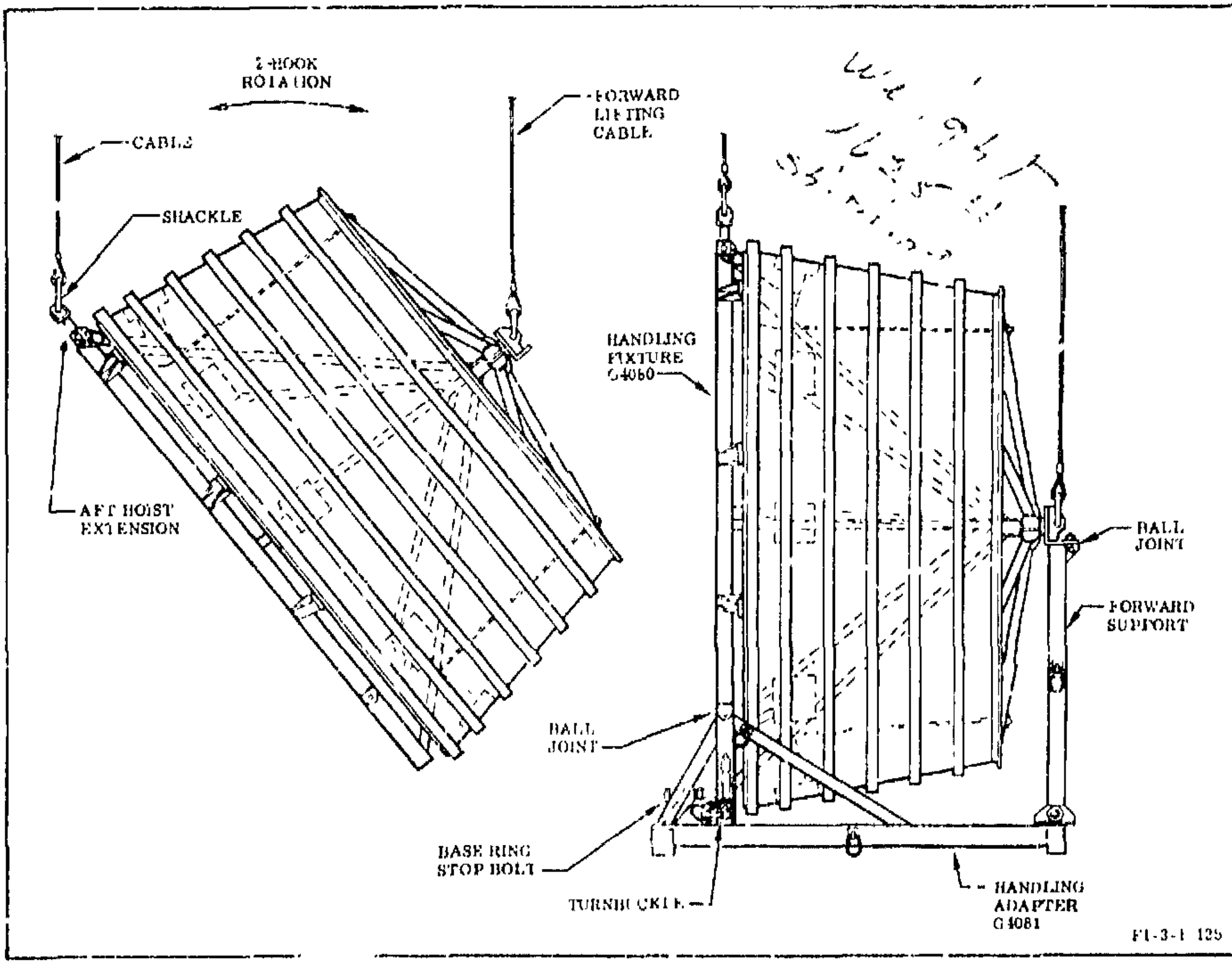


Figure 2-10. Removing and Installing Nozzle Extension Handling Fixture (Nozzle Extension Installed) on Nozzle Extension Handling Adapter

h. Loo[illegible]nect T-bolt that secures forwar[illegible].

i. Slow[illegible] lifting cable until forward suppo[illegible] be disengaged. Swing support forward until end rests on floor.

j. Slowly raise cables until loaded fixture is approximately 4 feet above floor.

k. Lower aft cable until nozzle extension is in vertical position.

l. Remove cable hook and shackle from aft hoist extension. Retract extension and secure with quick-release pin.

m. Slowly lower forward lifting cable until loaded fixture rests on floor. Disconnect cable from facility hoist.

2-53. INSTALLING FIXTURE-MOUNTED NOZZLE EXTENSION ON NOZZLE EXTENSION HANDLING ADAPTER G4081. (See figure 2-10.)

a. Install nozzle extension on nozzle extension handling fixture (paragraph 2-49).

b. Connect forward lifting cable of fixture to a facility hoist that is capable of lifting 5,000 pounds. Slowly lift loaded fixture approximately 4 feet above floor.

c. Extend aft hoist extension from fixture and secure with quick-release pin.

d. Attach a 3/4-inch shackle to aft hoist extension.

e. Connect hook from second facility hoist to shackle, and slowly lift aft end of fixture until nozzle extension is in a horizontal position.

f. On nozzle extension handling adapter, disengage forward support from stored position and swing it forward until end rests on floor.

g. Back out base ring stop bolt.

h. Position loaded fixture over adapter until ball joints on fixture and adapter are alined.

i. Slowly lower loaded fixture until ball joints are mated. Do not relieve tension on cables.

j. On adapter, swing forward support to vertical position, and aline ball joints on fixture and adapter.

CAUTION

> The loaded fixture must not be allowed to rotate from the horizontal position after the ball joints are seated, since damage to the equipment can result.

k. Slowly lower fixture until all ball joints are properly seated. Secure forward support ball joint with T-bolt. Torque nut to 240-300 in-lb.

l. Remove lower end of each turnbuckle from brackets on adapter. Attach turnbuckles to fixture ball-joint bracket with quick-release pins.

m. Torque turnbuckles to 240-300 in-lb and turnbuckle stopnuts to 60-120 in-lb.

n. Adjust base ring stop bolt until it contacts fixture. Torque stopnut to 360-480 in-lb.

o. Disconnect hoist cables from aft hoist extension and forward lifting cable. Store forward lifting cable at forward support of adapter, and move aft hoist extension in retracted position and secure with quick-release pin.

2-54. ENGINE VERTICAL INSTALLER G4049.

2-55. REMOVING NOZZLE EXTENSION FROM ENGINE VERTICAL INSTALLER G4049. (See figure 2-11.)

a. Disconnect lift-platform tiedown cables from nozzle extension.

b. Using a facility hoist capable of lifting 5,000 pounds, suspend Engine Handler Sling G4052 above nozzle extension. Make sure that nozzle handling cables (short cables) are attached to sling spreader bars.

c. Connect sling cables to 4 lifting lugs near upper end of nozzle extension.

d. Slowly lift nozzle extension clear of engine vertical installer.

2-56. INSTALLING NOZZLE EXTENSION ON ENGINE VERTICAL INSTALLER G4049. (See figure 2-11.)

a. Remove nozzle extension from nozzle extension handling fixture as outlined in paragraph 2-48.

b. Using a facility hoist capable of lifting 5,000 pounds, suspend Engine Handler Sling G4052 above nozzle extension. Make sure that nozzle handling cables (short cables) are attached to sling spreader bars.

c. Connect sling cables to 4 lifting lugs near upper end of nozzle extension.

d. Lift and position nozzle extension above engine vertical installer, and carefully lower onto 16:1 ring of installer.

e. Remove handler sling cables, and install lift-platform tiedown cables on nozzle extension lifting lugs.

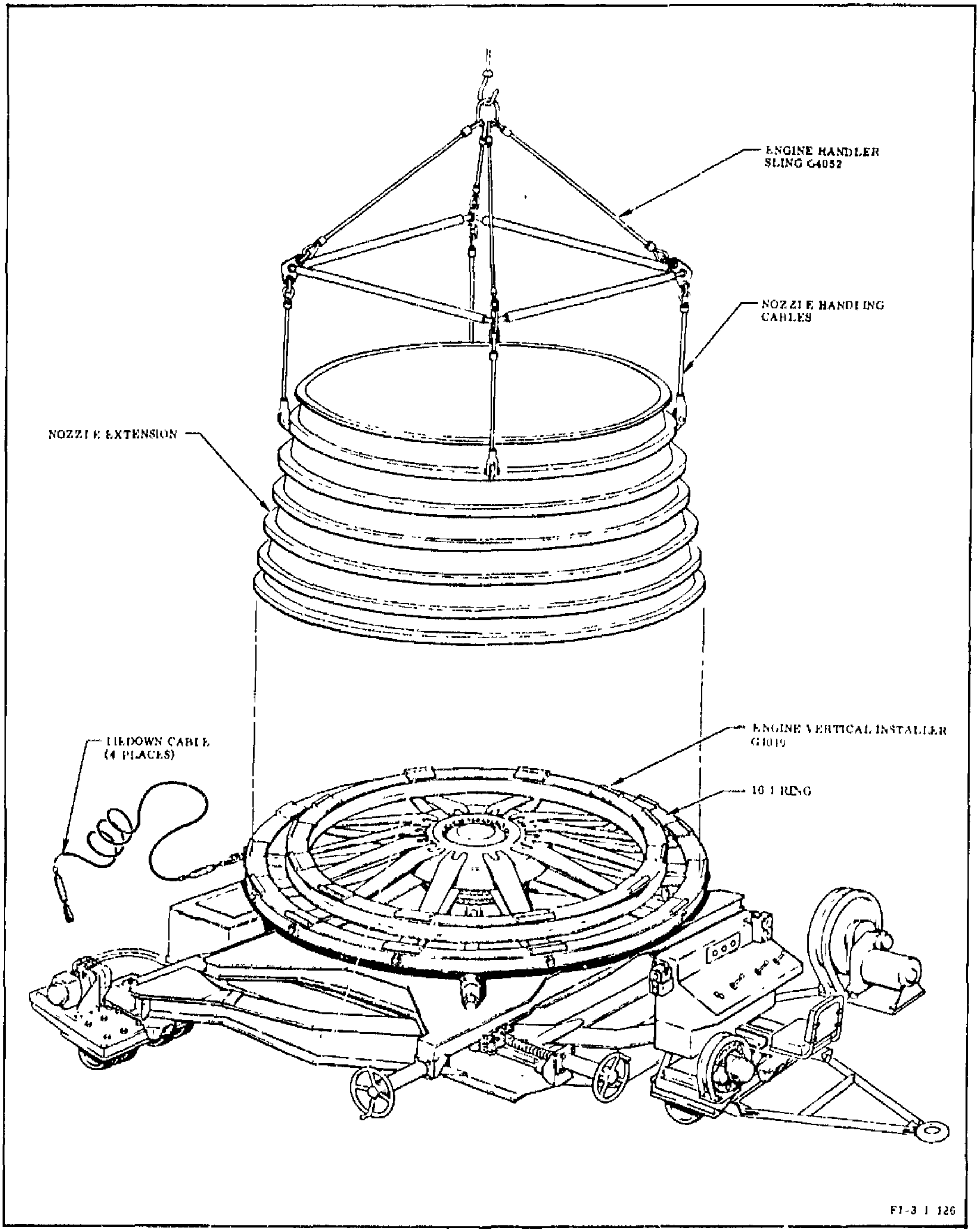


Figure 2-11 Removing and Installing Nozzle Extension on Engine Vertical Installer

SECTION III

COMPONENT REMOVAL AND INSTALLATION

WARNING

TEMPERATURE TRANSDUCER INSTALLER AND REMOVER KIT G2038 AND COMPONENT HANDLING FIXTURE SET G4068 MUST BE OPERATED BY AUTHORIZED PERSONNEL TRAINED IN THE USE OF THE EQUIPMENT.

3-1. SCOPE. This section contains the detailed procedures for removal and installation of engine components, parts of certain installed components, and the resulting effects on the engine. The procedures are oriented for a single, uninstalled engine in the vertical position. With the engine in any other position, the procedures may be used only as a guide, since requirements may or may not apply.

3-2. EFFECTS OF COMPONENT REINSTALLATION AND REPLACEMENT.

3-3. The scope of component reinstallation and replacement affecting the engine covers a broad area of data. As a result of maintenance tasks in this manual, the data has been separated into four categories: effects on engine alinement, post-maintenance test requirements, effects on thermal insulation brackets, and the effects on engine performance. The data covering effects of component reinstallation and replacement on engine alinement, engine performance, and thermal insulation brackets is tabulated in figure 3-1. The post-maintenance test requirements necessary to restore the integrity of the engine systems are tabulated in section IV. The individual component replacement effects on engine performance at sea level are contained in R-3896-11. The procedure for determining the maximum expected performance deviations for individual engines due to multiple component replacement is contained in R-3896-1. Removal and installation procedures for thermal insulation brackets are contained in R-3896-6.

3-4. EFFECTS OF COMPONENT REINSTALLATION AND REPLACEMENT ON ENGINE ALINEMENT, THERMAL INSULATION BRACKETS, AND ENGINE PERFORMANCE.

3-5. Figure 3-1 lists the alinements required following the installation (or reconnection) of engine components and lines. An "X" under an alinement procedure in one of the Alinement Required columns denotes applicability of the alinement task to the corresponding item listed in the Engine Components and Lines column. The components and lines are listed in the same sequence as the procedures appear in this section. The listed alinement tasks correspond to specific alinement tasks in this section that are presented as separate tasks under a separate paragraph title and do not include alinement tasks that are an integral part of an installation procedure. Two additional columns are included with the alinement tasks to indicate component replacement effects on thermal insulation brackets and on engine performance. A reference is made to the applicable R-3896-series manual that contains the detailed procedure.

3-6. ENGINE SEAL AND JOINT DATA.

3-7. Most of the engine system joints and the data pertaining to the joints (lubrication used, torque values, etc) are included as part of the specific component removal and installation procedures. Figures 3-2 and 3-3, schematics and legends, provide the location and description of each joint, type of joint and seal required, lubricant used and method of application, torque value applied at joint fasteners or connector, and a reference to figure 3-2A for type of protective closure recommended if joint is disconnected. Specified lubricating procedures (methods) are outlined in section I. A reference to figure 3-1 is noted in the legend for joints where alinement requirements apply. The schematics are zoned, and each joint is assigned a code number to aid in identification and cross-reference between each schematic and its legend. The code designation identifies the type of fluid used at a specific joint and the location of the joint. Figure 3-2A provides recommended protective device data for component openings. Clean polyethylene bags or film may be used as temporary closures (48 hours maximum) to protect open joints. The data in figures 3-2 and 3-3 does not include methods for performing component removal and installation and is not intended for use in place of detailed component removal and installation procedures. (For information concerning the description of the various types of seals, refer to seal description in R-3896-1.) Fluid identification used in the legends is as follows:

Fluid Identification

Fluid	Code
Oxidizer	O
Fuel	F
Hydraulic control	HC
Exhaust	E
Helium	H
Nitrogen	N

Paragraph / Alinements Required / Engine Components and Lines	3-93 Wrap-Around Line Alinement Check	3-103 Control and Purge Line Alinement	3-105 3-109 Fuel High-Pressure Duct Fit Check	3-107 3-111 Oxidizer High-Pressure Duct Fit Check	3-143 Fuel Valve Fit Check	3-145 Oxidizer Valve Fit Check	3-256 Gimbal Bearing Alinement	3-265 Heat Exchanger Customer Duct Support and Bracket Alinement	3-267 Hydraulic Customer Duct Support and Bracket Alinement	3-269 Heat Exchanger Duct Support and Bracket Alinement	3-271 Ground Supply Hydraulic Duct and Checkout Valve-to-Hydraulic Return Duct Alinement	3-273 No. 1 Oxidizer Valve Dome Purge Line and Pump Seal Purge Line Alinement	3-307 Fuel Inlet Elbow Alinement Check	(a) Engine Performance Affected	(b) Thermal Insulation Brackets Affected
1. Engine control harnesses and cables															
2. Flight instrumentation harnesses and cables															
3. Quick-disconnects and adapters.															
4. Flight instrumentation pressure transducers															
5. Turbine inlet manifold temperature transducer															
6. Environmental temperature transducer															
7. No. 2 fuel inlet temperature transducer															
8. Primary junction box															
9. Oxidizer flowmeter															
10. Heat exchanger check valve															
11. Wrap-around ducts and hoses	X							X	X						
11A. Heat exchanger and turbopump turbine															
12. Heat exchanger and heat exchanger ducts and hoses										X				X	X
12A. Igniter fuel supply tube		X(g)													
12B. Engine supply tube		X(g)													
13. Fuel high-pressure duct spacers and seals															X

(a) Refer to R-3896-11 for component replacement effects on engine performance at sea level.
(b) Refer to R-3896-6 for thermal insulation brackets removal and installation procedures.
(g) Refer to paragraph 3-104A for alinement for igniter fuel supply tube or engine supply tube.

Figure 3-1. Component Reinstallation and Replacement Effects on Engine Alinement, Thermal Insulation Brackets, and Engine Performance (Sheet 1 of 6)

Paragraph / Alinements Required / Engine Components and Lines	3-93 Wrap-Around Line Alinement Check	3-103 Control and Purge Line Alinement	3-105 3-109 Fuel High-Pressure Duct Fit Check	3-107 3-111 Oxidizer High-Pressure Duct Fit Check	3-143 Fuel Valve Fit Check	3-145 Oxidizer Valve Fit Check	3-256 Gimbal Bearing Alinement	3-265 Heat Exchanger Customer Duct Support and Bracket Alinement	3-267 Hydraulic Customer Duct Support and Bracket Alinement	3-269 Heat Exchanger Duct Support and Bracket Alinement	3-271 Ground Supply Hydraulic Duct and Checkout Valve-to-Hydraulic Return Duct Alinement	3-273 No. 1 Oxidizer Valve Dome Purge Line and Pump Seal Purge Line Alinement	3-307 Fuel Inlet Elbow Alinement Check	(a) Engine Performance Affected	(b) Thermal Insulation Brackets Affected
14. Fuel valve to fuel manifold orifice plate														X	
15. Oxidizer high-pressure duct spacers and seals				X											X
16. Oxidizer valve to oxidizer dome pressure-actuated seal															X
17. No. 1 fuel high-pressure duct		X(g)	X											X	X
18. No. 2 fuel high-pressure duct		X(g)	X											X	X
19. No. 1 oxidizer high-pressure duct				X										X	X
20. No. 2 oxidizer high-pressure duct				X										X	X
21. No. 1 fuel valve		X			X(c)									X	X
22. No. 2 fuel valve		X			X(c)									X	X
23. No. 1 oxidizer valve		X				X(c)								X	X
24. No. 2 oxidizer valve		X				X(c)								X	X
25. Fuel valve position transducers															

(a) Refer to R-3896-11 for component replacement effects on engine performance at sea level.
(b) Refer to R-3896-6 for thermal insulation brackets removal and installation procedures.
(c) Alinement required if component replaced.
(g) Refer to paragraph 3-104A for alinement for igniter fuel supply tube or engine supply tube.

Figure 3-1. Component Reinstallation and Replacement Effects on Engine Alinement, Thermal Insulation Brackets, and Engine Performance (Sheet 2 of 6)

Engine Components and Lines / Alinements Required / Paragraph	3-93 Wrap-Around Line Alinement Check	3-103 Control and Purge Line Alinement	3-105 3-109 Fuel High-Pressure Duct Fit Check	3-107 3-111 Oxidizer High-Pressure Duct Fit Check	3-143 Fuel Valve Fit Check	3-145 Oxidizer Valve Fit	3-256 Gimbal Bearing Alinement	3-265 Heat Exchanger Customer Duct Support and Bracket Alinement	3-267 Hydraulic Customer Duct Support and Bracket Alinement	3-269 Heat Exchanger Duct Support and Bracket Alinement	3-271 Ground Supply Hydraulic Duct and Checkout Valve-to-Hydraulic Return Duct Alinement	3-273 No. 1 Oxidizer Valve Dome Purge Line and Pump Seal Purge Line Alinement	3-307 Fuel Inlet Elbow Alinement Check	(a) Engine Performance Affected	(b) Thermal Insulation Brackets Affected
26. Oxidizer valve position transducers															
27. Oxidizer dome purge check valve		X													
27A. Sequence valve															
28. Bearing coolant control valve															
29. Bearing coolant control valve filters															
30. Hypergol manifold		X(g)													X
31. Hypergol manifold cartridge container															
32. Hypergol manifold cartridge installed switch															
32A. Ignition monitor valve cap															
33. Engine control valve		X(g)													
34. Engine and GSE hydraulic supply check valves		X(g)													
35. Engine control valve filters															
35A. Four-way solenoid valve															
36. Redundant shutdown valve															
37. Thrust OK pressure switches															

(a) Refer to R-3896-11 for component replacement effects on engine performance at sea level.
(b) Refer to R-3896-6 for thermal insulation brackets removal and installation procedures.
(g) Refer to paragraph 3-104A for alinement for igniter fuel supply tube or engine supply tube.

Figure 3-1. Component Reinstallation and Replacement Effects on Engine Alinement, Thermal Insulation Brackets, and Engine Performance (Sheet 3 of 6)

Paragraph	3-93	3-103	3-105 3-109	3-107 3-111	3-143	3-145	3-256	3-265	3-267	3-269	3-271	3-273	3-307		(a)	(b)
Alinements Required / Engine Components and Lines	Wrap-Around Line Alinement Check	Control and Purge Line Alinement	Fuel High-Pressure Duct Fit Check	Oxidizer High-Pressure Duct Fit Check	Fuel Valve Fit Check	Oxidizer Valve Fit Check	Gimbal Bearing Alinement	Heat Exchanger Customer Duct Support and Bracket Alinement	Hydraulic Customer Duct Support and Bracket Alinement	Heat Exchanger Duct Support and Bracket Alinement	Ground Supply Hydraulic Duct and Checkout Valve-to-Hydraulic Return Duct Alinement	No. 1 Oxidizer Valve Dome Purge Line and Pump Seal Purge Line Alinement	Fuel Inlet Elbow Alinement Check		Engine Performance Affected	Thermal Insulation Brackets Affected
38. Inert prefill check valve																
39. Checkout valve																
40. Checkout valve actuator																
41. Gas generator fuel duct																
42. Gas generator oxidizer duct (duct end)															X	
43. Gas generator oxidizer duct (valve end)															X	
44. Gas generator ball valve		X													X	
45. Gas generator		X													X	X
46. Gas generator ball valve position switch																
47. Gas generator oxidizer purge check valve																
48. Electrical cable support post																
49. Interface panel to oxidizer insulation seal																
50. Interface panel																X
51. Gimbal bearing							X									

(a) Refer to R-3896-11 for component replacement effects on engine performance at sea level.
(b) Refer to R-3896-6 for thermal insulation brackets removal and installation procedures.

Figure 3-1. Component Reinstallation and Replacement Effects on Engine Alinement, Thermal Insulation Brackets, and Engine Performance (Sheet 4 of 6)

Engine Components and Lines / Alinements Required / Paragraph	Wrap-Around Line Alinement Check (3-93)	Control and Purge Line Alinement (3-103)	Fuel High-Pressure Duct Fit Check (3-105, 3-109)	Oxidizer High-Pressure Duct Fit Check (3-107, 3-111)	Fuel Valve Fit Check (3-143)	Oxidizer Valve Fit Check (3-145)	Gimbal Bearing Alinement (3-256)	Heat Exchanger Customer Duct Support and Bracket Alinement (3-265)	Hydraulic Customer Duct Support and Bracket Alinement (3-267)	Heat Exchanger Duct Support and Bracket Alinement (3-269)	Ground Supply Hydraulic Duct and Checkout Valve-to-Hydraulic Return Duct Alinement (3-271)	No. 1 Oxidizer Valve Dome Purge Line and Pump Seal Purge Line Alinement (3-273)	Fuel Inlet Elbow Alinement Check (3-307)	Engine Performance Affected (a)	Thermal Insulation Brackets Affected (b)
52. Associated engine equipment	X							X	X	X	X	X			X
53. Gimbal bearing, oxidizer dome, and thrust chamber injector	X						X							X	X
54. Gimbal bearing and oxidizer dome	X						X							X	X
55. Oxidizer dome and thrust chamber injector	X						X							X	X
56. Oxidizer dome	X						X								X
57. Thrust chamber injector	X						X							X(d)	X
58. No. 1 fuel inlet elbow													X(c)	X	X
59. No 2 fuel inlet elbow (engines incorporating MD96 change)													X(c)	X	X
60. No. 2 fuel inlet elbow (engines not incorporating MD96 change)													X(c)	X	X
61. Turbopump	X	X	X	X	X	X				X		X	X	X(e)	X
61A. Turbopump heater thermostat															
62. Fuel impeller balance cavity supply tube															

(a) Refer to R-3896-11 for component replacement effects on engine performance at sea level.
(b) Refer to R-3896-6 for thermal insulation brackets removal and installation procedures.
(c) Alinement required if component replaced.
(d) Single-engine hot-fire test required.
(e) Component hot-fire test required.

Figure 3-1. Component Reinstallation and Replacement Effects on Engine Alinement, Thermal Insulation Brackets, and Engine Performance (Sheet 5 of 6)

Paragraph / Alinements Required / Engine Components and Lines	3-93 Wrap-Around Line Alinement Check	3-103 Control and Purge Line Alinement	3-105 3-109 Fuel High-Pressure Duct Fit Check	3-107 3-111 Oxidizer High-Pressure Duct Fit Check	3-143 Fuel Valve Fit Check	3-145 Oxidizer Valve Fit Check	3-256 Gimbal Bearing Alinement	3-265 Heat Exchanger Customer Duct Support and Bracket Alinement	3-267 Hydraulic Customer Duct Support and Bracket Alinement	3-269 Heat Exchanger Duct Support and Bracket Alinement	3-271 Ground Supply Hydraulic Duct and Checkout Valve-to-Hydraulic Return Duct Alinement	3-273 No. 1 Oxidizer Valve Dome Purge Line and Pump Seal Purge Line Alinement	3-307 Fuel Inlet Elbows Alinement Check	(a) Engine Performance Affected	(b) Thermal Insulation Brackets Affected
63. Fuel impeller balance cavity return hose															
63A. Fuel drain manifold															
64. Engine variable orifices		X												X	
65. Thrust chamber body[(d)]														X	
66. Thrust chamber nozzle extension[(f)]														X	
67. Oxidizer and nitrogen overboard drain lines[(f)]															
68. Fuel overboard drain lines[(f)]															
69. Hypergol cartridge[(f)]															
70. Igniters[(f)]															
71. Igniter harness[(f)]															
72. Interface panel access door[(f)]															
73. Thrust chamber throat security closure[(f)]															
74. Engine environmental cover[(f)]															
75. Fuel inlet elbow-to-interface panel insulation boot[(f)]															
76. Turbopump oxidizer inlet															

(a) Refer to R-3896-11 for component replacement effects on engine performance at sea level.
(b) Refer to R-3896-6 for thermal insulation brackets removal and installation procedures.
(d) Single-engine hot-fire test required.
(f) Refer to R-3896-11 for component removal and installation procedure.

Figure 3-1. Component Reinstallation and Replacement Effects on Engine Alinement, Thermal Insulation Brackets, and Engine Performance (Sheet 6 of 6)

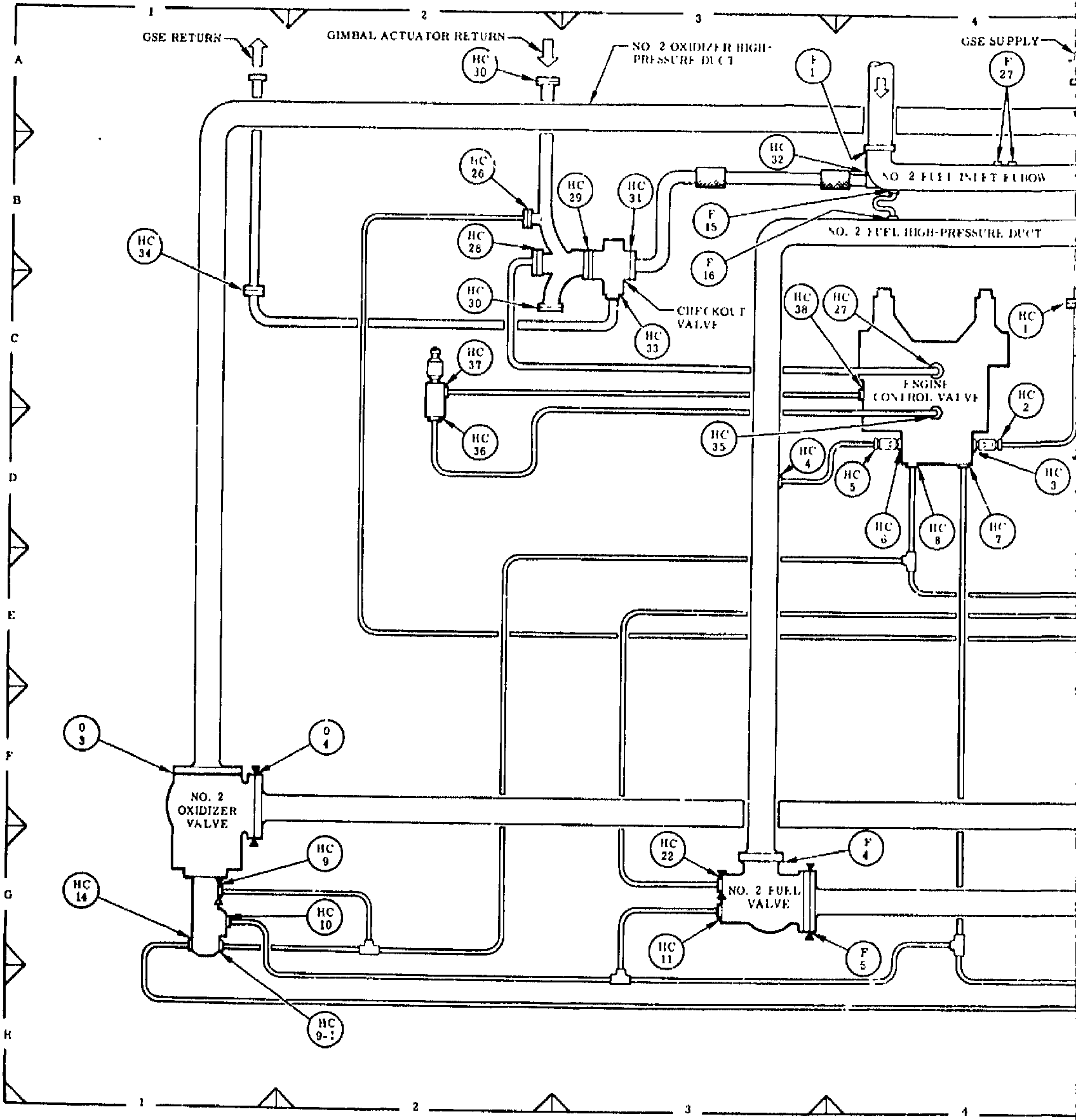
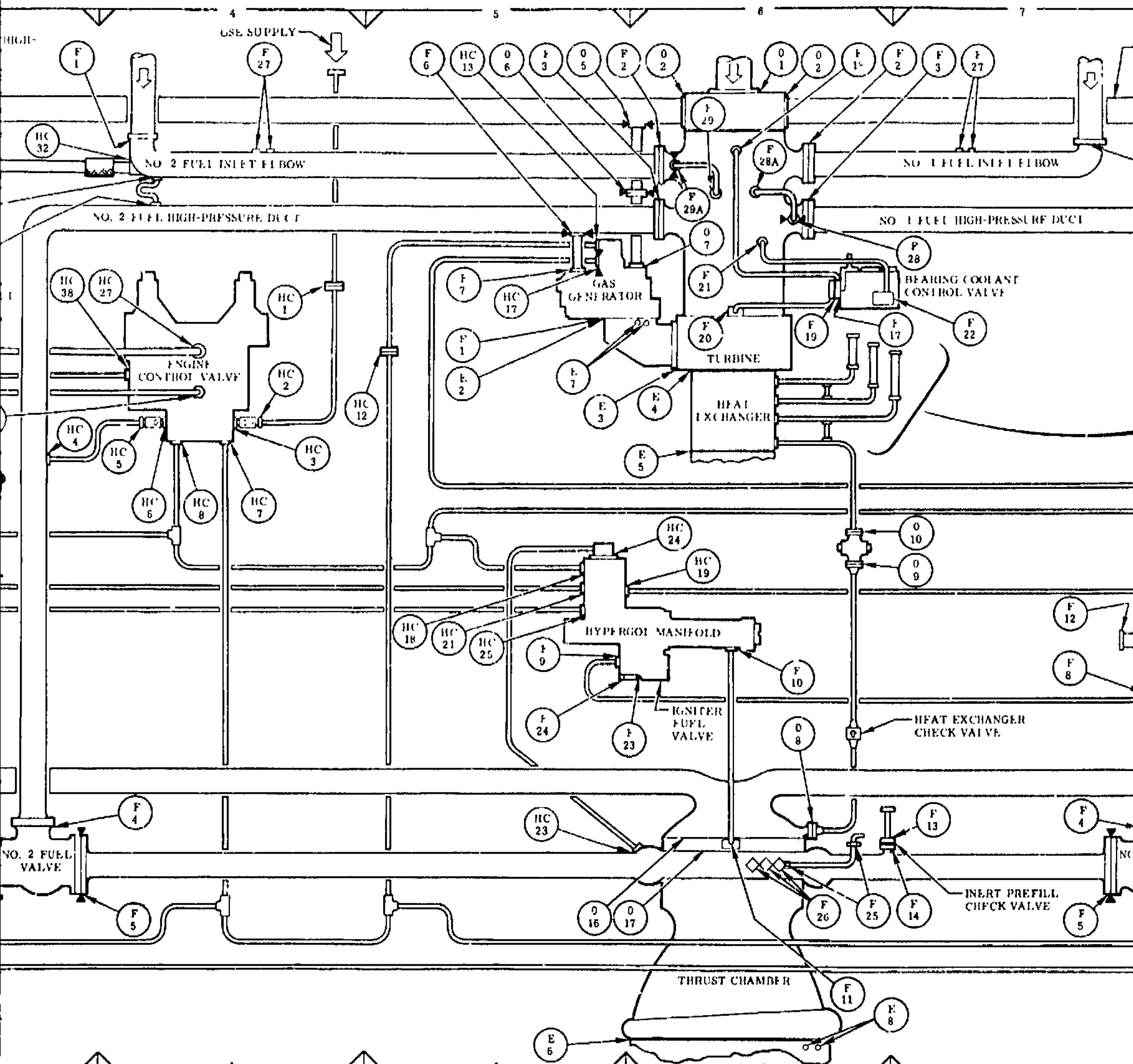
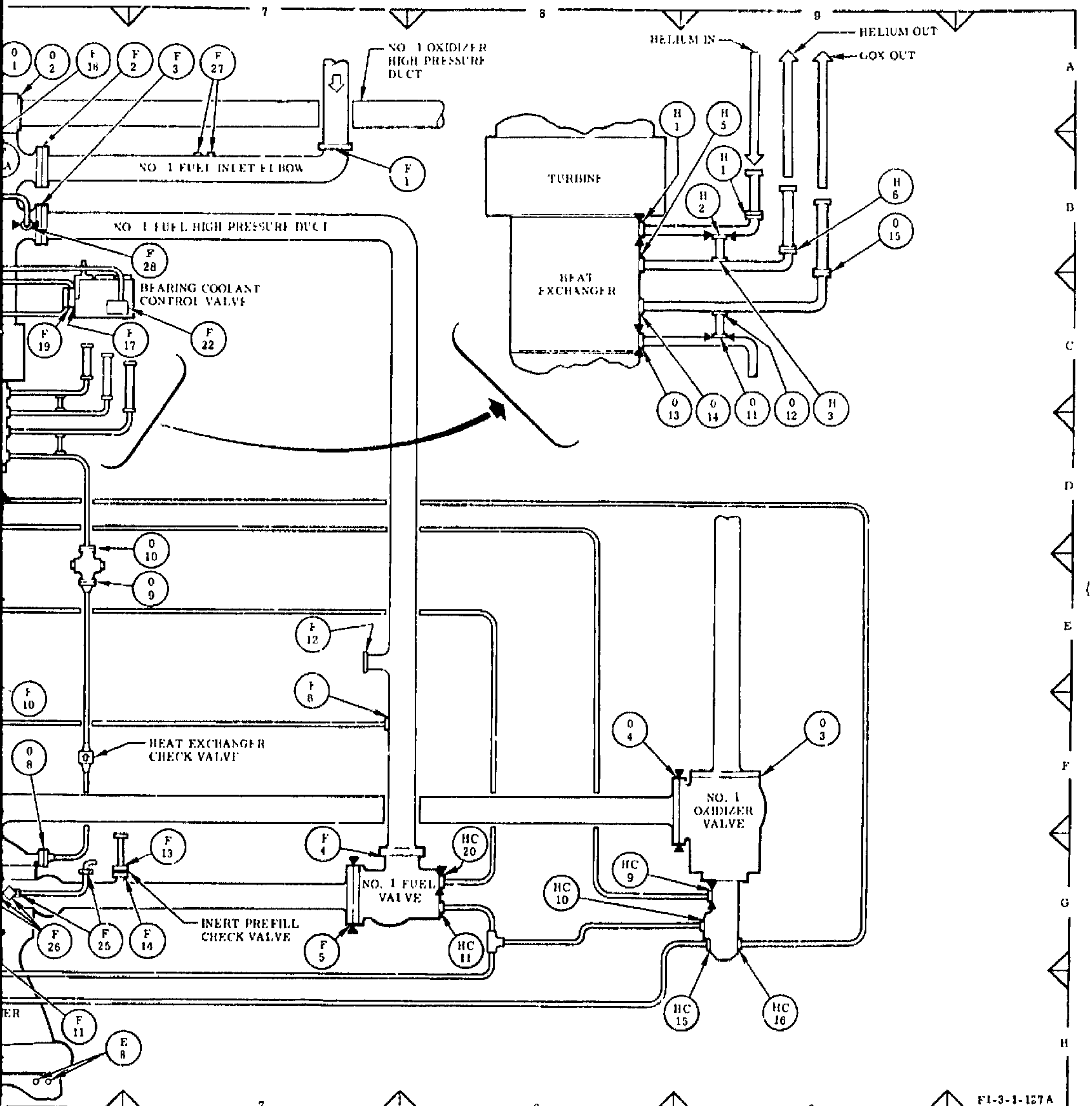


Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 1 of 20)


GSE SUPPLY
NO. 2 FUEL INLET ELBOW
NO. 2 FUEL HIGH-PRESSURE DUCT
NO. 1 FUEL INLET ELBOW
NO. 1 FUEL HIGH-PRESSURE DUCT
GAS GENERATOR
ENGINE CONTROL VALVE
BEARING COOLANT CONTROL VALVE
TURBINE
HEAT EXCHANGER
HYPERGOL MANIFOLD
IGNITER FUEL VALVE
HEAT EXCHANGER CHECK VALVE
NO. 2 FUEL VALVE
INERT PREFILL CHECK VALVE
THRUST CHAMBER

rol, Exhaust,



NO. 1 OXIDIZER HIGH PRESSURE DUCT
NO. 1 FUEL INLET ELBOW
NO. 1 FUEL HIGH PRESSURE DUCT
BEARING COOLANT CONTROL VALVE
HELIUM IN
HELIUM OUT
GOX OUT
TURBINE
HEAT EXCHANGER
HEAT EXCHANGER CHECK VALVE
NO. 1 OXIDIZER VALVE
NO. 1 FUEL VALVE
INERT PREFILL CHECK VALVE
7
8
9
A
B
C
D
E
F
G
H
F1-3-1-127A

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		OXIDIZER PROPELLANT FEED SYSTEM		
0-1	A6	Oxidizer suction duct to oxidizer pump	(b)	(b)
0-2	A6	Oxidizer pump to No. 1 oxidizer high-pressure duct[c]		
		Flange on duct		A 2 and 4
		Pressure-actuated seals	None	AF 1
		Spacer	None	AB
		Flange on pump		A 4
		Flange bolts (torque to 1,150-1,250 in-lb)		
0-3	F9	No. 1 oxidizer high-pressure duct to No. 1 oxidizer valve[c]		
		Flange on duct		A 2 and 4
		Pressure-actuated seals	None	AF 1
		Spacer	None	AB
		Flange on valve		A 4
		Flange bolts (torque to 1,150-1,250 in-lb)		
0-3	F1	No. 2 oxidizer high-pressure duct to No. 2 oxidizer valve[c]		
		Flange on duct		A 2 and 4
		Pressure-actuated seals	None	AF 1
		Spacer	None	AB
		Flange on valve		A 4
		Flange bolts (torque to 1,150-1,250 in-lb)		
0-4	F9	No. 1 oxidizer valve to thrust chamber oxidizer dome[c]		
		Flange on valve		A 4
		Pressure-actuated seal	None	AF 1
		Flange on dome		A 2 and 4
		Flange bolts (torque to 1,150-1,250 in-lb)		
0-4	F1	No. 2 oxidizer valve to thrust chamber oxidizer dome[c]		
		Flange on valve		A 4
		Pressure-actuated seal	None	AF 1
		Flange on dome		A 2 and 4
		Flange bolts (torque to 1,150-1,250 in-lb)		
0-5	A6	No. 2 oxidizer high-pressure duct to gas generator oxidizer duct (duct end)[c]		
		Flange on high-pressure duct		C 1
		Orifice plate	None	AF 1 or 2
		Flange on gas generator duct		G or B 3
		Flange bolts (torque to 350 ±10 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Customer connection.
(c) See figure 3-1 for alinement requirement.

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 2 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		OXIDIZER PROPELLANT FEED SYSTEM (cont)		
0-6	B6	Gas generator oxidizer duct (duct end) to gas generator oxidizer duct (valve end)		
		Flange on duct end		G or D 3
		Orifice plate	None	AF 1 or 2
		Seals	None	AF 1
		Flange on valve end		G or B 4
		Flange nuts (torque to 125 ±5 in-lb)		
0-7	B6	Gas generator oxidizer duct (valve end) to gas generator ball valve		
		Flange on gas generator duct		G or D 1
		Seal	None	AF 1 or 2
		Flange on gas generator ball valve		B 1
		Flange bolts (torque to 350 ±5 in-lb)		
0-8	G6	Oxidizer dome to heat exchanger check valve		
		Flange on oxidizer dome		C 1
		Pressure-actuated seal	None	AF 2
		Flange on check valve (dome end)		G or AL 1
		Flange nuts (torque to 255 ±5 in-lb)		
0-9	E6	Heat exchanger check valve to oxidizer flowmeter		
		Flange (check valve to flowmeter)		G
		Pressure-actuated seal	None	AF 2
		Flange (flowmeter to check valve)		G
		Flange nuts (torque to 255 ±5 in-lb)		
0-10	E6	Oxidizer flowmeter to heat exchanger oxidizer supply hose[c]		
		Flange on flowmeter		G
		Pressure-actuated seal	None	AF 2
		Flange on supply hose		G
		Flange bolts (torque to 255 ±5 in-lb)		
0-11	C9	Oxidizer supply hose to heat exchanger oxidizer bypass hose[c]		
		Flange on supply hose		F4
		Orifice plate	None	AF 2
		Seals	None	AF 1 or 2
		Flange on bypass hose		G
		Flange bolts (torque to 100 ±10 in-lb)		
0-12	C9	Oxidizer bypass hose to GOX duct (heat exchanger end)[c]		
		Flange on bypass hose		G
		Pressure-actuated seal	None	AF 2
		Flange on GOX duct		F4
		Flange bolts (torque to 100 ±10 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(c) See figure 3-1 for alinement requirement.

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 3 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		OXIDIZER PROPELLANT FEED SYSTEM (cont)		
0-13	C8	Oxidizer supply hose to heat exchanger[c]		
		Flange on supply hose		G
		Pressure-actuated seal	None	AF 2
		Flange on heat exchanger		C 6
0-14	C8	Heat exchanger to GOX return duct (heat exchanger end)[c]		
		Flange on heat exchanger		C 6
		Pressure-actuated seal	None	AF 1
		Flange on GOX return duct		G or C 9
		Flange bolts (torque to 295 ±10 in-lb)		
0-15	B9	GOX duct (heat exchanger end) to heat exchanger wrap-around duct[c]		
		Flange on GOX return duct		G or C 10
		Pressure-actuated seal	None	AF 2
		Flange on GOX wrap-around duct		G or C 10
		Flange nuts (torque to 265 ±10 in-lb)		
0-16	G6	Oxidizer dome to thrust chamber injector[c]		
		Flange on oxidizer dome		H 1 and 2
		Gasket	None	
		Flange on injector		E 1
		Inner dome bolts (torque to 685 ±35 ft-lb)	(e) A	
		Seals (dome bolts)	(d) R	
		Plugs (dome bolts) (torque to 105 ±5 ft-lb)	(e) A	
		Outer dome bolts (torque to 335 ±15 ft-lb)	(e) A	
		Washers	(e) F	
0-17	G6	Thrust chamber injector to thrust chamber fuel inlet manifold[c]		
		Flange on injector[g]		E 2
		Seal, upper	(f) K	
		Flange on fuel manifold[g]		J 1
		FUEL PROPELLANT FEED SYSTEM		
F-1	B4	Fuel suction duct to No. 1 fuel inlet elbow	(b)	(b)
		Flange on No. 1 fuel inlet elbow (uninstalled) engine)		AM
F-1	B7	Fuel suction duct to No. 2 fuel inlet elbow	(b)	(b)
		Flange on No. 2 fuel inlet elbow (uninstalled engine)		AM

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Customer connection.
(c) See figure 3-1 for alinement requirement
(d) Fluorinated oil Krytox 143AZ (Du Pont) or lubricant grease RB0140-012 (Rocketdyne).
(e) Lubricant grease RB0140-012 (Rocketdyne).
(f) FS1281 grease (Dow Corning Corp).
(g) Compressed by outer dome bolts.

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 4 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		FUEL PROPELLANT FEED SYSTEM (cont)		
F-2	B6	No. 1 fuel inlet elbow to fuel pump[c]		
		Flange on inlet elbow		K 1
		Seal plate	None	AF 1
		Flange on fuel pump		K 1
		Flange bolts (torque to 470 ±10 in-lb)		
F-2	B6	No. 2 fuel inlet elbow to fuel pump[c]		
		Flange on inlet elbow		K 1
		Seal plate	None	AF 1
		Flange on fuel pump		K 1
		Flange bolts (torque to 470 ±10 in-lb)		
F-3	B6	Fuel pump to No. 1 fuel high-pressure duct[c]		
		Flange on fuel pump		K 1
		Seal plate	None	AF 1
		Spacer	None	AB
		Seal plate	None	AF 1
		Flange on fuel high-pressure duct		A 1 and 4
		Flange bolts (torque to 1,150-1,250 ft-lb)		
F-3	B6	Fuel pump to No. 2 fuel high-pressure duct[c]		
		Flange on fuel pump		K 1
		Seal plate	None	AF 1
		Spacer	None	AB
		Seal plate	None	AF 1
		Flange on fuel high-pressure duct		A 1 and 4
		Flange bolts (torque to 1,150-1,250 ft-lb)		
F-4	G7	No. 1 fuel high-pressure duct to No. 1 fuel valve[c]		
		Flange on fuel high-pressure duct		A 1 and 4
		Seal plate	None	AF 1
		Spacer	None	AB
		Seal plate	None	AF 1
		Flange on fuel valve		A 4
		Flange bolts (torque to 1,150-1,250 ft-lb)		
F-4	G3	No. 2 fuel high-pressure duct to No. 2 fuel valve[c]		
		Flange on fuel high-pressure duct		A 1 and 4
		Seal plate	None	AF 1
		Spacer	None	AB
		Seal plate	None	AF 1
		Flange on fuel valve		A 4
		Flange bolts (torque to 1,150-1,250 ft-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(c) See figure 3-1 for alinement requirement.

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 5 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		FUEL PROPELLANT FEED SYSTEM (cont)		
F-5	G7	No. 1 fuel valve to thrust chamber fuel manifold[c]		
		Flange on fuel valve		A 4
		Orifice plate	None	AB
		Flange on fuel manifold		A 3 and 4
		Flange bolts (torque to 1,150-1,250 ft-lb)		
F-5	G3	No. 2 fuel valve to thrust chamber fuel manifold[c]		
		Flange on fuel valve		A 4
		Orifice plate	None	AB
		Flange on fuel manifold		A 3 and 4
		Flange bolts (torque to 1,150-1,250 ft-lb)		
F-6	B5	No. 2 fuel high-pressure duct to gas generator fuel duct		
		Flange on fuel high-pressure duct		C 2
		Orifice plate	None	AF 1
		Flange on gas generator fuel duct		G or C 2
		Flange bolts (torque to 280 ±10 in-lb)		
F-7	B5	Gas generator fuel duct to gas generator ball valve		
		Flange on fuel duct		G or B2
		Seal	None	AF 1
		Flange on ball valve		C 8
		Flange bolt (torque to 550 ±10 in-lb)		
F-8	F7	No. 1 fuel high-pressure duct to igniter fuel supply tube[c]		
		Flange on fuel high-pressure duct		F 4
		O-ring	(e)K	
		Spacer	None	AB
		O-ring	(e)K	
		Flange on igniter fuel supply tube		G or F 4
		Flange bolts (torque to 60 ±5 in-lb)		
F-9	E5	Igniter fuel supply tube to igniter fuel valve[c]		
		Flange on igniter fuel supply tube		G or F 4
		O-ring	(e)K	
		Spacer	None	AB
		O-ring	(e)K	
		Flange on igniter fuel valve		F 4
		Flange bolts (torque to 60 ±5 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(c) See figure 3-1 for alinement requirement.
(e) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 6 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		FUEL PROPELLANT FEED SYSTEM (cont)		
F-10	E6	Hypergol manifold to hypergol manifold outlet hose		
		Flange on hypergol manifold		F 1
		Seal plate	None	AF 1
		Flange on manifold outlet tube		G or L 5
		Flange bolts (torque to 85 ±5 in-lb)		
F-11	G6	Hypergol manifold outlet hose to thrust chamber injector		
		Flange on manifold outlet tube		G or L 5
		Seal plate	None	AF 1
		Flange on thrust chamber injector		L 5
		Flange bolts (torque to 85 ±5 in-lb)		
F-12	E7	No. 1 fuel high-pressure duct to gimbal supply plate		
		Flange on fuel high-pressure duct		C 5
		Seal plate	(b)	(b)
		Gimbal supply plate		(b)
		Flange bolts (torque to 60 ±5 in-lb)		
F-13	G6	Prefill wrap-around hose to inert prefill check valve[c]		
		Flange on prefill wrap-around hose		G
		Seal	None	AF 1
		Flange on inert prefill check valve		M 1
		Flange nuts (torque to 100 ±10 in-lb)		
F-13	G6	Inert prefill check valve plate to inert prefill check valve (prefill wrap-around hose not installed)		
		Inert prefill check valve plate		None
		Seal	None	AF 1
		Flange on inert prefill check valve		M 1
		Flange nuts (torque to 100 ±10 in-lb)		
F-14	G6	Inert prefill check valve to thrust chamber fuel manifold		
		Flange on inert prefill check valve		G
		Retainer	(e) J	
		Packing	(e) J	
		Retainer	(e) J	
		Flange on fuel manifold		M 1
		Flange nuts (torque to 100 ±10 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Customer connection.
(c) See figure 3-1 for alinement requirement.
(e) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 7 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		FUEL PROPELLANT FEED SYSTEM (cont)		
F-15	B4	No. 2 fuel inlet elbow to turbopump fuel bleed hose		
		Flange on fuel inlet elbow		L 4
		Seal plate	None	AF 1
		Flange on fuel bleed hose		G or L 4
		Flange bolts (torque to 25 ±2 in-lb)		
F-16	B4	Turbopump fuel bleed hose to No. 2 fuel high-pressure duct		
		Flange on fuel bleed hose		G or L 6
		Orifice plate	None	AB
		Flange on fuel high-pressure duct		L 6
		Flange bolts (torque to 25 ±2 in-lb)		
F-17	C6	Bearing coolant control valve to No. 1 and No. 2 bearings lube feed line		
		Flange on bearing coolant control valve		L 6
		Seal plate	None	AF 1
		Flanges on bearing lube feed line		G or L 6
		Flange bolts (torque to 40-50 in-lb)		
F-18	B6	No. 1 and No. 2 bearing lube feed tubes to turbopump		
		Coupling nut on bearing lube feed line (torque nut to 180-200 in-lb)	None	N 4
		Ring	None	
		Fitting on turbopump	None	AJ 1
F-19	C6	Turbine bearing lube feed hose to bearing coolant control valve		
		Flange on bearing lube feed hose		G or L 6
		Seal plate	None	AF 1
		Flange on bearing coolant control valve		L 4
		Flange bolts (torque to 40-50 in-lb)		
F-20	C6	Turbine bearing support lube feed hose to turbopump manifold		
		Flange on lube feed hose		G or L 6
		Flange on turbopump manifold	None	None
		Flange bolts (torque to 40-50 in-lb) or flange nuts (torque to 30-40 in-lb)		
F-21	B6	Turbopump to fuel coolant supply tube		
		Coupling nut on feed tube (torque to 330 ±15 in-lb)[h]	None	N 2
		Fitting on turbopump	None	AJ 4

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(h) Torque value above prevailing torque obtained before seating of tube flare. Prevailing torque must be 24-200 in-lb.

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 8 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		FUEL PROPELLANT FEED SYSTEM (cont)		
F-22	C6	Coolant supply tube to bearing coolant control valve		
		Flange on feed tube		G or P 1
		Seal plate	None	AF 1
		Flange on bearing coolant control valve		P 1
		Flange bolts (torque to 15-20 in-lb)		
F-23	F6	Hypergol manifold to hypergol manifold bleed adapter		
		Flange on hypergol manifold		F 3
		Seal plate	None	AF 1
		Flange on adapter		F 3
		Flange bolts (torque to 22 ±2 in-lb)		
F-24	F5	Hypergol manifold bleed adapter to hypergol bleed plug		
		Flange on adapter		F 3
		Gasket	(e) J	
		Hypergol bleed plug	(e) A	
F-25	G6	Facility check calips switch tube to interface panel adapter and to thrust OK pressure switch manifold		
		Coupling nut at interface panel adapter (torque to 270-345 in-lb)[i]	None	N 5
		Coupling nut at manifold adapter (torque to 270-345 in-lb)[i]	None	N 5
F-26	G6	Thrust OK pressure switch to thrust chamber fuel manifold		
		Flange on pressure switch		M 3
		Orifice plate	None	AF 1
		Flange on fuel manifold		M 3
		Flange bolts--1/4-inch (torque to 90 ±10 in-lb)		
		Flange bolts--3/8-inch (torque to 125 ±10 in-lb)		
F-27	B7	No. 1 fuel inlet elbow plugs		
		Flange on fuel inlet elbow		None
		Gasket	(e) J	
		Plug--1/8-inch (torque to 10-16 in-lb)	(e) A	
		Plug--1/4-inch (torque to 40-65 in-lb)	(e) A	

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(e) Lubricant grease RB0140-012 (Rocketdyne).
(i) Torque value above prevailing torque obtained during last one-half turn before seating of tube flare. Prevailing torque must be 50-200 in-lb.

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 9 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		FUEL PROPELLANT FEED SYSTEM (cont)		
F-27	B4	No. 2 fuel inlet elbow plugs		
		Flange on fuel inlet elbow		None
		Gasket	(e) J	
		Plug--1/8-inch (torque to 10-16 in-lb)		
		Plug--1/4-inch (torque to 40-65 in-lb)		
F-28	B6	No. 1 fuel turbopump outlet to fuel impeller balance cavity supply tube		
		Flange on supply tube		G or O 2
		Orifice	None	AF 1
		Flange on turbopump outlet		O 2
		Flange bolts (torque to 50-70 in-lb)	(e) A	
F-28A	B6	Fuel impeller balance cavity supply tube to fuel impeller balance cavity supply inlet		
		Flange on supply tube		G or AN 1
		Packing	(e) J	
		Flange on turbopump volute		M 2
		Flange bolts (torque to 170-270 in-lb)		
F-29	B6	Fuel impeller balance cavity return to fuel impeller balance cavity return hose		
		Flange on turbopump volute		M 2
		Packing	(e) J	
		Flange on return hose		G or AN 1
		Flange bolts (torque to 170-270 in-lb)		
F-29A	B6	Fuel impeller balance cavity return hose to No. 2 fuel pump inlet		
		Flange on return hose		G or C 4
		Orifice	None	AF 1
		Flange on fuel pump inlet		M 2
		Flange bolts (torque to 50-70 in-lb)	(e) A	
		HELIUM SYSTEM		
H-1	B9	Helium supply wrap-around duct to helium supply duct (heat exchanger end)[c]		
		Flange on wrap-around duct		G or M 6
		Seal plate	None	AF 2
		Flange on supply duct		G or M 6
		Flange nuts (torque to 265 ±5 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(c) See figure 3-1 for alinement requirement.
(e) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 10 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		HELIUM SYSTEM (cont)		
H-2	B9	Helium supply duct (heat exchanger end) to helium bypass hose[c]		
		Flange on supply duct		F 4
		Orifice	None	AF 2
		Flange on bypass hose		G
		Flange bolts (torque to 100 ±10 in-lb)		
H-3	B9	Helium bypass hose to helium return duct (heat exchanger end)[c]		
		Flange on bypass hose		G
		Seal plate	None	AF 2
		Flange on return duct		F 4
		Flange bolts (torque to 100 ±10 in-lb)		
H-4	B9	Helium supply duct (heat exchanger end) to heat exchanger[c]		
		Flange on supply duct		G or C 11
		Seal plate	None	AF 2
		Flange on heat exchanger		C 7
		Flange bolts (torque to 110 ±10 in-lb)		
H-5	B8	Heat exchanger to helium return duct (heat exchanger end)[c]		
		Flange on heat exchanger		C 7
		Seal plate	None	AF 2
		Flange on return duct		G or C 11
		Flange bolts (torque to 110 ±10 in-lb)		
H-6	B9	Helium return duct (heat exchanger end) to helium return wrap-around duct[c]		
		Flange on return duct		G or C 10
		Seal plate	None	AF 1
		Flange on wrap-around duct		G or C 10
		Flange nuts (torque to 265 ±10 in-lb)		
		HYDRAULIC CONTROL SYSTEM		
HC-1	C4	Hydraulic supply wrap-around duct to engine control valve ground hydraulic supply hose[c]		
		Flange on wrap-around duct		G or AM 1
		Seal plate	None	AF 1
		Flange on supply hose		G, P 2, or F 12[m]
		Flange nuts (torque to 225 ±15 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(c) See figure 3-1 for alinement requirement.
(m) Closure F 12 used with line installed on engine; closure fasteners torqued to 15-20 in-lb.

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 11 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		HYDRAULIC CONTROL SYSTEM (cont)		
HC-2	D4	Engine control valve ground hydraulic supply hose to GSE hydraulic supply check valve[c]		
		Flange on supply hose		G or L 8
		Seal plate	None	AF 1
		Flange on check valve		L 8
		Flange nuts (torque to 85 ±5 in-lb)		
HC-3	D4	GSE hydraulic supply check valve to engine control valve		
		Flange on check valve		Q 1
		Retainer	(j) M	
		Packing	(j) M	
		Retainer	(j) M	
		Flange on engine control valve		Q 1
		Flange bolts (torque to 80-100 in-lb)		
HC-4	D3	No. 2 fuel high-pressure duct to engine control valve supply tube[c]		
		Flange on high-pressure duct		F 4
		O-ring	(e) K	
		Spacer	None	AB
		O-ring	(e) K	
		Flange on supply tube		G or F 4
		Flange bolts (torque to 85 ±5 in-lb)		
HC-5	D4	Engine control valve supply tube to engine hydraulic supply check valve[c]		
		Flange on supply tube		G or L 8
		O-ring	(e) K	
		Spacer	None	AB
		O-ring	(e) K	
		Flange on check valve		L 8
		Flange bolts (torque to 85 ±5 in-lb)		
HC-6	D4	Engine hydraulic supply check valve to engine control valve		
		Flange on check valve		Q 1
		Retainer		
		Packing	(j) M	
		Retainer		
		Flange on engine control valve		Q 1
		Flange bolts (torque to 80-100 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(c) See figure 3-1 for alinement requirement.
(e) Lubricant grease RB0140-012 (Rocketdyne).
(j) Hydraulic fluid (MIL-H-5606).

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 12 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		HYDRAULIC CONTROL SYSTEM (cont)		
HC-7	D4	Engine control valve to propellant valves close tube[c] (Engines not incorporating MD96 change)		
		Flange on engine control valve		F 4
		Seal plate	None	AF 1
		Adapter	None	AB
		Seal plate	None	AF 1
		Flange on close tube		G or F 4
		Flange bolts (torque to 60 ±5 in-lb)		
HC-7	D4	Engine control valve to propellant valves close tube[c] (Engines incorporating MD96 change)		
		Flange on engine control valve		F 4
		Seal plate	None	AF 1
		Flange on close tube		G or F 4
		Flange bolts (torque to 85 ±5 in-lb)		
HC-8	D4	Engine control valve to propellant valves open tube[c] (Engines not incorporating MD96 change)		
		Flange on engine control valve		F 4
		Seal plate	None	AF 1
		Adapter	None	AB
		Seal plate	None	AF 1
		Flange on open tube		G or F 4
		Flange bolts (torque to 60 ±5 in-lb)		
HC-8	D4	Engine control valve to propellant valves open tube[c] (Engines incorporating MD96 change)		
		Flange on engine control valve		F 4
		Seal plate	None	AF 1
		Flange on open tube		G or F 4
		Flange bolts (torque to 85 ±5 in-lb)		
HC-9	G9	Propellant valves open tube to No. 1 oxidizer valve[c]		
		Flange on open tube		G or L 1
		Orifice plate	None	AF 2
		Flange on oxidizer valve		L 1
		Flange bolts (torque to 46 ±3 in-lb)		
HC-9	G1	Propellant valves open tube to No. 2 oxidizer valve[c]		
		Flange on open tube		G or L 1
		Orifice plate	None	AF 2
		Flange on oxidizer valve		L 1
		Flange bolts (torque to 46 ±3 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(c) See figure 3-1 for alinement requirement.

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 13 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		HYDRAULIC CONTROL SYSTEM (cont)		
HC-9	G1	Propellant valves open tube to No. 2 oxidizer valve[c]		
		Flange on open tube		G or L 6
		Seal plate	None	AF 1
		Flange on oxidizer valve		L 3
		Flange bolts (torque to 30 ±3 in-lb)		
HC-10	G9	Propellant valves close tube to No. 1 oxidizer valve[c]		
		Flange on close tube		G or L 6
		Seal plate	None	AF 1
		Flange on oxidizer valve		L 5
		Flange bolts (torque to 85 ±5 in-lb)		
HC-10	G1	Propellant valves close tube to No. 2 oxidizer valve[c]		
		Flange on close tube		G or L 6
		Seal plate	None	AF 1
		Flange on oxidizer valve		L 5
		Flange bolts (torque to 85 ±5 in-lb)		
HC-11	G8	Propellant valves close tube to No. 1 fuel valve[c]		
		Flange on close tube		G or L 5
		Seal	None	AF 1
		Flange on fuel valve		L 7
		Flange bolts (torque to 36 ±3 in-lb)		
HC-11	G3	Propellant valves close tube to No. 2 fuel valve[c]		
		Flange on close tube		G or L 5
		Seal	None	AF 1
		Flange on fuel valve		L 7
		Flange bolts (torque to 36 ±3 in-lb)		
HC-12	C5	Propellant valves close tube to gas generator close tube[c]		
		Flange on propellant valves close tube		G or L 6
		Seal plate	None	AF 1
		Flange on gas generator close tube		G or L 6
		Flange nuts (torque to 36 ±3 in-lb)		
HC-13	B5	Gas generator close tube to gas generator[c]		
		Flange on close tube		G or L 6
		Seal plate	None	AF 1
		Flange on gas generator		L 6
		Flange bolts (torque to 36 ±3 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(c) See figure 3-1 for alinement requirement.

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 14 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		HYDRAULIC CONTROL SYSTEM (cont)		
HC-14	G1	No. 2 oxidizer valve sequence valve to sequence valve line		
		Flange on sequence valve		L 3
		Seal plate	None	AF 1
		Flange on sequence valve line		G or L 6
		Flange bolts (torque to 36 ±3 in-lb)		
HC-15	G9	Sequence valve line to No. 1 oxidizer valve sequence valve[c]		
		Flange on sequence valve line		G or L 6
		Seal plate	None	AF 1
		Flange on sequence valve		L 3
		Flange bolts (torque to 30 ±3 in-lb)		
HC-16	G9	No. 1 oxidizer valve to gas generator open tube[c]		
		Flange on oxidizer valve		L 3
		Seal plate	None	AF 1
		Flange on gas generator open tube		G or L 7
		Flange bolts (torque to 36 ±3 in-lb)		
HC-17	B5	Gas generator open tube to gas generator[c]		
		Flange on open tube		G or R 2
		Orifice plate	None	AF 2
		Flange on gas generator		R 1
		Flange bolts (torque to 85 ±5 in-lb)		
HC-18	E5	Propellant valves open tube to ignition monitor valve[c]		
		Flange on open tube		G or L 5
		Seal plate	None	AF 1
		Flange on ignition monitor valve		L 5
		Flange bolts (torque to 85 ±5 in-lb)		
HC-19	E6	Ignition monitor valve to No. 1 fuel valve open control tube[c]		
		Flange on ignition monitor valve		L 6
		Seal plate	None	AF 1
		Flange on open control tube		G or L 6
		Flange bolts (torque to 36 ±3 in-lb)		
HC-20	G8	No. 1 fuel valve open control tube to No. 1 fuel valve[c]		
		Flange on open control tube		G or L 7
		Orifice plate	None	AF 2
		Flange on fuel valve		L 7
		Flange bolts (torque to 36 ±3 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(c) See figure 3-1 for alinement requirement.

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 15 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[(a)]
		HYDRAULIC CONTROL SYSTEM (cont)		
HC-21	E5	Ignition monitor valve to No. 2 fuel valve open control tube[(c)]		
		Flange on ignition monitor valve		L 6
		Seal plate	None	AF 1
		Flange on open control tube		G or L 6
		Flange bolts (torque to 36 ±3 in-lb)		
HC-22	G3	No. 2 fuel valve open control tube to No. 2 fuel valve[(c)]		
		Flange on open control tube		G or L 7
		Orifice plate	None	AF 2
		Flange on fuel valve		L 7
		Flange bolts (torque to 36 ±3 in-lb)		
HC-23	G5	Thrust chamber fuel manifold to ignition monitor valve sense tube[(c)]		
		Flange on fuel manifold		L 6
		Seal plate	None	AF 1
		Flange on sense tube		G or L 6
		Flange nuts (torque to 52 ±5 in-lb)		
HC-24	E5	Ignition monitor valve sense tube to ignition monitor valve[(c)]		
		Flange on sense tube		G or L 1
		Retainer	(e) J	
		O-ring	(e) J	
		Retainer	(e) J	
		Flange on ignition monitor valve		AD 2
		Flange bolts (torque to 75 ±5 in-lb)		
HC-25	E5	Ignition monitor valve to ignition monitor valve return line		
		Flange on ignition monitor valve		L 2
		Seal plate	None	AF 1
		Flange on return line		G or L 2
		Flange bolts (torque to 46 ±3 in-lb)		
HC-26	B2	Ignition monitor valve return line to actuator return line		
		Flange on ignition monitor valve return line		G or L 2
		Seal plate	None	AF 1
		Flange on actuator return line		L 2
		Flange bolts (torque to 46 ±3 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(c) See figure 3-1 for alinement requirement.
(e) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 16 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		HYDRAULIC CONTROL SYSTEM (cont)		
HC-27	C4	Engine control valve to system return line		
		Flange on engine control valve		M 1
		Seal plate	None	AF 1
		Flange on system return line		G or M 1
		Flange bolts (torque to 100 ±5 in-lb)		
HC-28	B2	System return line to actuator return line		
		Flange on system return line		G or M 1
		Seal plate	None	AF 1
		Flange on actuator return line		G or M 1
		Flange nuts (torque to 85 ±5 in-lb)		
HC-29	B3	Checkout valve to actuator return line		
		Flange on checkout valve		B 1
		Seal plate	None	AF 1
		Flange on actuator return line		G or G 12
		Flange bolts (torque to 185 ±5 in-lb)		
HC-30	C2	Actuator return line to actuator return line cover		
		Flange on return line (No. 1 side)		G or C 3
		Seal plate	None	AF 1
		Cover		
		Attach nuts (torque to 160 ±5 in-lb)		
		Flange on return line (No. 2 side)		G or C 3
		Seal plate	None	AF 1
		Cover		
		Flange nuts (torque to 160 ±5 in-lb)		
HC-31	B3	Checkout valve to checkout valve engine return hose		
		Flange on checkout valve		B 1
		Seal plate	None	AF 1
		Flange on return hose		G
		Flange bolts (torque to 185 ±5 in-lb)		
HC-32	B4	Checkout valve engine return hose to No. 2 fuel inlet elbow		
		Flange on return hose		G
		Seal plate	None	AF 1
		Flange on fuel inlet elbow		B 1
		Flange bolts (torque to 180 ±10 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 17 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		HYDRAULIC CONTROL SYSTEM (cont)		
HC-33	C3	Checkout valve to checkout valve ground return hose		
		Flange on checkout valve		C 3
		Seal plate	None	AF 1
		Flange on return hose		G
		Flange bolts (torque to 75 ±5 in-lb)		
HC-34	C1	Checkout valve ground return hose to hydraulic return wrap-around duct		
		Flange on return hose		G, R 2, or R 13[n]
		Seal	None	AF 1
		Flange on wrap-around duct		G or M 7
		Flange nuts (torque to 80 ±5 in-lb)		
HC-35	C4	Engine control valve to redundant shutdown supply line		
		Coupling nut on supply line (torque to 180-230 in-lb)[k]	None	N 1
		Fitting on engine control valve	None	AJ 1
HC-36	D2	Redundant shutdown supply line to redundant shutdown valve		
		Flange on supply line		G or S 1
		Seal plate	None	AF 1
		Flange on redundant shutdown valve		S 1
		Flange bolts (torque to 90 ±5 in-lb)		
HC-37	C2	Redundant shutdown valve to redundant shutdown valve override line		
		Flange on redundant shutdown valve		T 1
		Seal plate	None	AF 1
		Flange on override line		G or T 1
		Flange bolts (torque to 90 ±5 in-lb)		
HC-38	C4	Redundant shutdown override line to engine control valve		
		Coupling nut on override line (torque to 270-345 in-lb)[l]	None	N 2
		Fitting on engine control valve	None	AJ 2

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(k) Torque value above prevailing torque obtained during last one-half turn of coupling nut before seating of tube flare. Prevailing torque must be 35-300 in-lb.
(l) Torque value above prevailing torque obtained during last one-half turn of coupling nut before seating of tube flare. Prevailing torque must be 35-200 in-lb.
(n) Closure R 13 used with hose installed on engine; closure fasteners torqued to 15-20 in-lb.

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 18 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		EXHAUST SYSTEM		
E-1	C5	Gas generator ball valve (oxidizer) to gas generator injector[c]		
		Flange on gas generator ball valve		D 2
		Seal plate	None	AF 1
		Flange on gas generator injector		D 1
		Flange bolts (torque to 150-170 in-lb)		
E-2	C5	Gas generator ball valve (fuel) to housing tee and housing tee to gas generator injector[c]		
		Flange on gas generator ball valve		AD 3
		Retainer (2 reqd)	(f) J	
		O-ring/packing (2 reqd)	(f) J	
		Housing		
		Retainer	(f) J	
		O-ring/packing	(f) J	
		Flange on gas generator injector		V 1
		Flange nuts (torque fingertight)		
E-3M	C6	Gas generator combustor to turbine manifold inlet[c]		
		Flange on gas generator combustor		W 1
		Seal plate	None	AF 1
		Flange on turbine manifold inlet		X 1
		Flange bolts (torque to 930 ±10 in-lb)		
E-4M	C6	Turbine to heat exchanger		
		Flange on turbine		Y 1
		Pressure-actuated seal	None	AF 1
		Flange on heat exchanger		Y 1
		Flange nuts (torque to 135 +5 in-lb)		
E-5M	D6	Heat exchanger to exhaust manifold[c]		
		Flange on heat exchanger		Z 1
		Pressure-actuated seal	None	AF 1
		Flange on exhaust manifold		Z 2
		Flange nuts (torque to 135 +5 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(c) See figure 3-1 for alinement requirement.
(f) FS1281 grease (Dow Corning Corp).

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 19 of 20)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		EXHAUST SYSTEM (cont)		
E-6	H6	Thrust chamber to thrust chamber nozzle extension[c]		
		Flange on thrust chamber		AC 1
		Asbestos seal	None	
		Flange on nozzle extension		None
		Flange nuts (torque to 120 ±5 in-lb)		
E-7	C6	Gas generator igniter ports		
		Washer		AA 2
		Plug (torque to 600-650 in-lb)	None	AA 1
E-8	H6	Nozzle extension igniter ports		
		Plug (torque fingertight)	None	N 3

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(c) See figure 3-1 for alinement requirement.

Figure 3-2. Seal and Joint Schematic for Engine Propellant Feed, Hydraulic Control, Exhaust, and Pressurization Systems (Sheet 20 of 20)

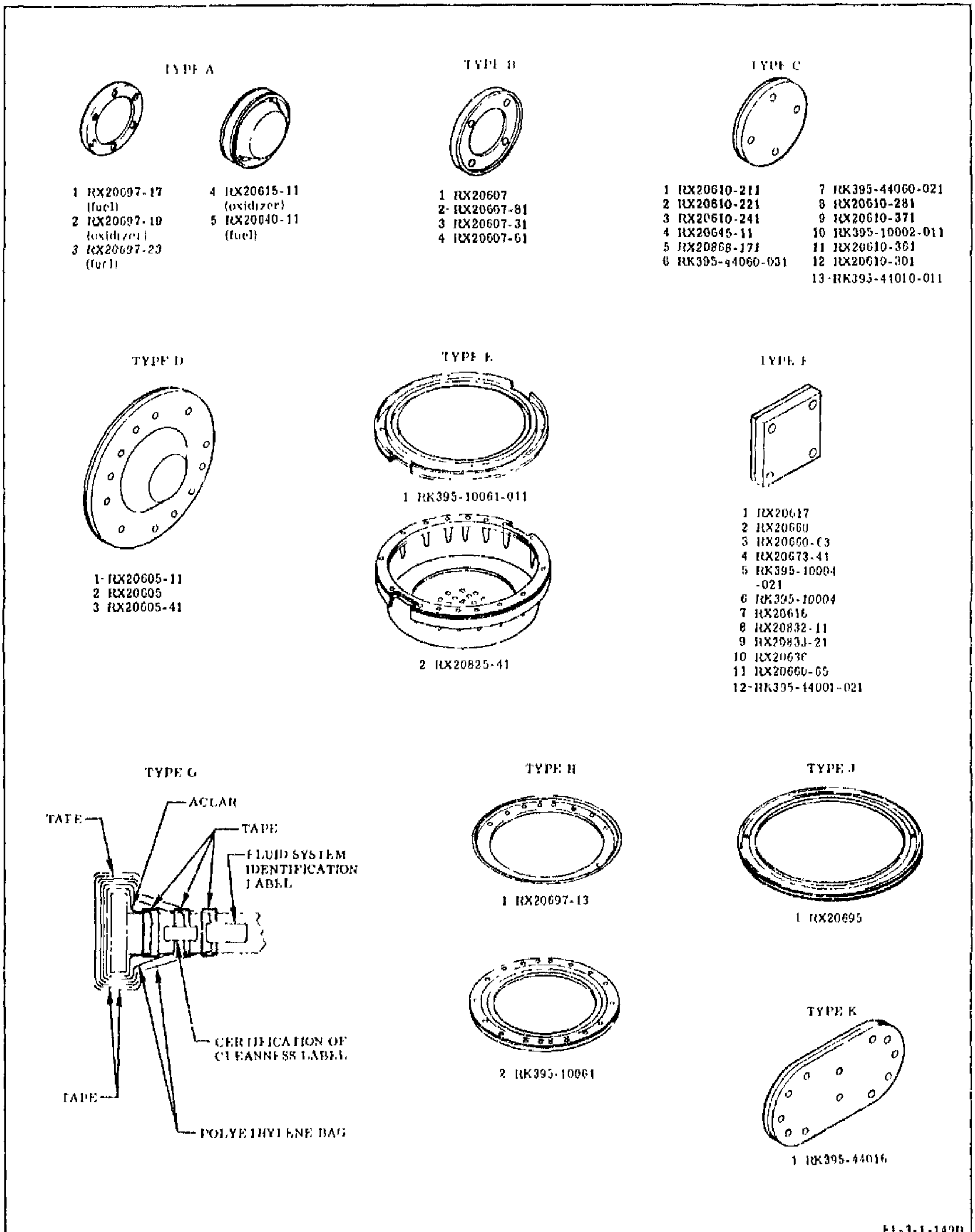


Figure 3-2A. Engine Protective Closures (Sheet 1 of 3)

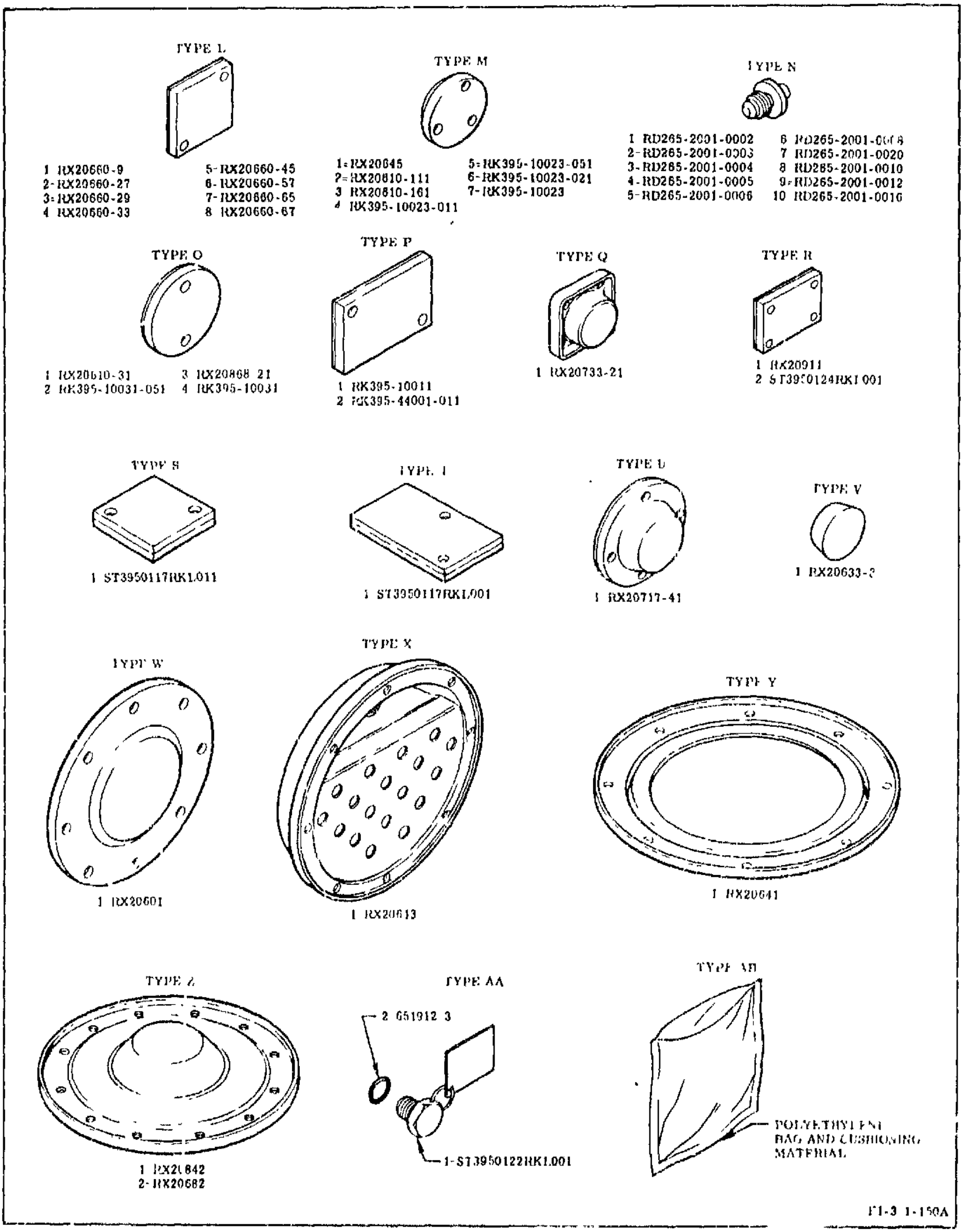


Figure 3-2A. Engine Protective Closures (Sheet 2 of 3)

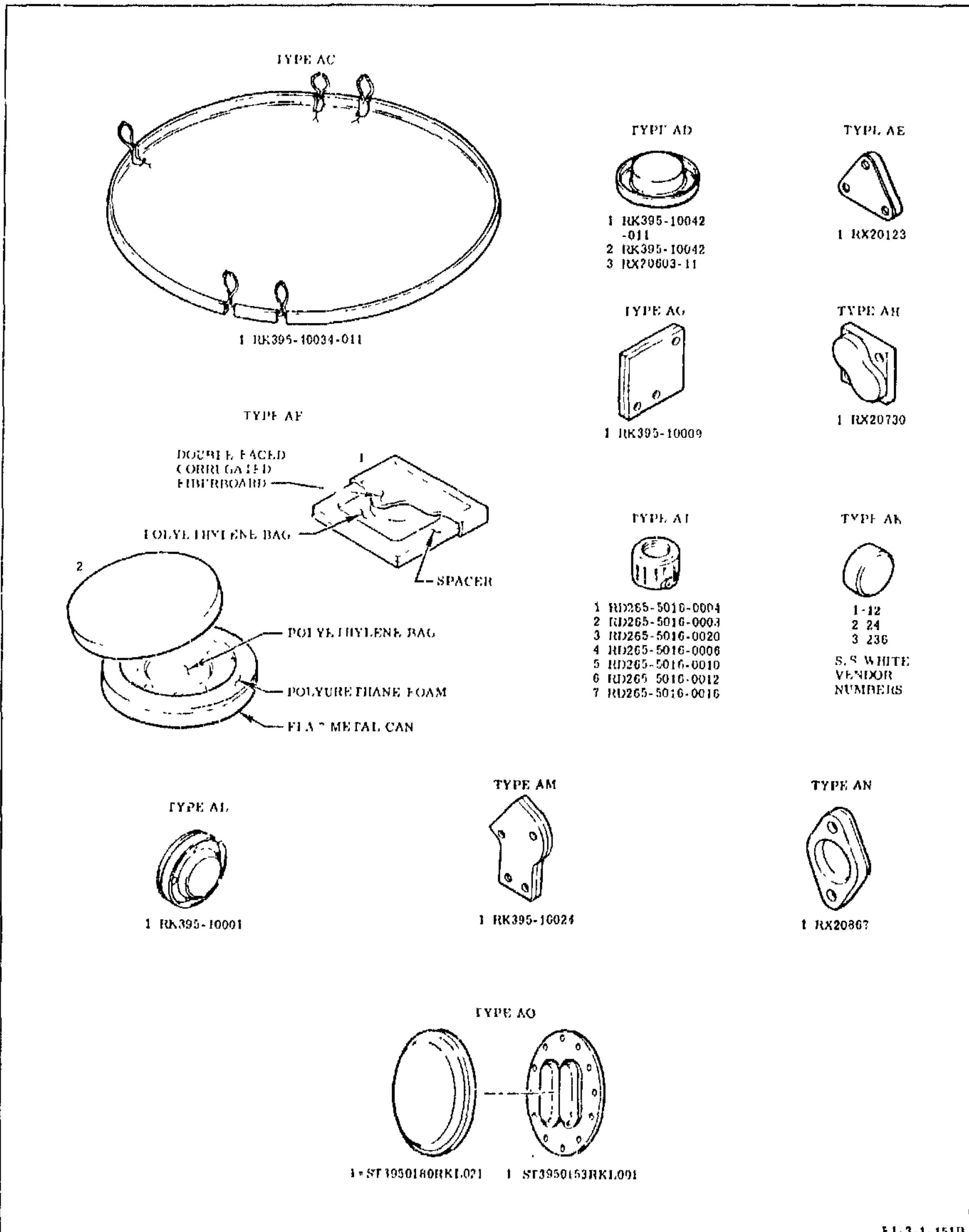
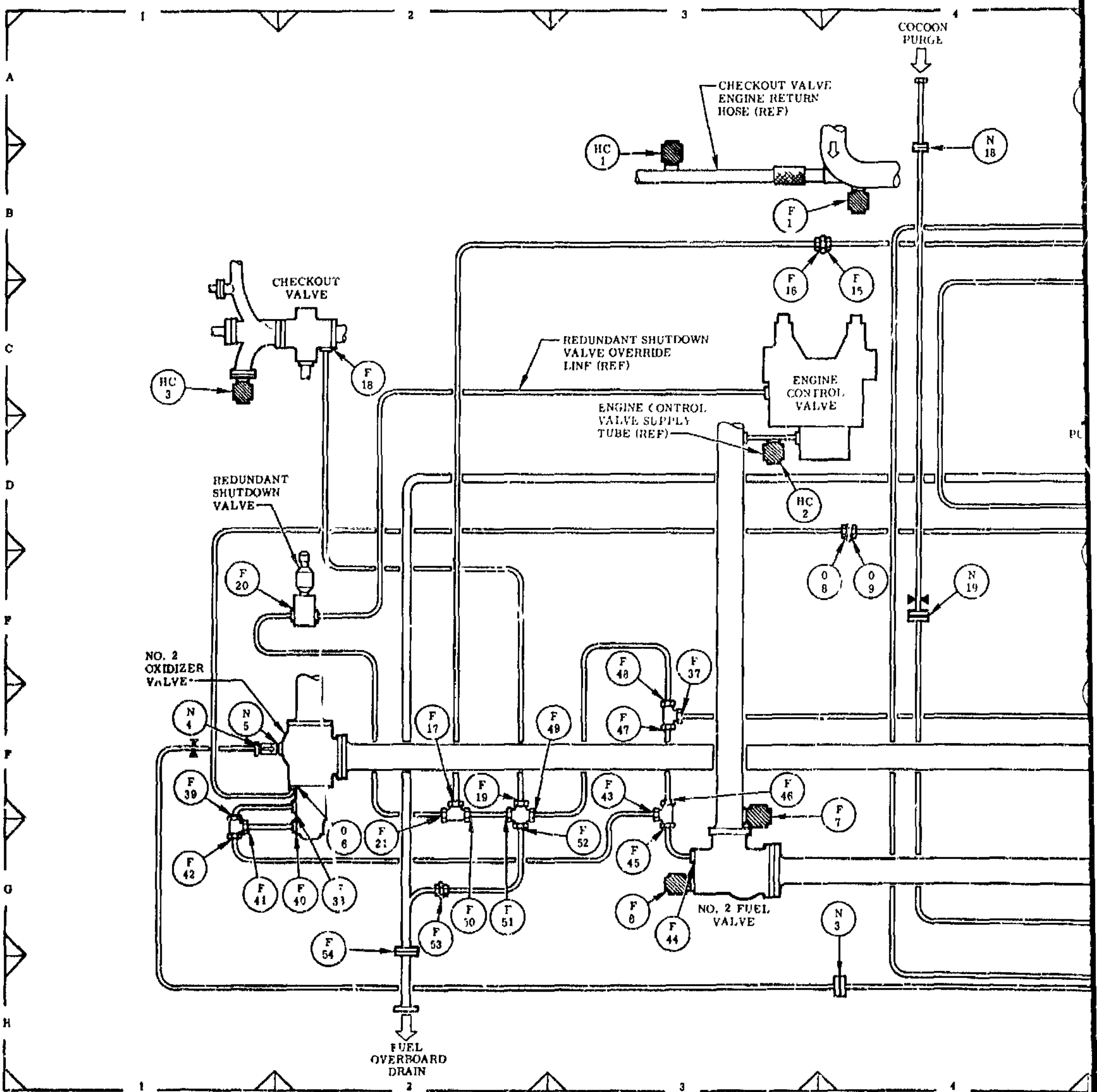


Figure 3-2A. Engine Protective Closures (Sheet 3 of 3)


COCOON PURGE
CHECKOUT VALVE ENGINE RETURN HOSE (REF)
CHECKOUT VALVE
REDUNDANT SHUTDOWN VALVE OVERRIDE LINE (REF)
ENGINE CONTROL VALVE
ENGINE CONTROL VALVE SUPPLY TUBE (REF)
REDUNDANT SHUTDOWN VALVE
NO. 2 OXIDIZER VALVE
NO. 2 FUEL VALVE
FUEL OVERBOARD DRAIN

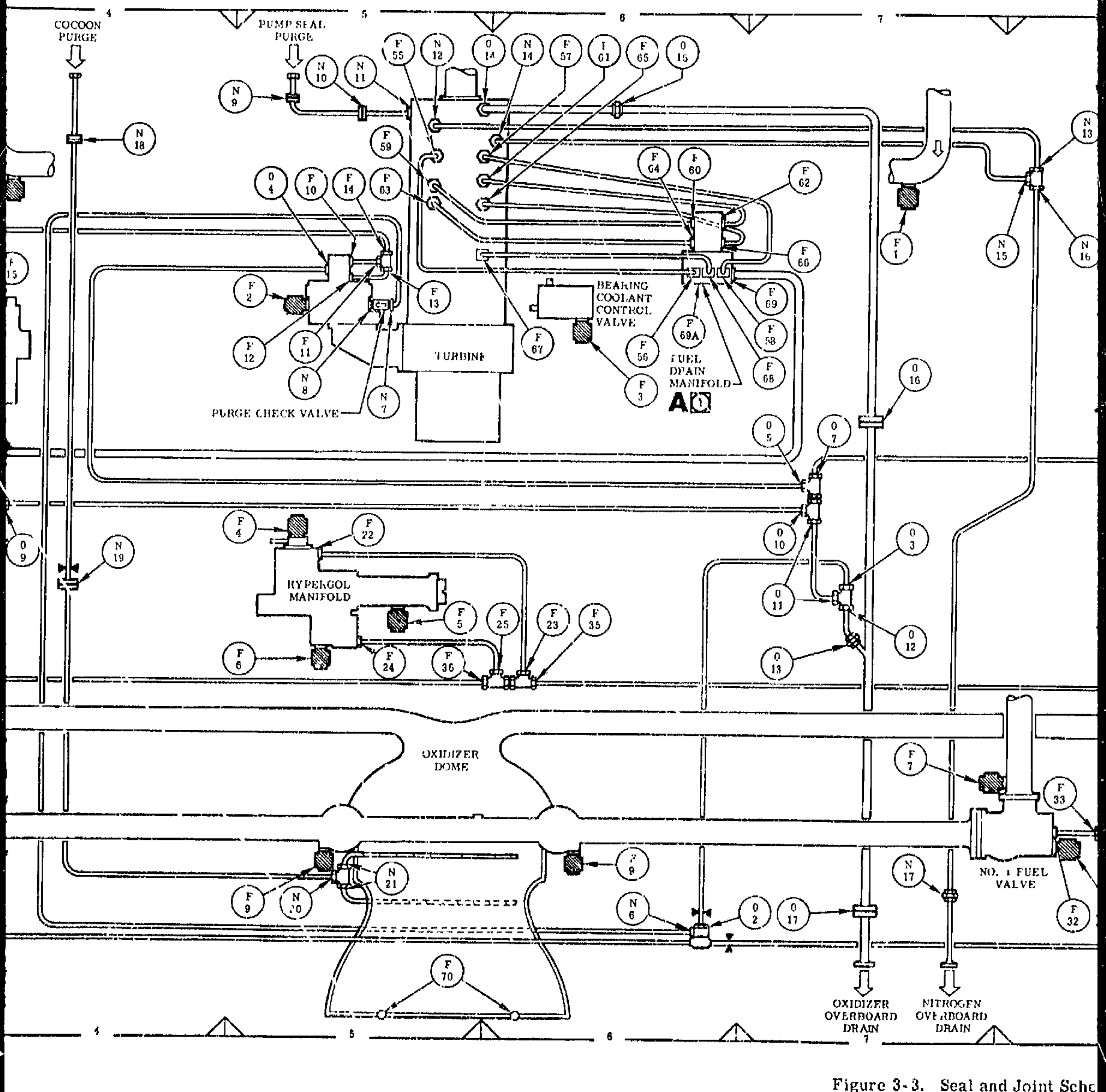


Figure 3-3. Seal and Joint Sche

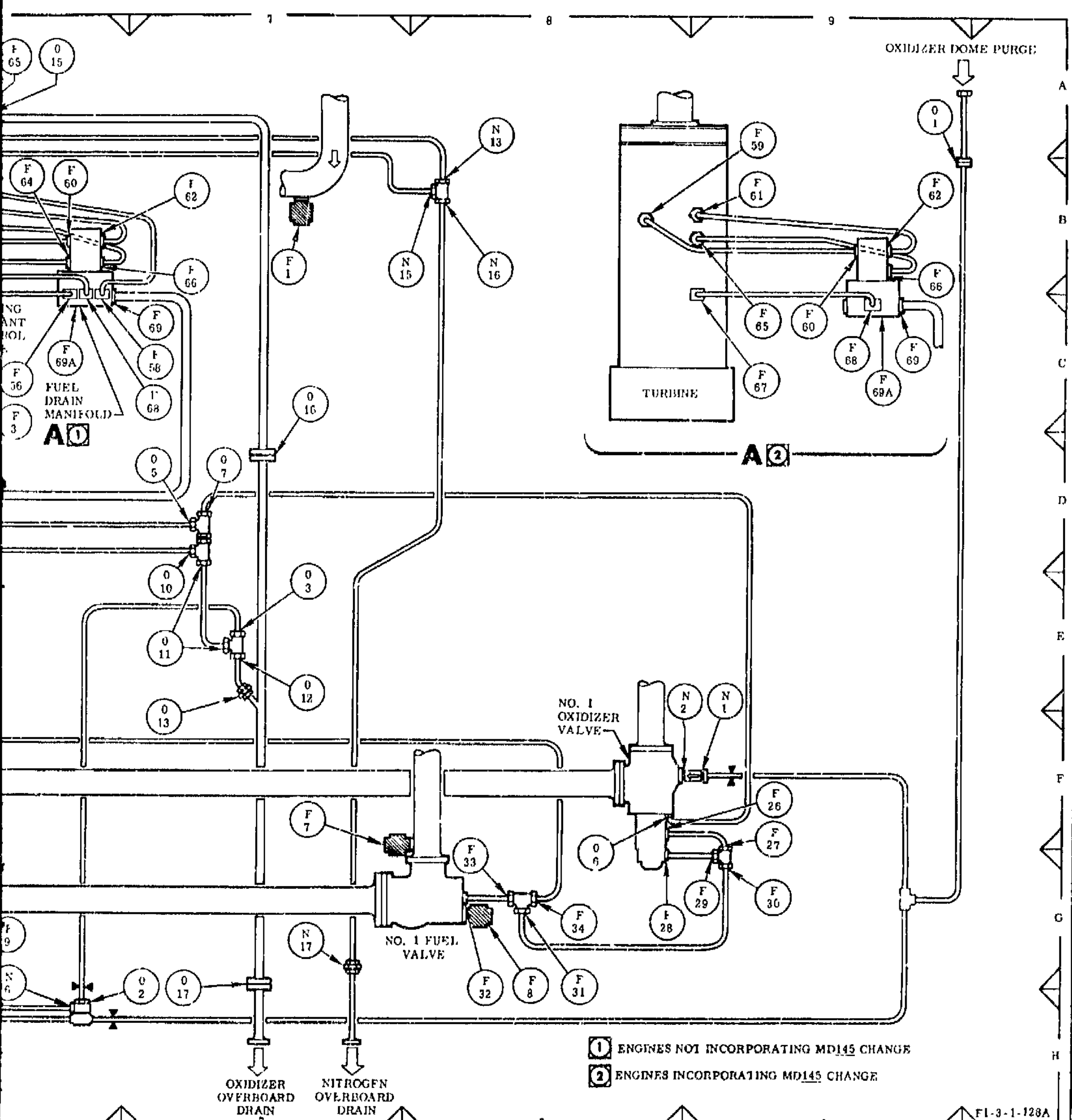


Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 1 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		OXIDIZER PURGE AND DRAIN SYSTEM		
0-1	A9	Oxidizer dome purge wrap-around hose to No. 1 oxidizer valve dome purge line[c]		
		Flange on wrap-around hose		G or L 5
		Seal plate	None	AF 1
		Flange on dome purge line		G or L 5
		Flange nuts (torque to 75 ±5 in-lb)		
0-2	H6	No. 1 oxidizer valve dome purge line to oxidizer overboard drain tube		
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 6
		Adapter on purge line	(b) A	AE
0-3	E7	Oxidizer overboard drain tube to tee		
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 6
		Tee	(b) A	AJ 2
0-4	C5	Gas generator ball valve to gas generator ball valve shaft oxidizer seal vent tube		
		Fitting on gas generator ball valve	(b) A	AJ 1
		Coupling nut on seal vent tube (torque to 135-185 in-lb)	(b) G	N 3
0-5	D7	Gas generator ball valve shaft oxidizer seal vent tube to tee		
		Coupling nut on seal vent tube (torque to 135-185 in-lb)	(b) G	N 3
		Tee	(b) A	AJ 1
0-6	F8	No. 1 oxidizer valve to No. 1 oxidizer valve actuator rod seal vent tube		
		Fitting on oxidizer valve	(b) A	AJ 1
		Coupling nut on vent tube (torque to 135-185 in-lb)	(b) G	N 3
0-6	F2	No. 2 oxidizer valve to No. 2 oxidizer valve actuator rod seal vent tube		
		Fitting on oxidizer valve	(b) A	AJ 1
		Coupling nut on vent tube (torque to 135-185 in-lb)	(b) G	N 3

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).
(c) See figure 3-1 for alinement requirement.

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 2 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		OXIDIZER PURGE AND DRAIN SYSTEM (cont)		
0-7	D7	No. 1 oxidizer valve actuator rod seal vent tube to tee		
		Coupling nut on vent tube (torque to 135-185 in-lb)	(b) G	N 3
		Tee	(b) A	AJ 1
0-8	D4	No. 2 oxidizer valve actuator rod seal vent tube to union		
		Coupling nut on vent tube (torque to 135-185 in-lb)	(b) G	N 3
		Union	(b) A	AJ 1
0-9	D4	Union to oxidizer vent overboard drain tube		
		Union	(b) A	AJ 1
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
0-10	D7	Oxidizer vent overboard drain tube to tee		
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
		Tee	(b) A	AJ 1
0-11	D7	Tee to oxidizer overboard drain tube (2 places)		
		Tee	(b) A	AJ 2
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 5
0-12	E7	Tee to oxidizer overboard drain tube		
		Tee	(b) A	AJ 2
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 5
0-13	E7	Oxidizer overboard drain tube to oxidizer overboard drain line		
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 5
		Fitting on drain line	(b) A	AJ 2
0-14	A5	Turbopump to oxidizer drain tube		
		Fitting on turbopump	(b) A	AJ 3
		Coupling nut on drain tube (torque to 500 ±25 in-lb)	(b) G	N 7

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 3 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure[(a)]
		OXIDIZER PURGE AND DRAIN SYSTEM (cont)		
0-15	A6	Oxidizer drain tube to oxidizer seal vent tube		
		Coupling nut on drain tube (torque to 1,500-1,800 in-lb)	(b) G	N 7
		Fitting on vent tube	(b) A	AJ 3
0-16	D7	Oxidizer seal vent tube to oxidizer overboard drain line		
		Flange on seal vent tube		G or F 10
		Pressure-actuated seal	None	AF 1
		Flange on overboard drain line		G or F 10
		Flange nuts (torque to 45 ±2 in-lb)		
0-17	G7	Oxidizer overboard drain line to oxidizer overboard drain line		
		Flange on overboard drain line		G or F 10
		Pressure-actuated seal	None	AF 1
		Flange on overboard drain line		G or F 10
		Flange nuts (torque to 36 ±2 in-lb)		
		FUEL PURGE AND DRAIN SYSTEM		
F-1	B7	No. 1 fuel inlet elbow drain quick-disconnect		
		Mounting boss		O 1
		Seal plate	None	AF 1
		Flanged adapter (torque bolts to 40-50 in-lb)		AK 3
		Retainer	(b) J	
		Packing	(b) J	
		Retainer	(b) J	
		Flange on quick-disconnect (torque bolts to 40-50 in-lb)		
		Cap (torque to 70-75 ft-lb)		
F-1	B4	No. 2 fuel inlet elbow drain quick-disconnect		
		Mounting boss		O 1
		Seal plate	None	AF 1
		Flanged adapter (torque bolts to 40-50 in-lb)		AK 3
		Retainer	(b) J	
		Packing	(b) J	
		Retainer	(b) J	
		Flange on quick-disconnect (torque bolts to 40-50 in-lb)		
		Cap (torque to 70-75 ft-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 4 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		FUEL PURGE AND DRAIN SYSTEM (cont)		
F-2	C5	Gas generator ball valve fuel drain quick-disconnect		
		Mounting boss		F 6
		Gasket	(b) J	
		Threaded adapter (torque to 220 ±10 in-lb)		N 5
		Gasket	(b) J	
		Body (torque to 220 ±10 in-lb)	(b) A	AJ 4
		Cap (torque to 220 ±10 in-lb)		
F-3	C6	Preservative inlet quick-disconnect		
		Flange on bearing coolant control valve		AG 1
		Retainer	(b) J	
		O-ring	(b) J	
		Retainer	(b) J	
		Flange on quick-disconnect		AK 2
		Flange bolts (torque to 40-50 in-lb)		
		Cap (torque to 30-40 ft-lb)		
F-4	E5	Ignition monitor valve control port quick-disconnect		
		Flange on ignition monitor valve		L 1
		Retainer	(b) J	
		O-ring	(b) J	
		Retainer	(b) J	
		Flange on quick-disconnect		AK 2
		Flange bolts (torque to 75 ±5 in-lb)		
		Cap (torque to 30-40 ft-lb)		
F-5	E5	Hypergol manifold drain quick-disconnect		
		Flange on hypergol manifold		F 8
		Retainer	(b) J	
		O-ring	(b) J	
		Retainer	(b) J	
		Flange on quick-disconnect		AK 1
		Flange bolts (torque to 27-30 in-lb)		
		Cap (torque to 30-40 ft-lb)		
F-6	F5	Hypergol manifold purge quick-disconnect		
		Flange on hypergol manifold		F 8
		Retainer	(b) J	
		O-ring	(b) J	
		Retainer	(b) J	
		Flange on quick-disconnect		AK 2
		Flange bolts (torque to 72-88 in-lb)		
		Cap (torque to 30-40 ft-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 5 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		FUEL PURGE AND DRAIN SYSTEM (cont)		
F-7	F7	No. 1 fuel high-pressure duct drain quick-disconnect		
		Flange on fuel high-pressure duct		O 4
		Retainer	(b) J	
		O-ring	(b) J	
		Retainer	(b) J	
		Flange on quick-disconnect		AK 2
		Flange bolts (torque to 43 ±3 in-lb)		
		Cap (torque to 30-40 ft-lb)		
F-8	G8	No. 1 fuel valve purge quick-disconnect		
		Flange on fuel valve		L 4
		Retainer	(b) J	
		Packing	(b) J	
		Retainer	(b) J	
		Flange on quick-disconnect		AK 2
		Flange bolts (torque to 35 ±2 in-lb)		
		Cap (torque to 30-40 ft-lb)		
F-8	G3	No. 2 fuel valve purge quick-disconnect		
		Flange on fuel valve		L 4
		Retainer	(b) J	
		Packing	(b) J	
		Retainer	(b) J	
		Flange on quick-disconnect		AK 2
		Flange bolts (torque to 35 ±2 in-lb)		
		Cap (torque to 30-40 ft-lb)		
F-9	G6	No. 1 fuel manifold inlet drain quick-disconnect		
		Mounting boss		F 6
		Retainer	(b) J	
		Packing	(b) J	
		Retainer	(b) J	
		Adapter (torque bolts to 75 ±5 in-lb)		N 5
		Gasket	(b) J	
		Quick-disconnect (torque to 135 ±15 in-lb)	(b) A	AJ 4
		Cap (torque to 30-40 ft-lb)		
F-9	G5	No. 2 fuel manifold inlet drain quick-disconnect		
		Mounting boss		F 6
		Retainer	(b) A	
		Packing	(b) J	
		Retainer	(b) A	
		Adapter (torque bolts to 75 ±5 in-lb)		N 5
		Gasket	(b) J	
		Quick-disconnect (torque to 135 ±15 in-lb)	(b) A	AJ 4
		Cap (torque to 30-40 ft-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 6 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure[(a)]
		FUEL PURGE AND DRAIN SYSTEM (cont)		
F-10	B5	Gas generator ball valve to gas generator ball valve actuator fuel seal vent tube		
		Fitting on actuator	(b) A	AJ 1
		Coupling nut on vent tube (torque to 135-185 in-lb)	(b) G	N 3
F-11	B5	Gas generator ball valve actuator fuel seal vent tube to tee		
		Coupling nut on vent tube (torque to 135-185 in-lb)	(b) G	N 3
		Tee	(b) A	AJ 1
F-12	C5	Gas generator ball valve to gas generator ball valve shaft fuel seal vent tube		
		Fitting on ball valve	(b) A	AJ 1
		Coupling nut on vent tube (torque to 135-185 in-lb)	(b) G	N 3
F-13	B5	Gas generator ball valve shaft fuel seal vent tube to tee		
		Coupling nut on vent tube (torque to 135-185 in-lb)	(b) G	N 3
		Tee	(b) A	AJ 1
F-14	B5	Tee to gas generator fuel seal vents tube		
		Tee	(b) A	AJ 4
		Coupling nut on vents tube (torque to 270-345 in-lb)	(b) G	N 5
F-15	B4	Gas generator fuel seal vents tube to union		
		Coupling nut on vents tube (torque to 270-345 in-lb)	(b) G	N 5
		Union	(b) A	AJ 4
F-16	B4	Union to gas generator fuel seal vents tube		
		Union	(b) A	AJ 4
		Coupling nut on vents tube (torque to 270-345 in-lb)	(b) G	N 5
F-17	F2	Gas generator fuel seal vents tube to tee		
		Coupling nut on vents tube (torque to 270-345 in-lb)	(b) G	N 5
		Tee	(b) A	AJ 4

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 7 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		FUEL PURGE AND DRAIN SYSTEM (cont)		
F-18	C2	Checkout valve to checkout valve actuator vent fuel overboard drain tube		
		Fitting on checkout valve	(b) A	AJ 4
		Coupling nut on drain tube (torque to 270-345 in-lb)	(b) G	N 5
F-19	F2	Checkout valve actuator vent fuel overboard drain tube to cross		
		Coupling nut on drain tube (torque to 270-345 in-lb)	(b) G	N 5
		Cross	(b) A	AJ 4
F-20	E2	Redundant shutdown valve to engine control valve override drain tube		
		Fitting on redundant shutdown valve	(b) A	AJ 1
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
F-21	F2	Engine control valve override drain tube to tee		
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
		Tee	(b) A	AJ 1
F-22	E5	Ignition monitor valve to ignition monitor valve drain tube		
		Fitting on ignition monitor valve	(b) A	AJ 4
		Coupling nut on drain tube (torque to 270-345 in-lb)	(b) G	N 5
F-23	F6	Ignition monitor valve drain tube to tee		
		Coupling nut on drain tube (torque to 270-345 in-lb)	(b) G	N 5
		Tee	(b) A	AJ 4
F-24	E5	Igniter fuel valve to igniter fuel valve vent overboard drain tube		
		Fitting on igniter fuel valve	(b) A	AJ 4
		Coupling nut on drain tube (torque to 270-345 in-lb)	(b) G	N 5
F-25	F6	Igniter fuel valve vent overboard drain tube to tee		
		Coupling nut on drain tube (torque to 270-345 in-lb)	(b) G	N 5
		Tee	(b) A	AJ 4

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 8 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure(a)
		FUEL PURGE AND DRAIN SYSTEM (cont)		
F-26	F8	No. 1 oxidizer valve to No. 1 oxidizer valve actuator seal fuel drain tube		
		Fitting on oxidizer valve	(b) A	AJ 1
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
F-27	F9	No. 1 oxidizer valve actuator seal fuel drain tube to tee		
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
		Tee	(b) A	AJ 1
F-28	G8	No. 1 oxidizer valve to No. 1 oxidizer valve shaft seal fuel drain tube		
		Fitting on oxidizer valve	(b) A	AJ 1
		Coupling nut on drain tube (torque to 135-185 in-lb)		
F-29	G9	No. 1 oxidizer valve shaft seal fuel drain tube to tee		
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
		Tee	(b) A	AJ 1
F-30	G9	Tee to No. 1 oxidizer valve fuel overboard drain tube		
		Tee	(b) A	AJ 4
		Coupling nut on drain tube (torque to 270-345 in-lb)	(b) G	N 5
F-31	G8	No. 1 oxidizer valve fuel overboard drain tube to tee		
		Coupling nut on drain tube (torque to 270-345 in-lb)	(b) G	N 5
		Tee	(b) A	AJ 4
F-32	G8	No. 1 fuel valve to No. 1 fuel valve position transducer vent drain tube		
		Fitting on fuel valve	(b) A	AJ 1
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
F-33	G8	No. 1 fuel valve position transducer vent drain tube to tee		
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
		Tee	(b) A	AJ 1

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 9 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure[(a)]
		FUEL PURGE AND DRAIN SYSTEM (cont)		
F-34	G8	Tee to fuel overboard drain tube (No. 1 side)		
		Tee	(b) A	AJ 2
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
F-35	F6	Fuel overboard drain tube to tee (No. 1 side)		
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
		Tee	(b) A	AJ 2
F-36	F6	Tee to fuel overboard drain tube		
		Tee	(b) A	AJ 5
		Coupling nut on drain tube (torque to 650-750 in-lb)	(b) G	N 8
F-37	F3	Fuel overboard drain tube to tee		
		Coupling nut on drain tube (torque to 650-750 in-lb)	(b) G	N 8
		Tee	(b) A	AJ 5
F-38	F-2	No. 2 oxidizer valve to No. 2 oxidizer valve actuator seal fuel drain tube		
		Fitting on oxidizer valve	(b) A	AJ 1
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
F-39	F1	No. 2 oxidizer valve actuator seal fuel drain tube to tee		
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
		Tee	(b) A	AJ 1
F-40	G2	No. 2 oxidizer valve to No. 2 oxidizer valve shaft seal fuel drain tube		
		Fitting on oxidizer valve	(b) A	AJ 1
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
F-41	G1	No. 2 oxidizer valve shaft seal fuel drain tube to tee		
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
		Tee	(b) A	AJ 1

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 10 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		FUEL PURGE AND DRAIN SYSTEM (cont)		
F-42	G1	Tee to No. 2 oxidizer valve fuel overboard drain tube		
		Tee	(b) A	AJ 4
		Coupling nut on drain tube (torque to 270-345 in-lb)	(b) G	N 5
F-43	F3	No. 2 oxidizer valve fuel overboard drain tube to tee		
		Coupling nut on drain tube (torque to 270-345 in-lb)	(b) G	N 5
		Tee	(b) A	AJ 4
F-44	G3	No. 2 fuel valve to No. 2 fuel valve position transducer vent drain tube		
		Fitting on fuel valve	(b) A	AJ 1
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
F-45	F3	No. 2 fuel valve position transducer vent drain tube to tee		
		Coupling nut on drain tube (torque to 135-185 in-lb)	(b) G	N 3
		Tee	(b) A	AJ 1
F-46	F3	Tee to fuel overboard drain tube (No. 2 side)		
		Tee	(b) A	AJ 2
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
F-47	F3	Fuel overboard drain tube to tee		
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
		Tee	(b) A	AJ 2
F-48	F3	Tee to fuel overboard drain tube		
		Tee	(b) A	AJ 6
		Coupling nut on drain tube (torque to 900-1,100 in-lb)	(b) G	N 9
F-49	F2	Fuel overboard drain tube to cross		
		Coupling nut on drain tube (torque to 900-1,100 in-lb)	(b) G	N 9
		Cross	(b) A	AJ 6

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 11 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure(a)
		FUEL PURGE AND DRAIN SYSTEM (cont)		
F-50	F2	Tee to fuel overboard drain tube		
		Tee	(b) A	AJ 2
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
F-51	F2	Fuel overboard drain tube to cross		
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
		Cross	(b) A	AJ 2
F-52	F2	Cross to fuel overboard drain tube		
		Cross	(b) A	AJ 5
		Coupling nut on drain tube (torque to 1,200-1,400 in-lb)	(b) G	N 10
F-53	G2	Fuel overboard drain tube to fuel overboard drain line		
		Coupling nut on drain tube (torque to 1,200-1,400 in-lb)	(b) G	N 10
		Fitting on drain line	(b) A	AJ 5
F-54	G2	Fuel overboard drain line to fuel overboard drain line		
		Flange on drain line		G or F 5
		Seal plate	None	AF 1
		Flange on drain line		G or F 5
		Flange nuts (torque to 36 ±2 in-lb)		
F-55(d)	B5	Turbopump to No. 2 bearing lube drain line		
		Fitting on turbopump		AJ 5
		Coupling nut on drain line (torque to 450-525 in-lb)(e)	None	N 8
F-56(d)	B6	No. 2 bearing lube drain line to fuel drain manifold		
		Flange on drain line		G or F 11
		Seal plate	None	AF 1
		Flange on drain manifold		G or F 11
		Flange bolts (torque to 45 ±2 in-lb)		
F-57(d)	B6	Turbopump to No. 1 bearing lube drain tube		
		Fitting on turbopump	None	AJ 5
		Coupling nut on drain tube (torque to 450-525 in-lb)(e)	None	N 8

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).
(d) Engines not incorporating MD145 change.
(e) Torque above running torque obtained during last one-half turn of coupling nut before seating of tube flare. Running torque must be 200-600 in-lb.

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 12 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		FUEL PURGE AND DRAIN SYSTEM (cont)		
F-58[d]	B6	No. 1 bearing lube drain tube to fuel drain manifold		
		Flange on drain tube		G or F 11
		Seal plate	None	AF 1
		Flange on drain manifold		G or F 11
		Flange bolts (torque to 45 ±2 in-lb)		
F-59	B5 B8	Turbopump to primary fuel seal drain tube (No. 2 side)		
		Fitting on turbopump	(b) A	AJ 2
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
F-60	B6 B9	Primary fuel seal drain tube (No. 2 side) to fuel drain manifold		
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
		Fitting on drain manifold	(b) A	AJ 2
F-61	B6 B9	Turbopump to primary fuel seal drain tube (No. 1 side)		
		Fitting on turbopump	(b) A	AJ 2
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
F-62	B6 B9	Primary fuel seal drain tube (No. 1 side) to fuel drain manifold		
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
		Fitting on drain manifold	(b) A	AJ 2
F-63[d]	B5	Turbopump to fuel inlet seal drain tube		
		Fitting on turbopump	(b) A	AJ 2
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
F-64[d]	B6	Fuel inlet seal drain tube (No. 2 side) to fuel drain manifold		
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
		Fitting on drain manifold	(b) A	AJ 2

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).
(d) Engines not incorporating MD145 change.

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 13 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure[(a)]
		FUEL PURGE AND DRAIN SYSTEM (cont)		
F-65	B6 B9	Turbopump to fuel inlet seal drain tube (No. 1 side)		
		Fitting on turbopump	(b) A	AJ 2 AJ 4
		Coupling nut on drain tube[(d)] (torque to 450-525 in-lb) (torque to 270-345 in-lb)	(b) G	N 6 N 5
F-66	B6 B9	Fuel inlet seal drain tube (No. 1 side) to fuel drain manifold		
		Coupling nut on drain tube[(d)] (torque to 450-525 in-lb) (torque to 270-345 in-lb)	(b) G	AJ 2 AJ 4
		Fitting on drain manifold	(b) A	N 6 N 5
F-67	B6 B9	Turbopump to turbine bearing lube drain hose		
		Flange on turbopump		L 7
		Seal plate	None	AF 1
		Flange on drain hose		G or L 4
		Flange bolts (torque to 35 ±2 in-lb)		
F-68	B6 C9	Turbine bearing lube drain hose to fuel drain manifold		
		Flange on drain hose		G or L 7
		Seal plate	None	AF 1
		Flange on drain manifold		L 7
		Flange bolts (torque to 45 ±2 in-lb)		
F-69	B6 C9	Fuel drain manifold to fuel overboard drain line		
		Flange on drain manifold		F 5
		Seal plate	None	AF 1
		Flange on drain line		G or F 5
		Flange bolts (torque to 45 ±2 in-lb)		
F-69A	B6 C9	Cover plate on fuel drain manifold		
		Flange on drain manifold		F 5
		Seal plate	None	AF 1
		Cover plate (torque bolts to 45 ±2 in-lb)		
F-70	H5 H6	Thrust chamber drain plugs (4 places)		
		Drain port		
		Gasket	None	
		Adapter		N 2
		K-seal	None	
		Drain plug (torque to 10 ±2 ft-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).
(d) Engines not incorporating MD145 change.

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 14 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		NITROGEN PURGE AND DRAIN SYSTEM		
N-1	F9	No. 1 oxidizer valve dome purge tube to No. 1 oxidizer dome purge check valve		
		Flange on purge tube		G or L 6
		Orifice plate	None	AF 2
		Flange on check valve		L 6
		Flange nuts (torque to 36 ±3 in-lb)		
N-2	F9	No. 1 oxidizer dome purge check valve to No. 1 oxidizer valve		
		Flange on check valve		AD 1
		Seal plate	None	AF 1
		Flange on oxidizer valve		O 3
		Flange bolts (torque to 110-130 in-lb)		
N-3	H4	No. 1 oxidizer valve dome purge tube to No. 2 oxidizer dome purge line		
		Flange on purge tube		G or L 8
		Seal plate	None	AF 1
		Flange on purge line		G or L 8
		Flange nuts (torque to 36 ±3 in-lb)		
N-4	F1	No. 2 oxidizer valve dome purge line to No. 2 oxidizer dome purge check valve		
		Flange on purge line		G or L 6
		Orifice plate	None	AF 2
		Flange on check valve		L 6
		Flange nuts (torque to 36 ±3 in-lb)		
N-5	F2	No. 2 oxidizer valve dome purge check valve to No. 2 oxidizer valve		
		Flange on check valve		AD 1
		Seal plate	None	AF 1
		Flange on oxidizer valve		O 3
		Flange bolts (torque to 110-130 in-lb)		
N-6	H6	No. 1 oxidizer valve dome purge line to gas generator oxidizer purge tube		
		Flange on purge line		G or F 7
		Seal plates (2 reqd)	None	AF 1
		Manifold flange		F 7
		Attach nuts (torque to 75 ±5 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 15 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		NITROGEN PURGE AND DRAIN SYSTEM (cont)		
N-7	C5	Gas generator oxidizer purge tube to purge check valve		
		Flange on purge tube		G or L 6
		Seal plate	None	AF 1
		Flange on check valve		G or F 4
		Flange nuts (torque to 100 ±5 in-lb)		
N-8	C5	Purge check valve to gas generator ball valve		
		Flange on check valve		G or AE 1
		Seal plate	None	AF 1
		Flange on ball valve		AE 1
		Flange nuts (torque to 45 ±5 in-lb)		
N-9	A5	Turbopump oxidizer seal purge wrap-around hose to pump seal purge line		
		Flange on wrap-around hose		G or L 6
		Seal plate	None	AF 1
		Flange on purge line		G or L 6
		Flange nuts (torque to 75 ±5 in-lb)		
N-10	A5	Pump seal purge line to oxidizer pump seal purge tube (pump end)		
		Flange on purge line		G or L 6
		Seal plate	None	AF 1
		Flange on purge tube		G or L 6
		Flange nuts (torque to 36 ±3 in-lb)		
N-11	A5	Pump seal purge tube (pump end) to turbopump		
		Flange on purge tube		G or M 5
		Seal plate	None	AF 1
		Flange on turbopump		M 5
		Flange nuts (torque to 36 ±3 in-lb)		
N-12	A5	Turbopump to nitrogen purge overboard drain tube (2 places)		
		Fitting on turbopump	(b) A	AJ 4
		Coupling nut on drain tube (torque to 270-345 in-lb)	(b) G	N 5
N-13	B8	Nitrogen purge overboard drain tube to tee		
		Coupling nut on drain tube (torque to 270-345 in-lb)	(b) G	N 5
		Tee	(b) A	AJ 4

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 16 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure[a]
		NITROGEN PURGE AND DRAIN SYSTEM (cont)		
N-14	A6	Turbopump to nitrogen purge overboard drain tube		
		Fitting on turbopump	(b) A	AJ 2
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
N-15	B3	Nitrogen purge overboard drain tube to tee		
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
		Tee	(b) A	AJ 2
N-16	B8	Tee to nitrogen purge overboard drain tube		
		Tee	(b) A	AJ 2
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
N-17	G7	Nitrogen purge overboard drain tube to nitrogen purge overboard drain tube		
		Coupling nut on drain tube (torque to 450-525 in-lb)	(b) G	N 6
		Fitting on drain tube	(b) A	AJ 2
N-18	B4	Cocoon purge wrap-around hose to purge tube		
		Flange on wrap-around hose		G or L 4
		Seal plate	None	AF 1
		Flange on purge tube		G or L 4
		Flange nuts (torque to 75 ±5 in-lb)		
N-19	E4	Purge tube to cocoon purge tube		
		Flange on purge tube		G or L 4
		Orifice plate	None	AF 2
		Flange on cocoon purge tube		G or L 4
		Flange nuts (torque to 38 ±3 in-lb)		
N-20	G5	Cocoon purge tube to tee		
		Coupling nut on purge tube (torque to 700-800 in-lb)[f]	(b) G	N 8
		Tee	(b) A	AJ 5
N-21	G5	Tee to cocoon purge tube (2 places)		
		Tee	(b) A	AJ 5
		Coupling nut on purge tube (torque to 700-800 in-lb)[f]	(b) G	N 8

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).
(f) Above maximum recorded running torque.

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 17 of 18)

Code	Zone	Joint Description	Lube and Method	Type Closure(a)
		HYDRAULIC CONTROL PURGE AND DRAIN SYSTEM		
HC-1	B3	Checkout valve engine return hose drain quick-disconnect		
		Flange on return hose		G
		Retainer	(b)J	
		O-ring	(b)J	
		Retainer	(b)J	
		Flange on quick-disconnect		AK 2
		Flange nut (torque to 45 ±5 in-lb)		
HC-2	D3	Engine control valve supply tube drain quick-disconnect		
		Flange on supply tube		AH 1
		Retainer	(b)J	
		O-ring	(b)J	
		Retainer	(b)J	
		Flange on quick-disconnect		AK 2
		Flange bolt (torque to 80 ±5 in-lb)		
HC-3	C1	Actuator return line drain quick-disconnect		
		Flange on return line		G or L 4
		Retainer	(b)J	
		O-ring	(b)J	
		Retainer	(b)J	
		Flange on quick-disconnect		AK 2
		Flange nuts (torque to 45 ±5 in-lb)		

(a) See figure 3-2A for closure description and R-3896-4 for attaching hardware.
(b) Lubricant grease RB0140-012 (Rocketdyne).

Figure 3-3. Seal and Joint Schematic for Engine Purge and Overboard Drain Systems (Sheet 18 of 18)

3-7A. ENGINE LINES SUPPORTS, CLAMPS, AND BRACKETS.

3-7B. Certain engine lines supports, clamps, and brackets are included in the specific component removal and installation procedures in this section. Figure 3-3-1 contains the locations, arrangements, and torque values for this hardware. The seal and joint information in paragraph 3-3 may be used in conjunction with this information for removing and installing various engine lines that are not covered by or within specific procedures in this section. The safety, contamination and damage prevention, torquing, and safetywiring requirements outlined in section I are applicable.

3-8. INSTRUMENTATION AND PURGE PORT PLUG AND SEAL REQUIREMENTS.

3-9. The port location, plug, and seal requirements for all numbered ports, including those no longer used for instrumentation purposes, are listed in figure 3-3A. Specified lubricating procedures (methods) are outlined in section I.

3-10. SEAL MONITORING PORT PLUG AND SEAL REQUIREMENTS.

3-11. The port location, plug, and seal requirements for seal monitoring ports are listed in figure 3-3B. Specified lubricating procedures (methods) are outlined in section I.

3-12. REMOVING AND INSTALLING ELECTRICAL HARNESSES AND CABLES.

3-13. The following procedures outline the removal and installation or replacement of electrical harnesses and cables. Paragraphs 3-14 and 3-15 outline the procedures for disconnecting and connecting electrical connectors to prevent damage to plugs, receptacles, and harnesses, including torque values and acceptance criteria and damage limits for plugs. (See figures 3-4 and 3-5.) Paragraphs 3-16 and 3-17 outline the procedures for disconnecting and connecting electrical plugs to flight instrumentation transducers. (See figure 3-6.)

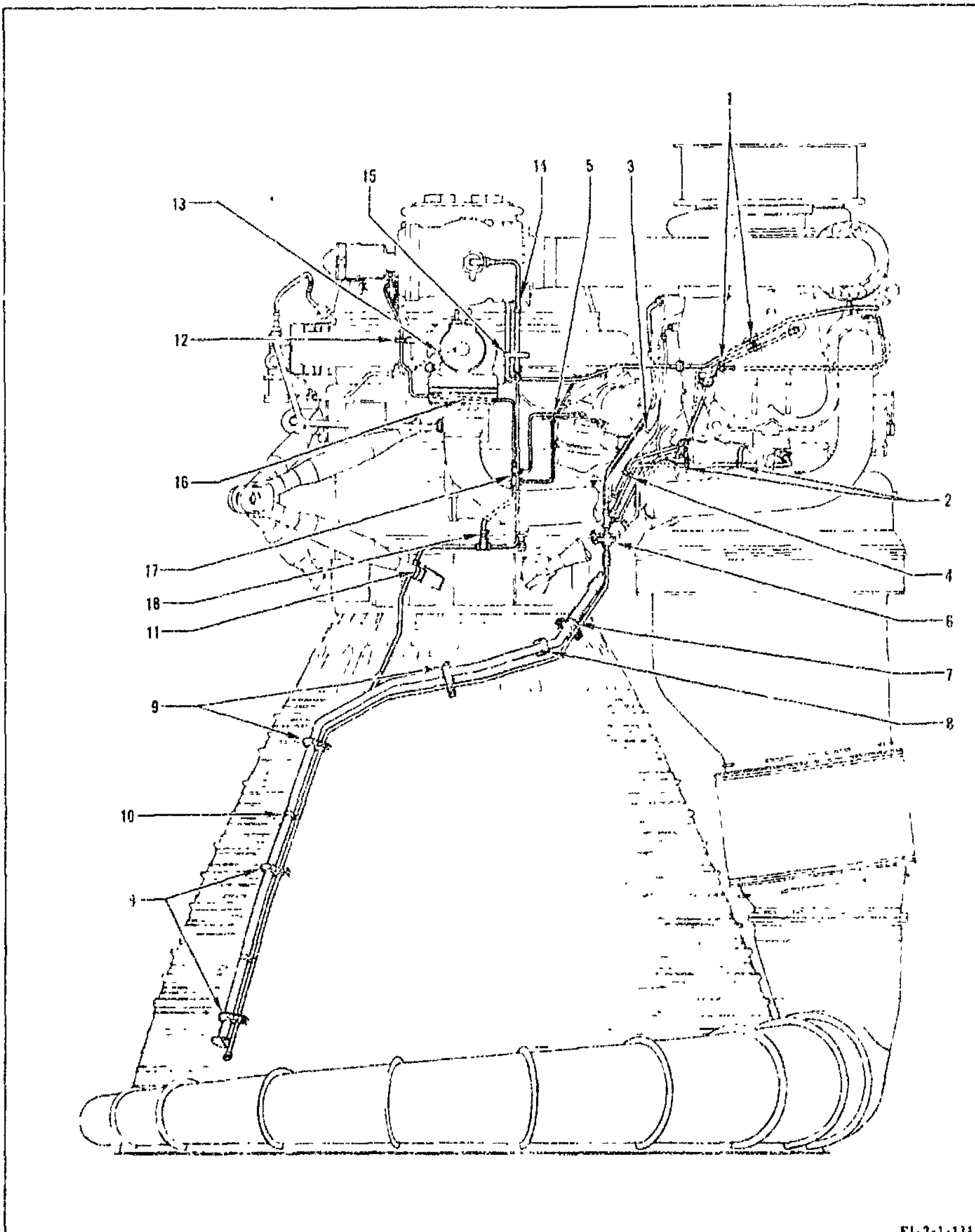
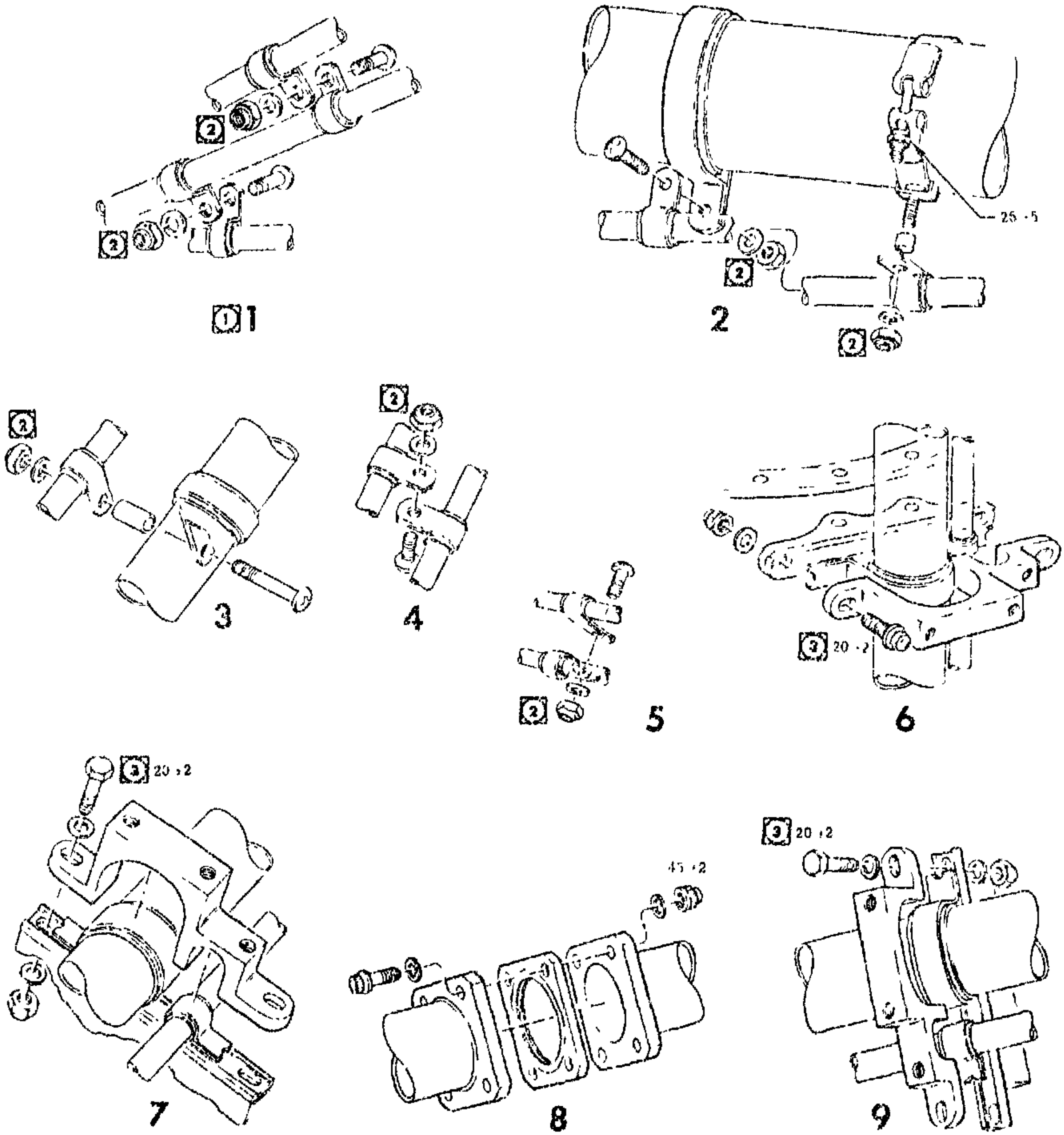


Figure 3-3-1. Engine Lines Supports, Clamps, and Brackets (Sheet 1 of 8)

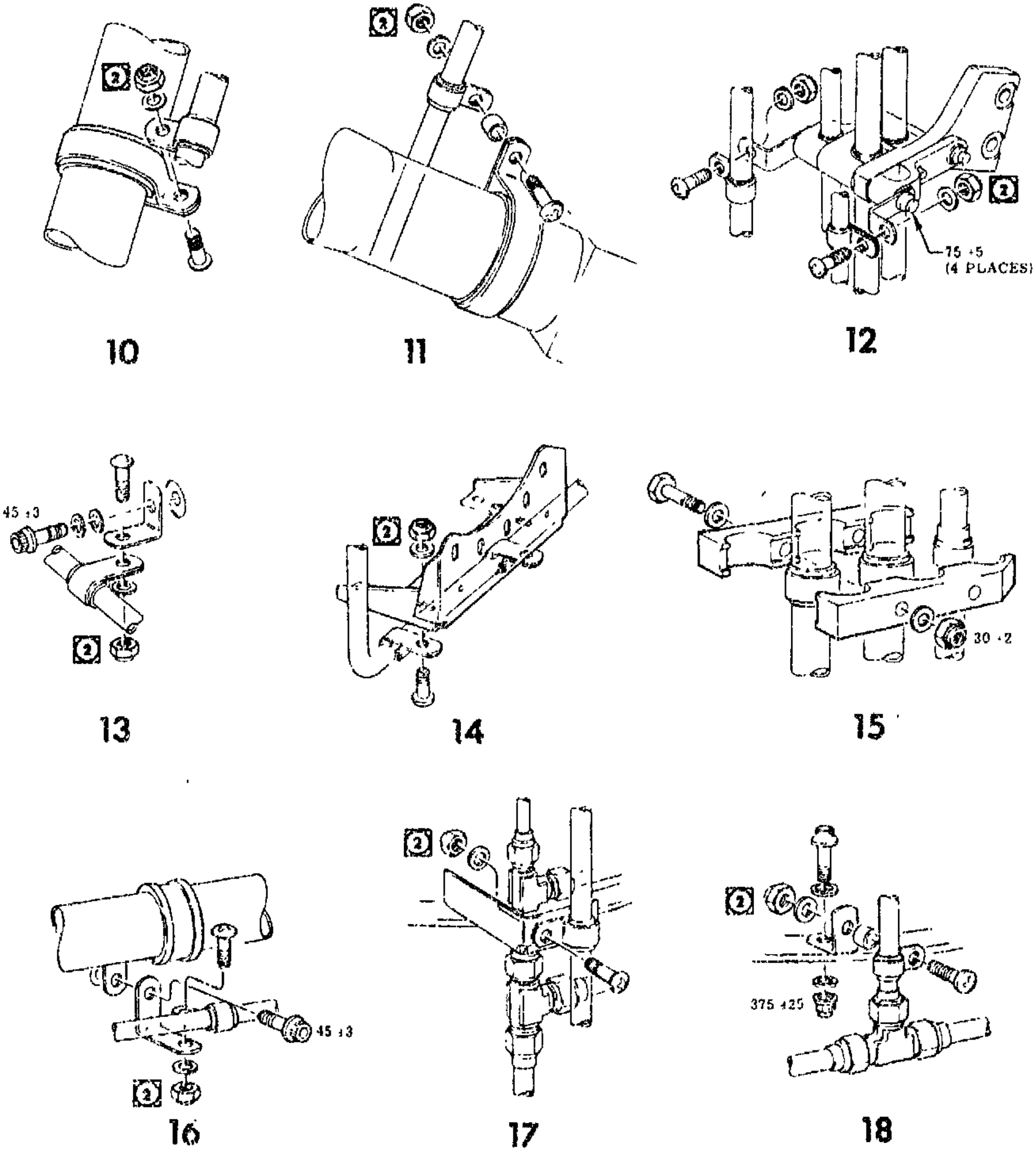


1 ENGINES NOT INCORPORATING MD145 CHANGE
2 8-10 IN-LB
3 ABOVE RUNNING TORQUE OF NUT

NOTE
ALL TORQUE VALUES ARE IN INCH-POUNDS.

F1-3-1-139

Figure 3-3-1. Engine Lines Supports, Clamps, and Brackets (Sheet 2 of 8)



NOTE

ALL TORQUE VALUES ARE IN INCH-POUNDS.

2 8-10 IN-LB

FI-3-1-140

Figure 3-3-1. Engine Lines Supports, Clamps, and Brackets (Sheet 3 of 8)

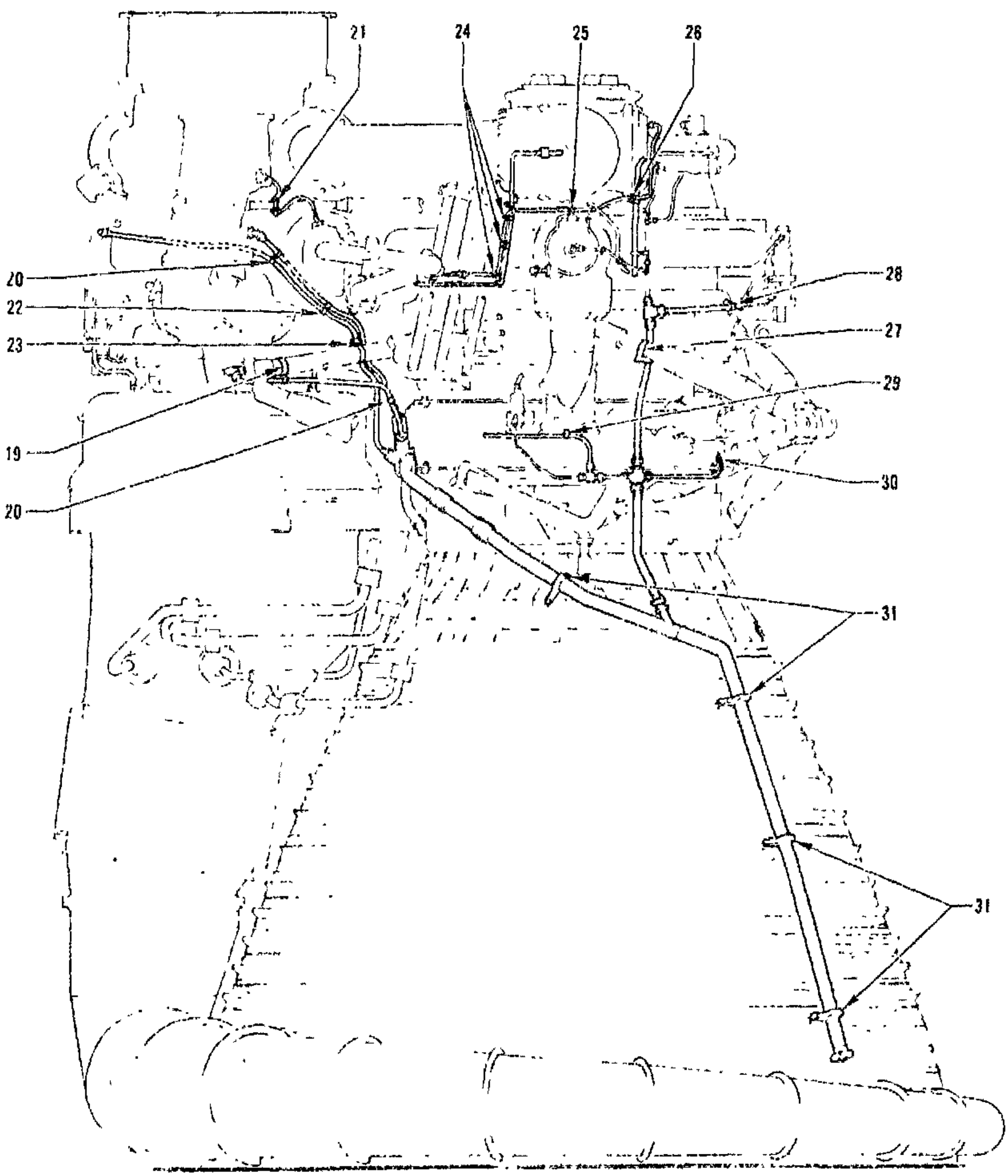
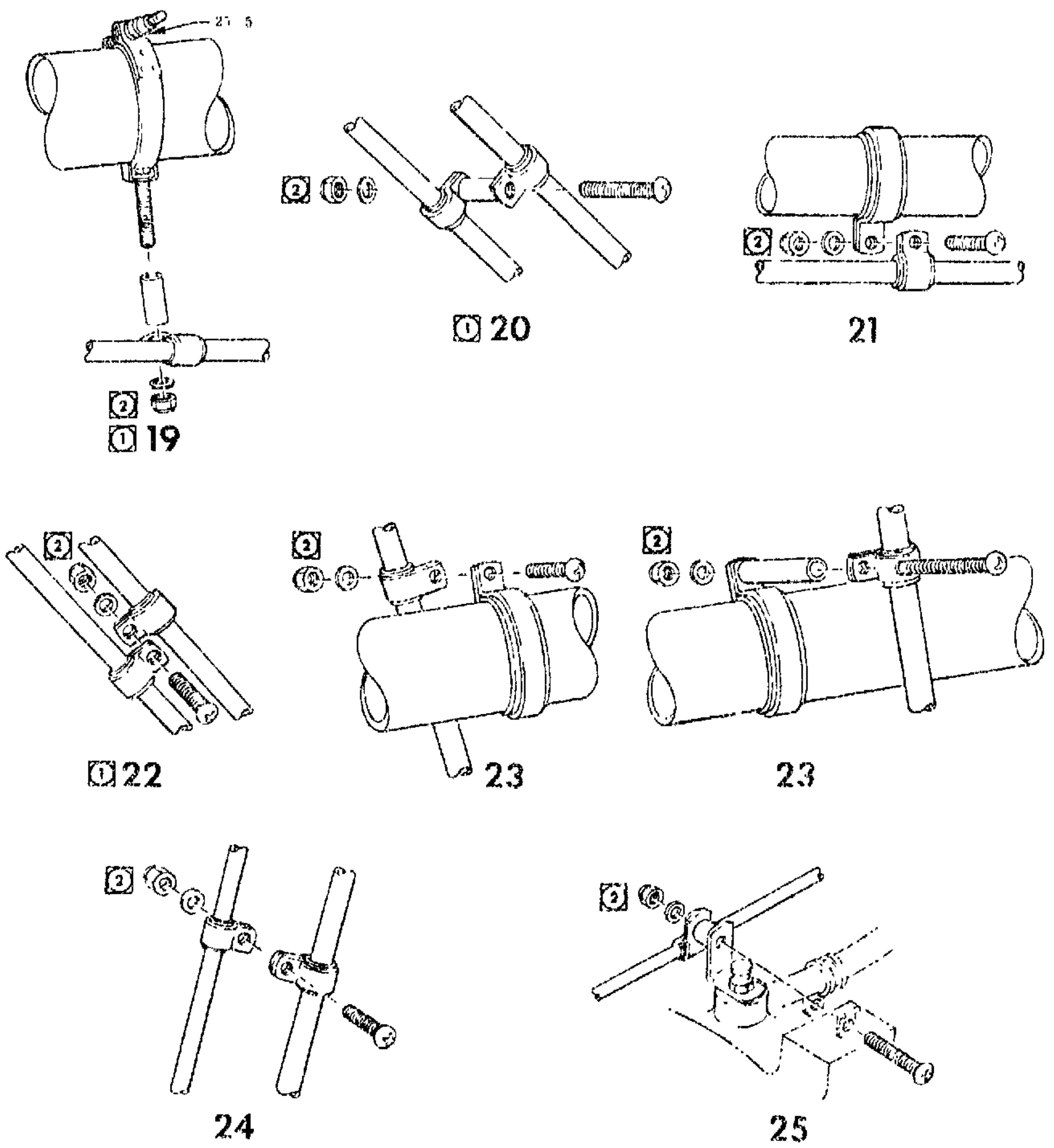


Figure 3-3-1. Engine Lines Supports, Clamps, and Brackets (Sheet 4 of 8)



1 ENGINES NOT INCORPORATING MD145 CHANGE

2 8-10 IN-LB

NOTE

ALL TORQUE VALUES ARE IN INCH-POUNDS.

F1-3-1-141

Figure 3-3-1. Engine Lines Supports, Clamps, and Brackets (Sheet 5 of 8)

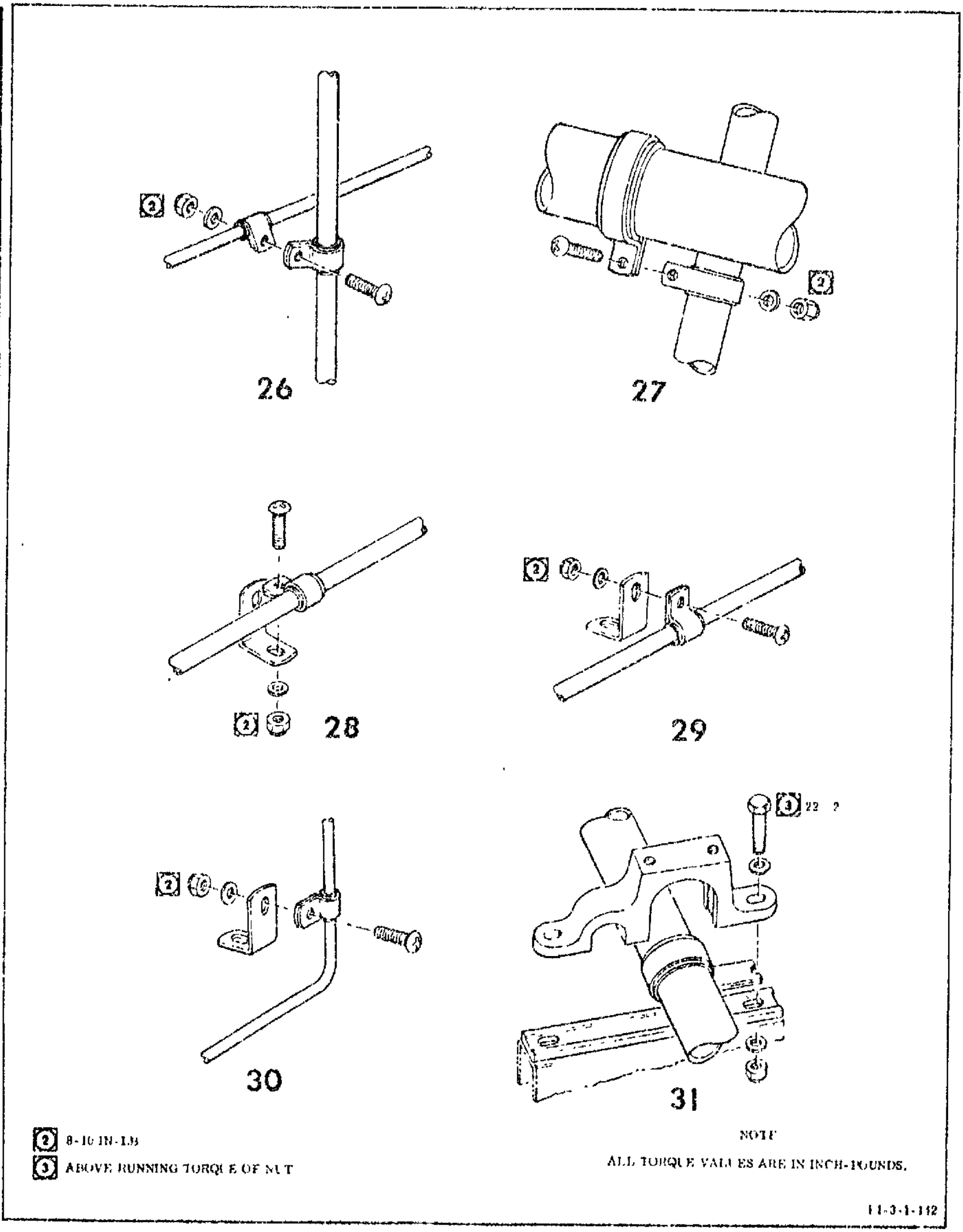


Figure 3-3-1. Engine Lines Supports, Clamps, and Brackets (Sheet 6 of 8)

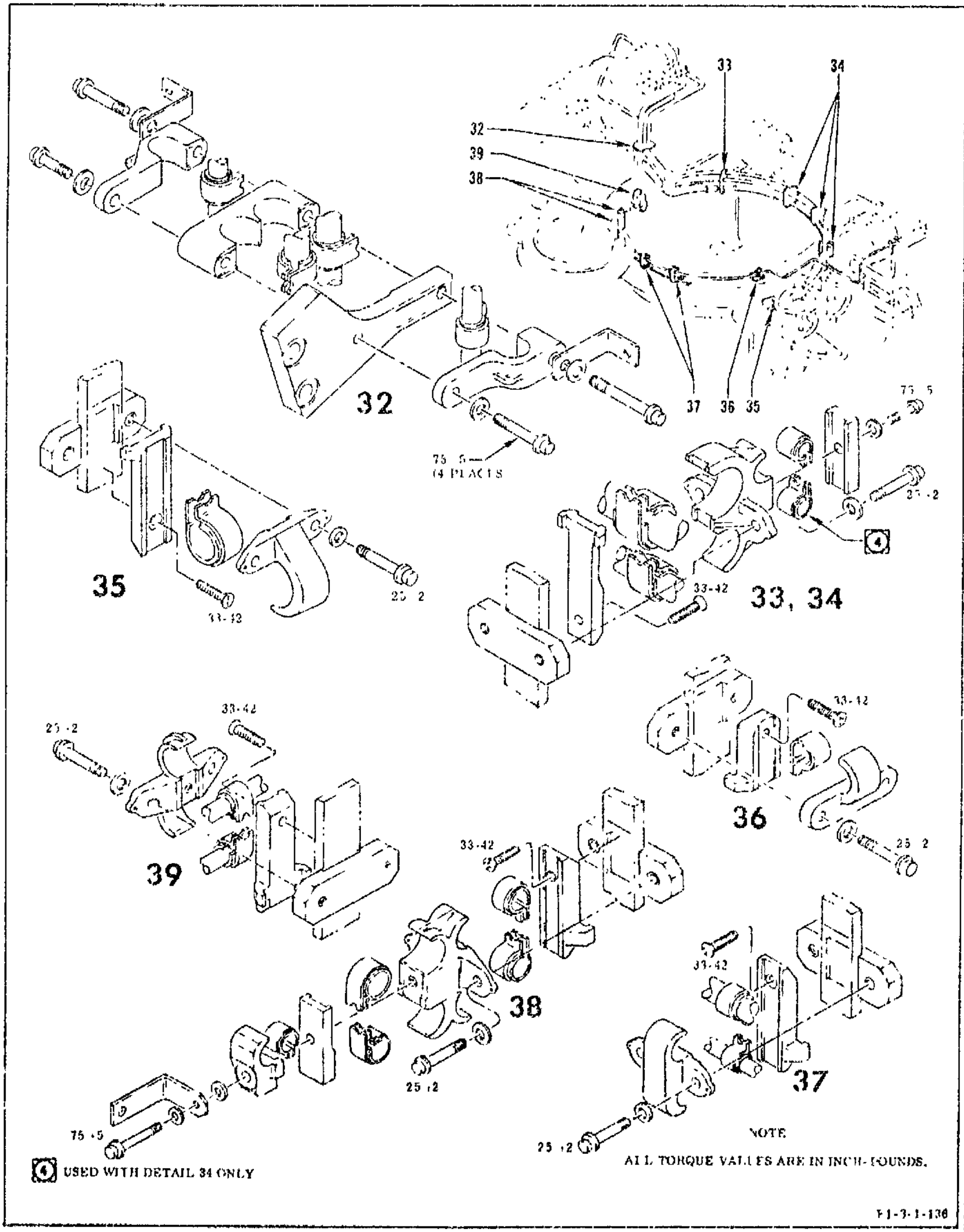


Figure 3-3-1. Engine Lines Supports, Clamps, and Brackets (Sheet 7 of 8)

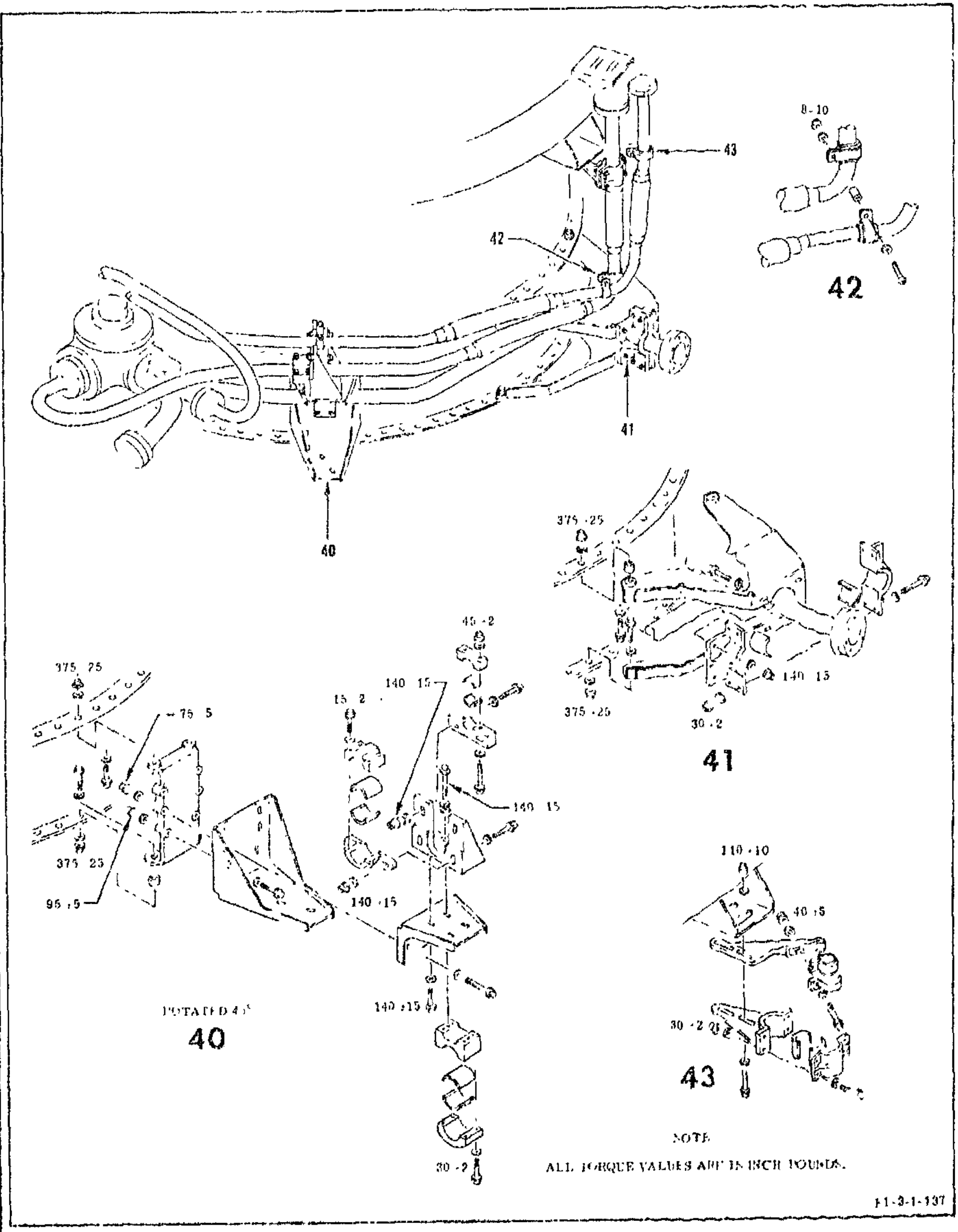


Figure 3-3-1. Engine Lines Supports, Clamps, and Brackets (Sheet 8 of 8)

Tap	Description	Fitting	Seal	Lubricant	Torque (in-lb)	Location
PF2b-1	No. 1 fuel pump discharge	AN814-4JL[a]	RD262-3001-0004[b]	RB0140-012	40-65	No. 1 fuel high-pressure duct
PF2a-2	No. 2 fuel pump discharge	(Flange)	---	---	---	No. 2 fuel high-pressure duct
PF2b-2	No. 2 fuel pump discharge	AN814-4JL[a]	RD262-3001-0004[b]	RB0140-012	40-65	No. 2 fuel high-pressure duct
PF3a-1	No. 1 fuel valve inlet	AN814-4JL[a]	MS29512-04[b]	RB0140-012	125 ±5	No. 1 fuel high-pressure duct
PF3a-2	No. 2 fuel valve inlet	AN814-4JL[a]	MS29512-04[b]	RB0140-012	100 ±5	No. 2 fuel high-pressure duct
CF1a	Fuel manifold	AN814-4JL[a]	RE261-3004-0004[c][d]	RB0140-012	85 ±5	Thrust chamber body
CF1b[e]	Fuel manifold	AN814-4JL[a]	RE261-3004-0004[c][d]	RB0140-012	85 ±5	Thrust chamber body
CF1c	Fuel manifold	AN814-4JL[a]	RE261-3004-0004[c][d]	RB0140-012	85 ±5	Thrust chamber body
CF1d	Fuel manifold	(Flange)	---	---	---	Thrust chamber body
KF6a-1	No. 1 fuel pump inlet	(Flange)	---	---	---	No. 1 fuel pump inlet elbow
KF6b-1	No. 1 fuel pump inlet	AN814-4JL[a]	RD262-3001-0004[b]	RB0140-012	40-65	No. 1 fuel pump inlet elbow
CF2a	Fuel injection	AN814-4JL[a]	RE261-3004-0004[c][d]	RB0140-012	85 ±5	Thrust chamber body
CF2b[e]	Fuel injection	AN814-4JL[a]	RE261-3004-0004[c][d]	RB0140-012	85 ±5	Thrust chamber body

(a) Lubricate (Method A).
(b) Lubricate (Method J).
(c) Interchangeable with 12100CR4.
(d) Lubricate (Method R) with fluorinated oil Krytox 143AZ (Du Pont).
(e) Engines not incorporating MD140 change.

Figure 3-3A. Instrumentation and Purge Port Requirements (Sheet 1 of 8)

Tap	Description	Fitting	Seal	Lubricant	Torque (in-lb)	Location
CF2c	Fuel injection	AN814-4JL[a]	RE261-3004-0004[c][d]	RB0140-012	85 ±5	Thrust chamber body
KF6b-2[f]	No. 2 fuel pump inlet	AN814-4J[a]	RD262-3001-0004[b]	RB0140-012	40-65	No. 2 fuel pump inlet elbow
PO2b-1	No. 1 oxidizer pump discharge	AN814-4JL[a]	RE261-3004-0004[c]	RB0140-012	90 ±10	No. 1 oxidizer high-pressure duct
PO2a-2	No. 2 oxidizer pump discharge	(Flange)	---	---	---	No. 2 oxidizer high-pressure duct
PO2b-2	No. 2 oxidizer pump discharge	AN814-4JL[a]	RE261-3004-0004[c]	RB0140-012	90 ±10	No. 2 oxidizer high-pressure duct
PO3-1	No. 1 oxidizer valve inlet	AN814-4JL[a]	RE261-3004-0004[c]	RB0140-012	90 ±10	No. 1 oxidizer high-pressure duct
PO3-2	No. 2 oxidizer valve inlet	AN814-4JL[a]	RE261-3004-0004[c]	RB0140-012	90 ±10	No. 2 oxidizer high-pressure duct
CO3j	Oxidizer injection	208029[a]	RE261-3004-0004[c][g]	RB0140-012	85 ±5	Oxidizer dome
CO3b[e]	Oxidizer injection	AN814-4JL[a]	RE261-3004-0004[c][g]	RB0140-012	85 ±5	Oxidizer dome
CO3c	Oxidizer injection	AN814-4JL[a]	RE261-3004-0004[c][g]	RB0140-012	85 ±5	Oxidizer dome
CO1b-1	No. 1 oxidizer dome inlet	AN814-4JL[a]	RE261-3004-0004[c][g]	RB0140-012	85 ±5	Oxidizer dome

(a) Lubricate (Method A).
(b) Lubricate (Method J).
(c) Interchangeable with 12100CR4.
(d) Lubricate (Method R) with fluorinated oil Krytox 143AZ (Du Pont).
(e) Engines not incorporating MD140 change.
(f) Engines not incorporating MD146 change.
(g) Lubricate (Method R) with fluorinated oil Krytox 143AZ (Du Pont) or lubricant grease RB0140-012 (Rocketdyne).

Figure 3-3A. Instrumentation and Purge Port Requirements (Sheet 2 of 8)

Tap	Description	Fitting	Seal	Lubricant	Torque (in-lb)	Location
COlb-2	No. 2 oxidizer dome inlet	AN814-4JL[a]	RE261-3004-0004[c][g]	RB0140-012	85 ±5	Oxidizer dome
CG1a	Combustion chamber	AN814-4JL[a]	RE261-3004-1004[h][j]	C5A	85 ±5	Thrust chamber injector
CG1b	Combustion chamber	AN814-4JL [a]	RE261-3004-1004[h]	C5A	135 ±5	Thrust chamber injector
CG1c[i]	Combustion chamber	AN814-4JL[a]	RE261-3004-1004[h][j]	C5A	85 ±5	Thrust chamber injector
CG1d	Combustion chamber	AN814-4JL [a]	RE261-3004-1004[h]	C5A	135 ±5	Thrust chamber injector
GF1	Gas generator fuel inlet	AN814-4JL[a]	RD262-3001-0004[b]	RB0140-012	40-65	Gas generator fuel duct
TG4a	Turbine manifold inlet	(Flange)	---	---	---	Turbine manifold
TG4b	Turbine manifold inlet	AN814-4JL[a]	RE261-3004-1004[h]	C5A	240-276	Turbine manifold
TG5a	Turbine outlet	AN814-4JL [a]	RE261-3004-1004[h]	C5A	135 ±5	Heat exchanger
TG5b	Turbine outlet	AN814-4JL[a]	RE261-3004-1004[h]	C5A	135 ±5	Heat exchanger
GG1a[e]	Gas generator chamber	RD273-6003-0004[a]	RE261-3004-1004[h]	C5A	200-240	Gas generator injector

(a) Lubricate (Method A).
(b) Lubricate (Method J).
(c) Interchangeable with 12100CR4.
(e) Engines not incorporating MD140 change.
(g) Lubricate (Method R) with fluorinated oil Krytox 143AZ (Du Pont) or lubricant grease RB0140-012 (Rocketdyne).
(h) Interchangeable with 12100AA4.
(i) Engines not incorporating MD177 change.
(j) Lubricate (Method R) with Brayco 777 hydraulic fluid (Bray Oil Co).

Figure 3-3A. Instrumentation and Purge Port Requirements (Sheet 3 of 8)

Tap	Description	Fitting	Seal	Lubricant	Torque (in-lb)	Location
GG1b	Gas generator chamber	AN814-4JL[a]	RE261-3004-1004[h]	C5A	135 ±5	Gas generator injector
GG1c	Gas generator chamber	RD273-6003-0004[a]	RE261-3004-1004[h]	C5A	200-240	Gas generator injector
GG2a	Gas generator chamber	AN814-4JL[a]	RE261-3004-1004[h]	C5A	135 ±5	Gas generator injector
GG2b	Turbine manifold	RD273-6003-0004[a]	RE261-3004-1004[h]	C5A	200-240	Gas generator combustor
PF10	Fuel impeller balance cavity	AN814-4JL[a]	RD262-3001-0004[b]	RB0140-012	40-65	Turbopump fuel volute
NH4[e]	Engine control system return	AN814-4JL[a]	RD262-3001-0004[b]	RB0140-012	40-65	System return line
NH7[e]	Ignition monitor valve outlet	AN814-4JL[a]	RD262-3001-0004[b]	RB0140-012	40-65	No. 1 fuel valve open control tube
IF2	Igniter fuel valve inlet	AN814-4SL[a]	RD262-3001-0004[b]	RB0140-012	40-65	Hypergol manifold
IF3	Hypergol container inlet	AN814-4J[a]	RD262-3001-0004[b]	RB0140-012	40-65	Hypergol manifold
HH3c	Heat exchanger helium outlet	AN814-4JL[a]	12100CL4	RB0140-012	80 ±5	Helium return duct
HH4	Heat exchanger helium outlet	AN814-4JL[a]	12100CL4	RB0140-012	80 ±5	Helium return duct

(a) Lubricate (Method A).
(b) Lubricate (Method J).
(c) Interchangeable with 12100CR4.
(e) Engines not incorporating MD140 change.
(h) Interchangeable with 12100AA4.

Figure 3-3A. Instrumentation and Purge Port Requirements (Sheet 4 of 8)

Tap	Description	Fitting	Seal	Lubricant	Torque (in-lb)	Location
HO1c	Heat exchange. oxidizer inlet	RD265-3004-2002[a]	RE261-3004-0004[c]	RB0140-012	180 ±10	Heat exchanger check valve
HO2	Heat exchanger oxidizer inlet	RD265-3004-2002[a]	RE261-3004-0004[c]	RB0140-012	180 ±10	Heat exchanger check valve
HO3	Heat exchanger GOX outlet	RD265-3017-0004[a]	RD261-3005-1004	RB0140-012	135 ±10	GOX duct
HO4c	Heat exchanger GOX outlet	RD265-3017-0004[a]	RD261-3005-1004	RB0140-012	135 ±10	GOX duct
LS1	No. 1 bearing	AN814-3JL[a]	MS29512-03[b]	RB0140-012	30-40	Turbopump
LS2	No. 2 bearing	AN814-3JL[a]	MS29512-03[b]	RB0140-012	35 ±5	Turbopump
LS3	Turbine bearing	AN814-3JL[a]	12120CR3	RB0140-012	70 ±5	Turbopump
CO2c[e]	Oxidizer manifold	AN814-4JL[a]	RE261-3004-0004[c][g]	RB0140-012	85 ±5	Oxidizer dome
CO3h	Oxidizer injection	208029[a]	RE261-3004-0004[c][g]	RB0140-012	85 ±5	Oxidizer dome
CO3k[e]	Oxidizer injection	208029[a]	RE261-3004-0004[c][g]	RB0140-012	85 ±5	Oxidizer dome
CO3m[e]	Oxidizer injection	208029[a]	RE261-3004-0004[c][g]	RB0140-012	85 ±5	Oxidizer dome
CG1e	Combustion chamber	(Flange)	---	---	---	Thrust chamber injector
TG5c	Turbine outlet	(Flange)	---	---	---	Heat exchanger

(a) Lubricate (Method A).
(b) Lubricate (Method J).
(c) Interchangeable with 12100CR4.
(e) Engines not incorporating MD140 change.
(g) Lubricate (Method R) with fluorinated oil Krytox 143AZ (Du Pont) or lubricant grease RB0140-012 (Rocketdyne).

Figure 3-3A. Instrumentation and Purge Port Requirements (Sheet 5 of 8)

Tap	Description	Fitting	Seal	Lubricant	Torque (in-lb)	Location
PF2c-1[f]	No. 1 fuel pump discharge	AN814-4JL[a]	MS29512-04[b]	RB0140-012	40-65	No. 1 fuel high-pressure duct
PF2d-1	No. 1 fuel pump discharge	AN814-4JL[a]	MS29512-04[b]	RB0140-012	40-65	No. 1 fuel high-pressure duct
PF2c-2	No. 2 fuel pump discharge	AN814-4JL[a]	MS29512-04[b]	RB0140-012	40-65	No. 2 fuel high-pressure duct
NH2b	Engine control closing	AN814-4JL[a]	RD262-3001-0004[b]	RB0140-012	40-65	Propellant valves close tube
NH3b	Engine control opening	AN814-4JL[a]	RD262-3001-0004[b]	RB0140-012	40-65	Propellant valves open tube
NH5a[i]	Common hydraulic return	AN814-4JL[a]	RD262-3001-0004[b]	RB0140-012	40-65	Actuator return line
NH5b	Common hydraulic return	AN814-4JL[a]	RD262-3001-0004[b]	RB0140-012	40-65	Actuator return line
NH5c	Common hydraulic return	(Flange)	---	---	---	Actuator return line
KF7a-1	No. 1 fuel pump inlet	AN814-4J[a]	RD262-3001-0004[b]	RB0140-012	40-65	No. 1 fuel pump inlet elbow
KF6d-2	No. 2 fuel pump inlet	AN814-4JL[a]	RD262-3001-0004[b]	RB0140-012	40-65	No. 2 fuel pump inlet elbow
KF7a-2[f]	No. 2 fuel pump inlet	AN814-4J[a]	RD262-3001-0004[b]	RB0140-012	40-65	No. 2 fuel pump inlet elbow
GG1d	Gas generator chamber	(Flange)	---	---	---	Gas generator injector

(a) Lubricate (Method A).
(b) Lubricate (Method J).
(f) Engines not incorporating MD146 change.
(i) Engines not incorporating MD177 change.

Figure 3-3A. Instrumentation and Purge Port Requirements (Sheet 6 of 8)

Tap	Description	Fitting	Seal	Lubricant	Torque (in-lb)	Location
GF2a	Gas generator fuel injection	RD273-6003-0004(a)	RE261-3004-1004(h)	RB0140-012	200-240	Gas generator injector
GF2b	Gas generator fuel injection	RD273-6003-0004(a)	RE261-3004-1004(h)	RB0140-012	200-240	Gas generator injector
GO2a	Gas generator oxidizer injection	AN814-4JL(a)	RE261-3004-0004(c)	RB0140-012	80-90	Gas generator injector
GO2b(e)	Gas generator oxidizer injection	AN814-4JL(a)	RE261-3004-0004(c)	RB0140-012	80-90	Gas generator injector
GO1a	Gas generator oxidizer inlet	AN814-4JL(a)	RE261-3004-0004(c)	RB0140-012	240-276	Gas generator oxidizer duct (valve end)
GO1b	Gas generator oxidizer inlet	AN814-4JL(a)	RE261-3004-0004(c)	RB0140-012	240-276	Gas generator oxidizer duct
NHOa	Ground hydraulic supply	RD265-3004-2002(a)	MS29512-04(b)	RB0140-012	125 ±5	Hydraulic supply wrap-around duct
HO5(e)	Heat exchanger GOX outlet	RD265-3017-0004(a)	RE261-3005-1004(c)	RB0140-012	135 ±10	GOX duct
HH2c	Heat exchanger helium inlet	AN814-4JL(a)	RE261-3004-0004(c)	RB0140-012	80 ±5	Helium supply duct
LB1a	Oxidizer pump bearing jet	(Flange)	---	---	---	Bearing coolant control valve
LB1b	Oxidizer pump bearing jet	AN814-4JL(a)	RD262-3001-0004(b)	RB0140-012	40-65	Bearing coolant control valve

(a) Lubricate (Method A).
(b) Lubricate (Method J).
(c) Interchangeable with 12100CR4.
(e) Engines not incorporating MD140 change.
(h) Interchangeable with 12100AA4.

Figure 3-3A. Instrumentation and Purge Port Requirements (Sheet 7 of 8)

Tap	Description	Fitting	Seal	Lubricant	Torque (in-lb)	Location
PO2c-1[f]	No. 1 oxidizer pump discharge	AN814-4JL[a]	RE261-3004-0004[c]	RB0140-012	90 ±10	No. 1 oxidizer high-pressure duct
PO2d-1	No. 1 oxidizer pump discharge	AN814-4JL[a]	RE261-3004-0004[c]	RB0140-012	90 ±10	No. 1 oxidizer high-pressure duct
PO2c-2	No. 2 oxidizer pump discharge	AN814-4JL[a]	RE261-3004-0004[c]	RB0140-012	90 ±10	No. 2 oxidizer high-pressure duct
PO7b	Oxidizer pump seal cavity	AN837-4J	AN929-4J[k]	RB0140-012	135-185	Turbopump
NH1a	Control system supply	AN814-4JL[a]	RD262-3001-0004[b][n]	RB0140-012	40-65	Engine control valve
NH1b	Control system supply	AN814-4JL[a]	RD262-3001-0004[b][n]	RB0140-012	40-65	Engine control valve
NH8	Control system override supply	AN814-4JL[a]	RD262-3001-0004[b]	RB0140-012	40-65	Redundant shutdown valve override hose
GG2c	Gas generator chamber	RD273-8003-0004(a)	RE261-3004-1004[h]	C5A	220 ±20	Gas generator combustor
GO5	Gas generator oxidizer inlet	AN814-4JL[a]	RE261-3004-0004[c]	RB0140-012	240 ±10	Gas generator ball valve
Purge 1A, 1B, 2A, 2B	Oxidizer dome purge	AN814-8JL[a]	RE261-3004-0008[l]	RB0140-012	350 ±15	Oxidizer dome
No. 3 PURGE, No. 4 PURGE	Oxidizer dome purge	AN814-12JL[a]	RE261-3004-0012[m]	RB0140-012	960 ±120	Oxidizer dome

(a) Lubricate (Method A).
(b) Lubricate (Method J).
(c) Interchangeable with 12100CR4.
(f) Engines not incorporating MD146 change.
(h) Interchangeable with 12100AA4.
(k) Lubricate (Method G).
(l) Interchangeable with 12100CR8.
(m) Interchangeable with 12100CR12.
(n) Allowable alternate MS29512-04 (age controlled).

Figure 3-3A. Instrumentation and Purge Port Requirements (Sheet 8 of 8)

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
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

(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 3-3B. 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 (on pump end flange and valve end flange) (2 reqd)	MS9015-02[e]	MS29512-02[j]	75 ±5
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 P02a-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 down-stream 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

(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 3-3B. Seal Monitoring Port Requirements (Sheet 2 of 3)

Port Location	Plug and Bleeder[a]	Seal	Plug Torque (in-lb)
Heat exchanger oxidizer supply hose to heat exchanger (on heat exchanger)	AN814-2JL[e]	RE261-3004-1002[c]	70 ±5
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 (Felt Products).
(c) Interchangeable with 12100AA2.
(e) Lubricate (Method A) with lubricant grease RB0140-012 (Rocketdyne).

Figure 3-3B. Seal Monitoring Port Requirements (Sheet 3 of 3)

3-14. DISCONNECTING ELECTRICAL CONNECTORS. To prevent corrosion and other types of damage to electrical connectors and harnesses or cables, this procedure must be followed when disconnecting electrical connectors other than those connected to flight instrumentation transducers. For procedure concerning disconnection of electrical plugs from transducers, refer to paragraph 3-16.

WARNING

Disconnecting electrical connectors without turning off the power source can cause arcing, resulting in serious injury to personnel and damage to equipment.

a. Make sure electrical power source is turned off.

b. Remove enough harness support clamps to allow connector to be disconnected without straining harness.

c. Slide protective boot back on harness. Cut and remove lockwire.

d. Using appropriate wrench, loosen and back off coupling nut until nut can be turned by hand.

CAUTION

The bend radius of the harness must never be less than one times the outside diameter of the harness; otherwise, damage to the harness can result.

e. Grasp and carefully pull connector straight away from receptacle. Do not twist or turn connectors, or pull or bend harness beyond a bend radius of less than one times outside diameter of harness.

f. Install protective dust caps on all disconnected connectors. Dust cap requirements, by connector reference designation number, are listed in R-3896-4.

g. Torque dust caps to applicable torque value. Dust-cap torque requirements, by connector number, are listed in figure 3-4.

3-15. CONNECTING ELECTRICAL CONNECTORS. This procedure must be a continuous operation. If a delay in completion is encountered, all openings must be capped and the complete procedure repeated starting with step a. This procedure must be followed when connecting electrical connectors other than those connected to flight instrumentation transducers. For procedure concerning connection of electrical plugs to transducers, refer to paragraph 3-17.

NOTE

This procedure applies to electrical connectors of engine harnesses. Only step a and substeps 1, 2, and 3 apply to electrical connectors that are an integral part of an engine component.

a. Remove protective dust caps, and inspect connectors for the following:

(1) Foreign particles, dust, dirt, moisture, or lubricant on contact pins, sockets, or inserts. Clean connectors as outlined in section I, if necessary.

NOTE

Since lubricant may have the appearance of moisture, the substance must be examined carefully.

(2) Bent pin contacts. Pin contacts that are not bent more than 20 degrees from connector axis may be repaired. (See figure 3-5.) (Refer to R-3896-3, Volume II, for electrical harness repair information.) Replace harness if pin contacts are bent more than 20 degrees from connector axis.

(3) Pin contacts with more than one bend, regardless of angularity of each bend, are not acceptable. (See figure 3-5.) Replace harness if pin contact contains more than one bend.

(4) Bent or misalined female socket contacts are not acceptable. Replace harness if socket contacts are damaged.

(5) Extended or recessed pin contacts that exceed limits specified in figure 3-5. Replace harness if limits are exceeded.

Connector RDI No.	Torque[a] (in-lb)	Description
J18	155-185	Interface panel
J19	90-115	Interface panel
J20	130-165	Interface panel
J100	90-115	Interface panel
J101	130-165	Interface panel
J102	100-125	Interface panel
J103	100-125	Interface panel
J104	90-115	Interface panel
J106	90-115	Interface panel
J140[b]	60-80	Interface panel
J141[b]	155-185	Interface panel
J142	40-50	Interface panel
J143[b]	115-145	Interface panel
J174	40-50	Interface panel
J470	130-165	Interface panel
J800	80-100	Interface panel
P30	60-80	Checkout valve
P35[c]	40-50	Prefill level detector
P43, P44	40-50	Gas generator igniter
P45, P46	40-50	Turbine exhaust igniter
P47	100-125	Interconnect to igniters (J47)
P50[d]	40-50	Redundant shutdown valve
P51	40-50	Engine control valve start solenoid
P52	30-40	Engine control valve stop solenoid
P53	40-50	Gas generator ball valve position switch
P56	40-50	Hypergol cartridge-installed switch
P70	60-80	No. 1 oxidizer valve position transducer
P71	60-80	No. 2 oxidizer valve position transducer
P73	40-50	No. 1 thrust OK pressure switch
P73[f]	40-50	No. 2 thrust OK pressure switch
P74	40-50	No. 3 thrust OK pressure switch
P75[e]	40-50	Turbopump interface (J75)
P76	60-80	No. 1 fuel valve position transducer
P77	60-80	No. 2 fuel valve position transducer
P78	40-50	No. 2 thrust OK pressure switch
P78[f]	40-50	No. 1 thrust OK pressure switch
P85, P86	30-40	Turbopump heater No. 1
P87, P88	30-40	Turbopump heater No. 2
P108	80-100	Primary instrumentation junction box
P109	130-165	Primary instrumentation junction box
P110	100-125	Primary instrumentation junction box
P111	130-165	Primary instrumentation junction box
P112	115-145	Primary instrumentation junction box
P113	100-125	Primary instrumentation junction box
P114	90-115	Primary instrumentation junction box
P115	100-125	Primary instrumentation junction box
P116	40-50	Fuel pump inlet No. 1 (KF6a-1)
P117	40-50	Oxidizer pump discharge No. 2 (PO2a-2)
P118	40-50	Oxidizer pump bearing jet (LB1a)

(a) Torque is applicable for dust caps if component is to be stored or shipped. For servicing or maintenance, install dust caps fingertight.
(b) Engines not incorporating MD96 change
(c) Engines not incorporating MD113 or MD114 change
(d) Engines incorporating MD113 or MD114 change
(e) Engines not incorporating MD22 or MD62 change
(f) Engines incorporating MD157 or MD158 change

Figure 3-4. Torque Requirements for Electrical Connectors and Dust Caps (Sheet 1 of 2)

Connector RDI No.	Torque [a] (in-lb)	Description
P119	40-50	Gas generator chamber (GG1d)
P120	40-50	Fuel pump discharge No. 2 (PF2a-2)
P121	40-50	Turbine outlet (TG5c)
P122	40-50	Common hydraulic return (NH5c)
P123	40-50	Combustion chamber (CG1e)
P128	30-40	Engine control valve stop solenoid and engine cutoff signal to vehicle (J128)
P129[e]	90-115	Interconnect to prefill level detector (J129)
P130	40-50	Turbopump interface (J130)
P132	40-50	Heat exchanger LOX inlet flow No. 1 (F16)
P134	30-40	Bearing No. 1 (LSJ)
P135[g]	30-40	Engine environmental (CGT1)
P137	30-40	Turbine inlet manifold (TG4a)
P138	30-40	Engine environmetal (CGT1)
P175[h]	40-50	Turbopump thermostat
P230	40-50	Turbopump RPM No. 1 (T1)
P450	30-40	Igniter harness shield (J450)

AUXILIARY INSTRUMENTATION SYSTEM[b]

Connector RDI No.	Torque [a] (in-lb)	Description
P146	100-125	Auxiliary instrumentation junction box
P147	80-100	Auxiliary instrumentation junction box
P148	155-185	Auxiliary instrumentation junction box
P151	155-185	Auxiliary instrumentation junction box
P152	100-125	Auxiliary instrumentation junction box
P155	40-50	Fuel pump discharge No. 1 (PF2a-1)
P158	40-50	Engine control opening (NH3a)
P159	40-50	Oxidizer pump discharge No. 1 (PO2a-1)
P160	40-50	Engine control closing (NH2a)
P161	40-50	Turbine outlet (TG5c)
P162	40-50	Oxidizer pump seal cavity (PO7a)
P163	40-50	Heat exchanger helium outlet (HH3a)
P164	40-50	Heat exchanger helium inlet (HH2a)
P165	40-50	Heat exchanger oxidizer inlet (HO1b)
P166	40-50	Heat exchanger GOX outlet (HO4a)
P184	30-40	Fuel pump inlet No. 2 (KF6a-2)
P185	30-40	Heat exchanger oxidizer inlet (HO1a)
P186	30-40	Heat exchanger GOX outlet (HO4b)
P187	30-40	Heat exchanger helium outlet (HH3b)

(a) Torque is applicable for dust caps if component is to be stored or shipped. For servicing or maintenance, install dust caps fingertight.
(b) Engines not incorporating MD96 change
(e) Engines not incorporating MD22 or MD62 change
(g) Engines incorporating MD108 change
(h) Engines incorporating MD22 or MD62 change

Figure 3-4. Torque Requirements for Electrical Connectors and Dust Caps (Sheet 2 of 2)

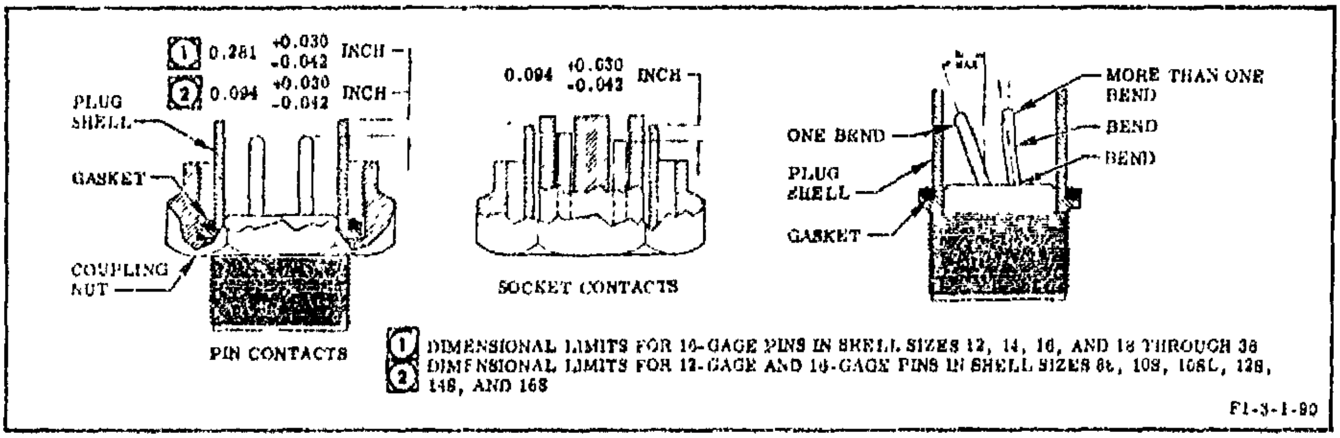


Figure 3-5. Damage Limits and Allowable Repairs for Electrical Plugs

(5A) Tarnished pins. Clean pins as outlined in section I.

(6) Damaged threads, corroded sockets, and cracked, split or punctured connector inserts. Replace harness if any of these conditions exist.

(7) Rotational movement of the connector adapter with respect to the harness armor braid is acceptable if the harness meets a resistance test of 0.1 ohm maximum between the connector adapter and the harness armor braid. Strain must not be applied between the connector adapter and the armor braid to determine connector rotation.

CAUTION

A plastic, wooden, or other nonabrading tool must be used to remove the gasket to avoid damaging the connector.

b. Replace plug gasket (between plug shell and coupling nut). (See figure 3-5.) Gasket requirements are listed by connector number in R-3896-4. Apply a thin coat of FS1281 grease (Dow Corning Corp), using Method J outlined in section I, to gasket before installation.

WARNING

Compressed gas must not be used for drying or cleaning unless effective chip guarding is used and personal protection equipment is worn.

c. Immediately before connecting connector, clean plug and receptacle by blowing 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.

d. Apply a thin coat of FS1281 grease (Dow Corning Corp), using Method A outlined in section I, to threads of receptacle before connecting plug. Do not allow lubricant to contact pins, sockets, or inserts. Remove excess grease with a clean, lint-free cloth.

CAUTION

The harness bend radius must never be less than one times the outside diameter of the harness; otherwise, damage to the harness can result.

e. Carefully mate plug and receptacle, keeping plug and receptacle faces parallel and keyways alined. Do not bend, break, or damage contact pins or sockets. Attempt to maintain a bend radius of not less than 5 times outside diameter of harness wherever possible. Bend radius must not be less than one times outside diameter of harness.

f. Turn coupling nut by hand and move plug forward toward receptacle until plug and receptacle are correctly mated. If coupling nut cannot be turned by hand, remove connector and recheck pin alinement.

CAUTION

The torque value of the plug coupling nut must not be exceeded, since overtorquing can damage the electrical connectors.

- After a second torque of the coupling nut and safetywire installation, no additional torquing must be performed, since damage to the plug sealing gasket can result.

g. Torque plug coupling nut to applicable torque value. Torque requirements, by connector number, are listed in figure 3-4. After a minimum of 30 minutes, retorque plug coupling nut to required torque value.

h. Safetywire coupling nut, and slide protective boot over connector.

i. Install harness support clamps.

j. If an electrical connector appears to be loose even though the connector is torqued and safetywired, the acceptance criteria and disposition are as follows:

(1) A loose connector is defined as one in which the coupling nut can be turned by hand in the tightening direction one-quarter turn or more.

(2) If a connector is found to be loose, the connector must be disconnected as outlined in paragraph 3-14 and the plug gasket replaced as outlined in this procedure and connector retorqued.

3-16. DISCONNECTING ELECTRICAL PLUG FROM FLIGHT INSTRUMENTATION PRESSURE TRANSDUCERS. (See figure 3-6.)

a. Make sure electrical power source is turned off.

WARNING

Disconnecting electrical connectors without turning off the power source can cause arcing, resulting in serious injury to personnel and damage to equipment.

b. Remove enough harness support clamps to allow harness electrical plug to be disconnected from transducer without straining harness.

CAUTION

When disconnecting the electrical plug from the gas generator chamber pressure transducer (P119) or thrust chamber combustion chamber pressure transducer (P123), the transducer must be disconnected or loosened from its respective attach bracket or adapter prior to disconnecting the plug, to prevent possible damage to the harness or transducer.

c. Remove harness support clamp (1).

d. Cut and remove lockwire and remove transducer insulator, if installed.

e. Using appropriate wrench, loosen and back off coupling nut until nut can be turned by hand.

CAUTION

The bend radius of the harness must never be less than one times the outside diameter of the harness; otherwise damage to the harness can result.

f. Grasp and carefully pull plug straight away from transducer receptacle. Do not twist or turn plug, or pull or bend harness beyond a bend radius of less than one times outside diameter of harness.

g. Lift harness from cradle of its respective harness support block (3) and remove clamp (2) from harness.

h. Install protective dust caps. Dust cap requirements, by connector reference designation number, are listed in R-3896-4.

i. Torque dust caps to applicable torque value. Dust cap torque requirements, by connector number, are listed in figure 3-4.

3-17. CONNECTING ELECTRICAL PLUG TO FLIGHT INSTRUMENTATION PRESSURE TRANSDUCERS. (See figure 3-6.) This procedure must be a continuous operation. If a delay in completion is encountered, all openings must be capped and the complete procedure repeated, starting with step a.

a. Remove protective dust caps, and inspect connectors for the following:

(1) Foreign particles, dust, dirt, moisture, or lubricant on contact pins, sockets, or inserts. Clean connectors as outlined in section I, if necessary.

NOTE

Since lubricant may have the appearance of moisture, the substance must be examined carefully.

(2) Bent pin contacts. Pin contacts that are not bent more then 20 degrees from connector axis may be repaired. (See figure 3-5.) (Refer to R-3896-3, Volume II, for electrical harness repair information.) Replace harness if pin contacts are bent more than 20 degrees from connector axis.

(3) Pin contacts with more than one bend, regardless of angularity of each bend, are not acceptable. (See figure 3-5.) Replace harness if pin contact contains more than one bend.

(4) Bent or misalined female socket contacts are not acceptable. Replace harness if socket contacts are damaged.

(5) Extended or recessed pin contacts that exceed limits specified in figure 3-5. Replace harness if limits are exceeded.

(5A) Tarnished pins. Clean pins as outlined in section I.

(6) Damaged threads, corroded sockets, and cracked, split or punctured connector inserts. Replace harness if any of these conditions exist.

(7) Rotational movement of the connector adapter with respect to the harness armor braid is acceptable if the harness meets a resistance test of 0.1 ohm maximum between the connector adapter and the harness armor braid. Strain must not be applied between the connector adapter and the armor braid to determine connector rotation.

CAUTION

A plastic, wooden, or other nonabrading tool must be used to remove the gasket to avoid damaging the connector.

b. Replace plug gasket (between plug shell and coupling nut). (See figure 3-5.) Gasket requirements are listed by connector number in R-3896-4. Apply a thin coat of FS1281 grease (Dow Corning Corp), using Method A outlined in section I, to gasket before installation.

c. Immediately before connecting connector, clean plug and transducer receptacle by blowing with a regulated source of low-pressure (50-100 psig) gaseous nitrogen (MIL-P-27401) or clean, dry air conforming to the cleanness and humidity requirements of MIL-P-27401.

d. Apply a thin coat of FS1281 grease (Dow Corning Corp), using Method A outlined in section I, to threads of receptacle before connecting plug. Do not allow lubricant to contact pins, sockets, or inserts. Remove excess grease with a clean, lint-free cloth.

CAUTION

When connecting the instrumentation harness to the gas generator chamber pressure transducer (P119) or thrust chamber combustion chamber pressure transducer (P123), the transducer must be disconnected or loosened from its attach bracket or adapter prior to connecting the harness, to prevent damage to the harness or transducer.

- The harness bend radius must never be less than one times the outside diameter of the harness; otherwise, damage to the harness can result.

e. Carefully mate plug and transducer receptacle, keeping plug and receptacle faces parallel and keyways alined. Do not bend, break, or damage contact pins or sockets. Attempt to maintain a bend radius of not less than 5 times outside diameter of harness wherever possible. Bend radius must never be less than one times outside diameter of harness.

f. Turn coupling nut by hand and move plug forward toward receptacle until plug and receptacle are correctly mated. If coupling nut cannot be turned by hand, remove plug and recheck pin alinement.

g. Torque plug coupling nut to applicable torque value. Torque requirements, by connector number, are listed in figure 3-4. After a minimum of 30 minutes, retorque plug coupling nut to required torque value.

CAUTION

The torque value of the plug coupling nut must not be exceeded, since overtorquing can damage the electrical connectors.

- After a second torque of the coupling nut and safetywire installation, no additional torquing must be performed, since damage to the plug sealing gasket can result.

h. If applicable, cross-torque nuts that secure transducer P119 or P123 to 125 ±10 in-lb after harness plug is fully mated and torqued.

i. Loosen bolts that secure harness support block (3, figure 3-6) to its bracket enough to allow free movement of block for proper alinement of harness with transducer.

j. Install clamp (2) on harness, and place harness in cradle of its respective harness support block (3).

(6) boss. Torque union to 55-80 inch-pounds. Safetywire union.

v. On engines incorporating MD141 change, lubricate bolt (7) with a thin coating of fluorinated lubricant RB0140-010 (Rocketdyne) and install new seals (8, 2), elbow (9), and bolt (7). Torque bolt to 55-80 inch-pounds. Maximum acceptable tilt under head of bolt must not exceed 0.020 inch. Safetywire bolt.

w. Install support (3), with transducer and tube (1) attached on duct (6), using 5 bolts and washers. Torque bolts to 22 ±5 inch-pounds. Safetywire bolts.

x. Connect tube (1) to union (4) or elbow (9). Torque tube coupling nut to 160 ±10 inch-pounds. Safetywire coupling nut.

y. Reconnect any clamps or parts disconnected during removal of duct (6).

z. Refer to section IV for post-maintenance test equirements.

3-69. NO. 2 OXIDIZER HIGH-PRESSURE DUCT (RIGID). (See figure 3-19.)

3-70. Equipment required for removing or installing No. 2 oxidizer high-pressure duct consists of oxidizer line adapter 9025434, lift fixture 9024921-11, and turbopump support strut 9025193 from Component Handling Fixture Set G4068.

3-71. REMOVAL.

CAUTION

Protective closures, outlined in R-3896-4, must be installed as soon as possible after an engine joint or connection is disconnected, to prevent contamination.

a. Observe contamination prevention requirements outlined in section I.

b. Remove thermal insulation bracketry, as necessary, to remove No. 2 oxidizer high-pressure duct. Refer to R-3896-6 for thermal insulation bracket removal instructions.

c. Disconnect tube (1) from elbow (23). Remove and discard seal (2).

d. Remove 2 bolts and washers that attach brackets (3) to duct (6).

e. Remove 5 bolts and washers that attach support (4) to duct (6).

f. Remove transducer (5), support (4), brackets (3), and tube (1) as an assembly.

g. Remove 8 bolts and washers that attach line (7) to boss (10). Remove seals (8) and orifice plate (9).

h. Remove 4 bolts and washers that attach tube (11) to duct (6). Remove seal (12).

i. Remove 2 bolts and washers that attach bracket (13) to turbopump oxidizer volute (20).

j. Remove 4 bolts and washers that attach tube (14) and armored harness (15) to bracket (16).

k. Remove 5 bolts and washers that attach bracket (16) to duct (6). Remove bracket.

l. Install adapter 9025434 on duct (6).

m. Using lift-fixture lift point, position and install lift-fixture 9024921-11 on adapter.

n. Connect hoist hook to proper lift point on lift-fixture.

o. Install strut 9025193 between turbopump and oxidizer dome.

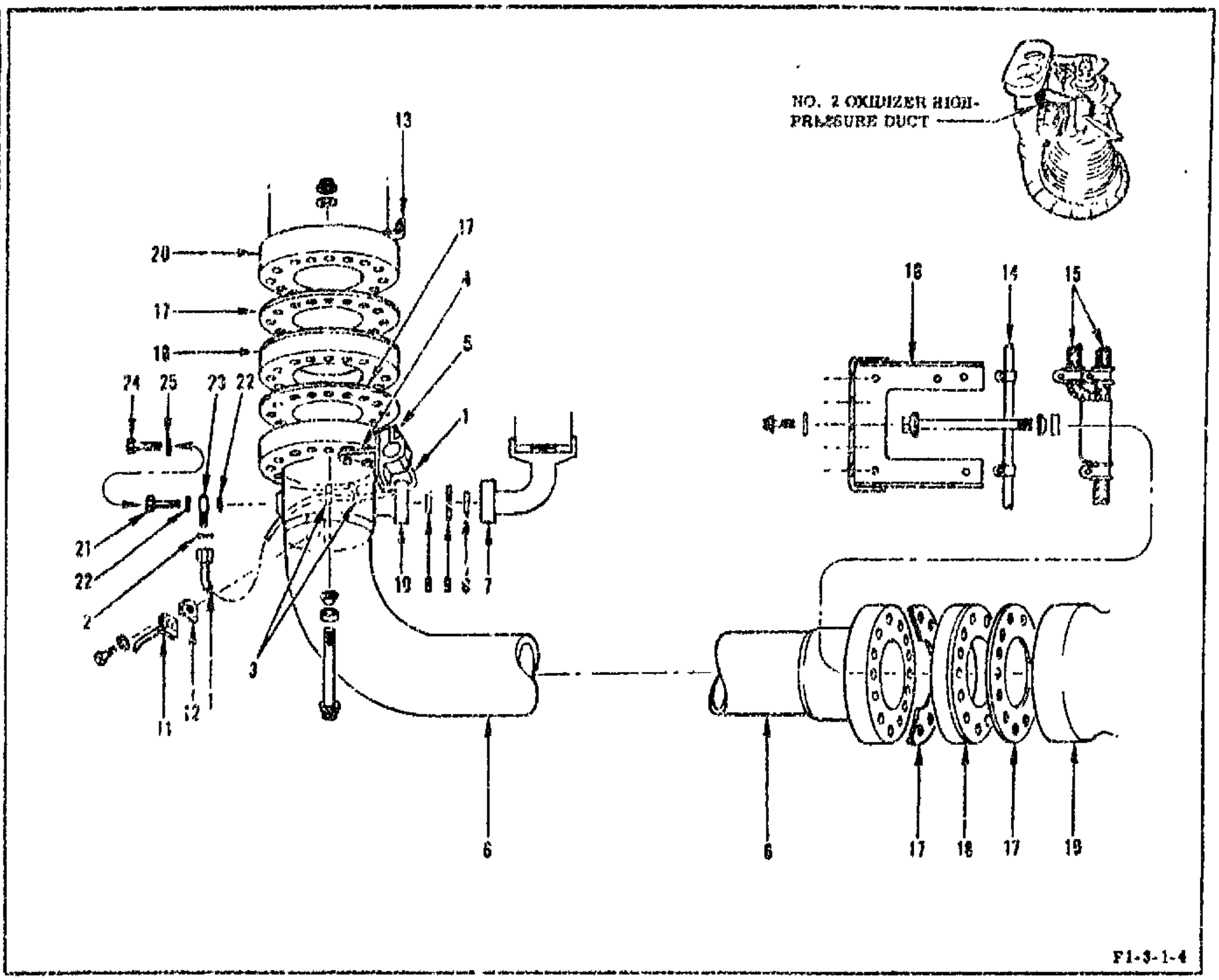
p. Remove bolts and washers that attach duct (6) to No. 2 main oxidizer valve and turbopump oxidizer volute.

CAUTION

Seals (17), spacers (18), duct main oxidizer valve, and turbopump oxidizer volute sealing surfaces must be protected when removing duct (6).

q. Using hoist, remove duct (6) from engine and place on prepared surface. Disconnect hoist and lift-fixture 9024921-11, and remove adapter 9025433 from duct.

r. On engines F-2017 through F-2063, if duct (6) is to be replaced, remove bolt (21), seals (22), and fitting (23).



1	LOX pump outlet tube	13	No. 2 LOX pump harness discharge flange bracket
2	Seal	14	No. 2 main oxidizer valve dome purge line
3	Bracket	15	Armored harness
4	Transducer LOX pump outlet flange support	16	Support bracket
5	Transducer	17	Pressure-actuated seal
6	No. 2 oxidizer high-pressure duct	18	Rigid-duct oxidizer spacer
7	Oxidizer feed high-pressure duct end line	19	No. 2 main oxidizer valve
8	Seal	20	No. 2 turbopump oxidizer volute flange
9	Orifice plate	21	Bolt
10	No. 2 high-pressure oxidizer duct boss	22	Seal
11	No. 2 pressure LOX pump outlet flanged tube	23	Fitting
12	Instrumentation pressure-actuated seal	24	Plug
		25	Seal

Figure 3-19. No. 2 Oxidizer High-Pressure Duct (Rigid)

s. On engines F-2064 through F-2072, if duct (6) is to be replaced, remove plug (24) and seal (25).

3-72. INSTALLATION.

CAUTION

Closures must not be removed until immediately prior to making applicable connections.

- When multiple fasteners are used at joints, the applicable torque and safetywiring methods outlined in section I must be used.

a. Observe contamination prevention requirements outlined in section I.

b. If duct (6) is being reinstalled, proceed to step e.

c. On engines F-2017 through F-2063, if duct (6) is being replaced, inspect new seals (22) for nicks and scratches that might impair sealing function. Lubricate bolt (21) with fluorinated lubricant RB0140-010 (Rocketdyne). Install new seals (22), fitting (23), and bolt (21) in duct (6). Torque bolt to 55-80 inch-pounds. Safetywire bolt.

d. On engines F-2064 through F-2072, if duct (6) is being replaced, inspect new seal (25) for nicks and scratches that might impair sealing function. Lubricate plug (24) with fluorinated lubricant RB0140-010 (Rocketdyne). Install new seal (25) and plug (24) in duct (6). Torque bolt to 55-80 inch-pounds. Safetywire plug.

e. Inspect sealing surfaces of duct (6), main oxidizer valve (19), turbopump oxidizer volute flange (20), new seals (17), and spacers (18) for nicks and scratches that might impair sealing function.

f. Install adapter 902534 on duct (6).

g. Using lift-fixture lift point, position and install lift-fixture 9024921-11 on adapter.

h. Connect hoist hook to proper lift point on lift-fixture. Using hoist, place duct (6) in installation position.

i. Using bolts, washers, and nuts, install seals (17), spacers (18), bracket (13), and duct (6). Torque bolts that connect duct to main oxidizer valve to 1,150 to 1,250 inch-pounds. Safetywire bolts. Torque nuts that connect duct to turbopump oxidizer volute to 1,150 to 1,250 inch-pounds. Minimum and maximum torques required to turn bolt through locking feature of nut must be 15 and 300 inch-pounds respectively. Safetywire 2 bolts that attach bracket (13) only.

j. Disconnect and remove strut 9025193 from between turbopump and oxidizer dome.

k. Install bracket (16) using 5 bolts and washers. Torque bolts to 75 ±5 inch-pounds. Safetywire bolts.

l. Install clamps that attach line (14) and armored harness (15) to bracket (16).

m. Inspect sealing surfaces of new seal (12), tube (11), and duct (6) boss for nicks and scratches that might impair sealing function.

n. Using new seal (12), attach tube (11) to duct (6) with 4 bolts and washers. Torque bolts to 70 ±5 inch-pounds. Safetywire bolts.

o. Inspect sealing surfaces of duct boss (10), orifice plate (9), and line (7) for nicks and scratches that might impair sealing function.

p. Using new seals (8), attach line (7) to duct boss (10) with 8 bolts and washers. Torque bolts to 350 ±10 inch-pounds. Safetywire and seal bolts.

q. Install transducer (5) and bracket (4) using 5 bolts and washers. Torque bolts to 22 ±5 inch-pounds. Safetywire bolts.

r. Using new seal (2), connect tube (1) to elbow (23). Torque tube coupling nut to 160 ±10 inch-pounds. Safetywire coupling nut.

CAUTION

The position of harness support block (3) must not be allowed to change while torquing the bolts.

k. Install harness support clamp (1). Torque bolts that secure clamp (1) to harness support block (3) to 45 ±5 in-lb. Safetywire bolts.

l. Aline harness with transducer by adjusting harness support block (3) so that no strain is applied to harness or transducer; then torque bolts that secure support block to 70 ±5 in-lb.

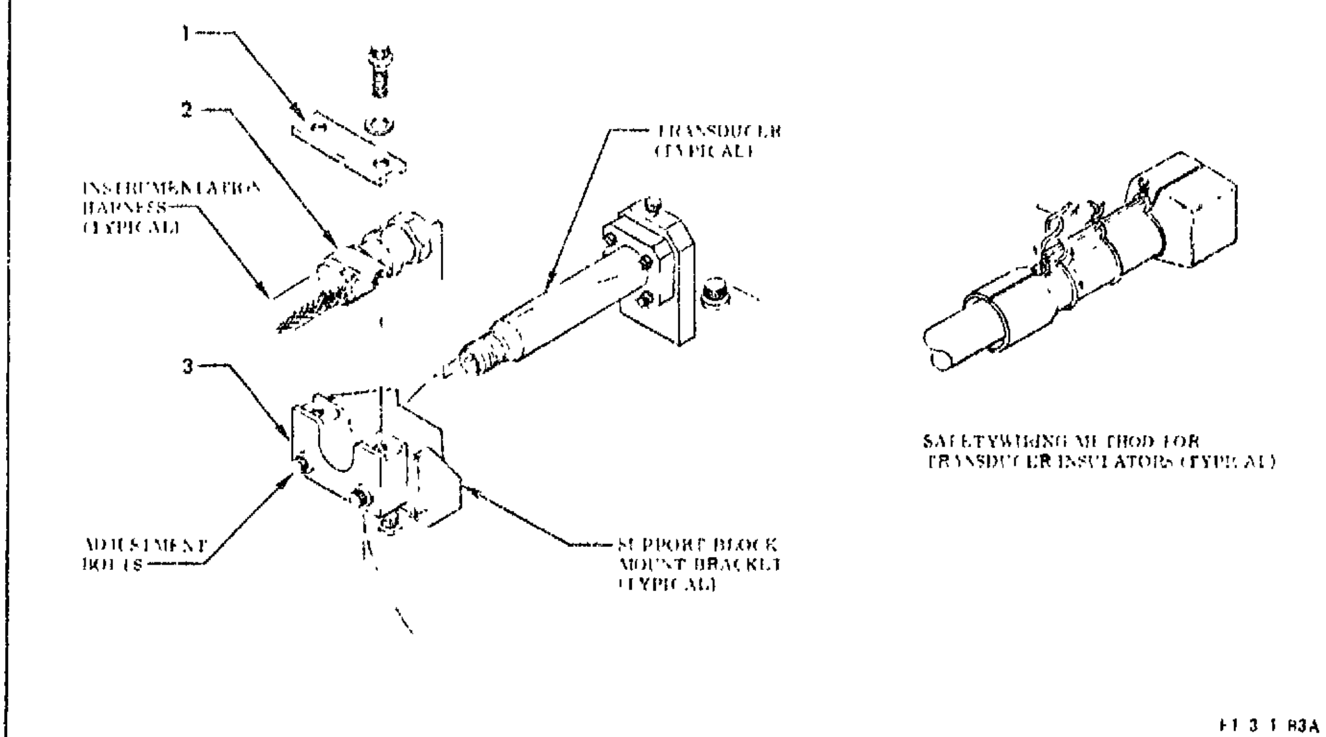
m. Install transducer insulator and safetywire, if applicable. See figure 3-6 for typical safety-wiring method used on transducer insulators.

n. Install harness support clamps.

o. If an electrical plug to a transducer appears to be loose even though the plug is torqued and safetywired, the acceptance criteria and disposition are as follows:

(1) A loose plug is defined as one in which the coupling nut can be turned by hand in the tightening direction one-quarter turn or more.

(2) If a plug is found to be loose, the plug must be disconnected, as outlined in paragraph 3-16, and the plug gasket replaced, as outlined in this procedure and connector retorqued.



Index No.	Name and Attaching Parts	Part Number	Quantity
1	Harness support clamp	703002	1
	Bolt	RD111-4008-3405	2
	Washer	RD153-5002-0004	2
2	Clamp	RE127-2002-0010	1
3	Harness support block	703001	1
	Bolt	RD111-4011-6423	2
	Washer	RD153-1002-0004	2
	Washer	RD153-5002-0004	2
	Nut	RD114-8005-1004	2

Figure 3-6. Electrical Plug Connection to Flight Instrumentation Pressure Transducers (Typical)

3-18. HARNESS AND CABLE INSTALLATION REQUIREMENTS. The following steps outline the essential requirements that are applicable when installing any electrical harness or cable.

a. If installing a replacement harness or cable, verify that harness or cable preinstallation tests outlined in section I have been performed.

b. Position harness on engine, routing various branches to respective connect points. Check breakout molds for proper location.

c. Wherever possible, connect electrical connectors to their respective counterparts as outlined in paragraph 3-15, prior to installing harness support clamps, to prevent possible preloading of connectors. If instrumentation harness is installed, connect harness to transducers (if applicable) as outlined in paragraph 3-17.

d. Install harness support clamps, making sure no excessive strain is applied to harness. Tighten support clamp screws sufficiently to prevent harness movement within clamp, yet not damage harness. Clamps, up to and including three sizes smaller or larger than those specified, may be substituted when it is necessary to ensure proper clamping. Typical harness support clamp installations are shown in figure 3-7.

NOTE

Distance between harness support clamps must not exceed 16 inches.

e. Position clamps to obtain maximum separation between harnesses and adjoining surfaces. Additional clamps and spacers may be added between harnesses or cables to obtain proper clearance. When additional clamps are used, they must be installed between adjacent harnesses or cables, and not to other components. The following clamp assembly of proper size must be used: clamp RE127-2005-XXXX, screw AN520C10, washer LD153-0010-0007, and nut NAS679C3W. Acceptable clearances are as follows:

(1) A 1/8-inch clearance must be maintained between harness and all tubing.

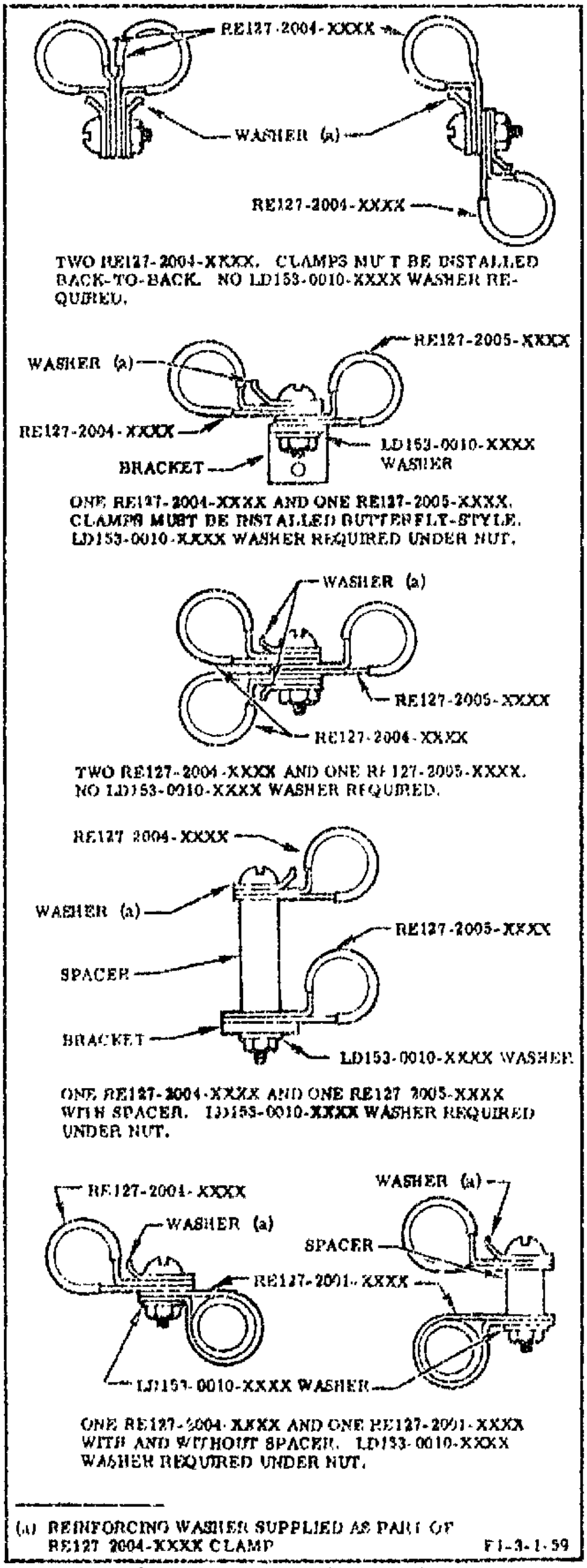


Figure 3-7. Typical Electrical Harness Clamping Installations

(2) Harnesses must not be allowed to come into direct contact with any component that contains hot gas, other than the normal harness electrical plug connection to a component used in the hot-gas system. Indirect contact, such as contact with a harness support clamp attached to a hot-gas component, is acceptable.

(3) Harnesses must not be allowed to contact any surface with a sharp edge (less than 0.12 inch radius).

(4) Harnesses may touch all other surfaces, including other harnesses, except those listed.

3-19. ENGINE CONTROL HARNESSES AND CABLES.

3-20. The following procedures outline the removal and reinstallation and/or replacement of engine control harnesses and cables.

3-21. J18 AND J20 HARNESS.

3-22. REMOVING J18 AND J20 HARNESS. (See figure 3-8.)

a. Make sure that electrical power source is turned off.

WARNING

Disconnecting or connecting electrical connectors without turning off the power source can cause electrical arcing between connectors, resulting in serious injury or death to personnel and damage to equipment.

b. Disconnect electrical interface receptacles J18 (2) and J20 (2) from interface panel.

c. Where necessary, remove enough harness support clamps to allow electrical connectors to be disconnected without strain to harness.

d. Disconnect electrical plug P30 (3) from checkout valve, plugs P51 (4) and P52 (5) from engine control valve, plug P75 (6) from thermostat support bracket, plug P78 (7) from No. 2 thrust OK pressure switch (redesignated No. 1 switch on engines incorporating MD157 or MD158 change), and plug P128 (8) from bracket at thrust chamber as outlined in paragraph 3-14.

e. Remove remaining harness support clamps, and carefully remove harness (1) from engine.

f. Install protective dust caps on electrical plugs and receptacles. Dust-cap requirements, by connector reference designation number, are listed in R-3896-4.

g. For servicing or maintenance, install dust caps fingertight on electrical connectors. If harness is to be stored or shipped, torque dust caps on electrical connectors. Dust-cap torque requirements, by connector number, are listed in figure 3-4.

h. If harness is to be transported to a repair area or stored, wrap harness with cushioning material to prevent possible damage. Wrap each individual electrical connector with cushioning material to prevent damage to connectors or other parts of harness.

3-23. INSTALLING J18 AND J20 HARNESS. (See figure 3-8.)

a. Observe harness installation requirements outlined in paragraph 3-18.

b. Position harness on engine, routing various branches to respective connect points. Check breakout molds for proper location.

c. Connect electrical plugs P30 (3), P51 (4), P52 (5), P75 (6), P78 (7), and P128 (8), as outlined in paragraph 3-15, to their respective counterparts prior to installing harness support clamps, to prevent possible preloading of connectors.

d. Connect electrical interface receptacles J18 (2) and J20 (2) to interface panel. Install 4 attach bolts located toward centerline of turbopump from aft side of interface panel. Torque nuts to 70 ±5 in-lb.

e. Install harness support clamp assemblies (9) through (30) (clamp assemblies (26) through (30) are applicable to engines not incorporating MD96 change), starting with clamp assembly (9) and working toward electrical plug P30 (3), making sure no excessive strain is applied to harness. Tighten harness support clamp screws sufficiently to prevent harness movement within clamp, yet not damage harness.

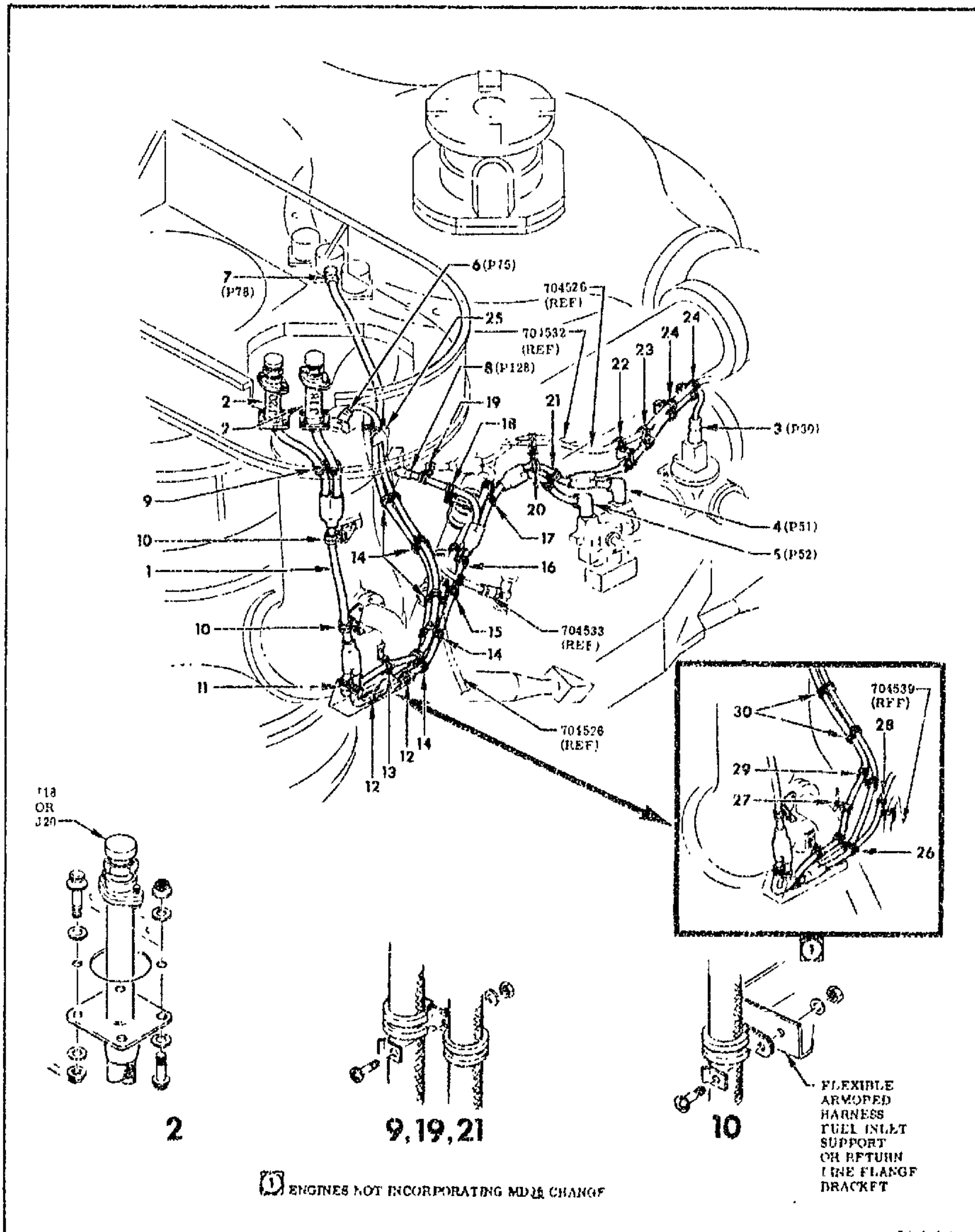


Figure 3-8. J18 and J20 Harness (Sheet 1 of 3)

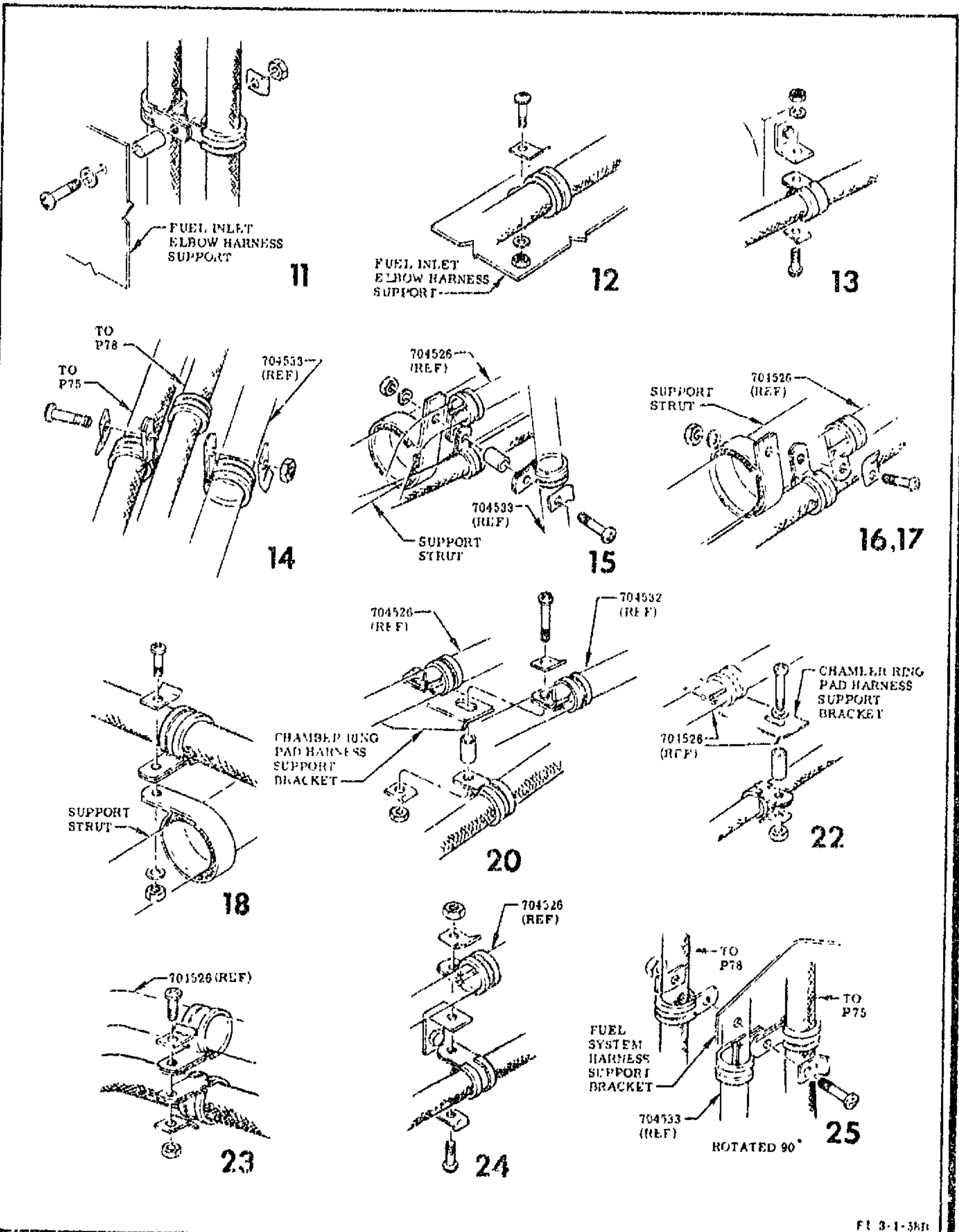
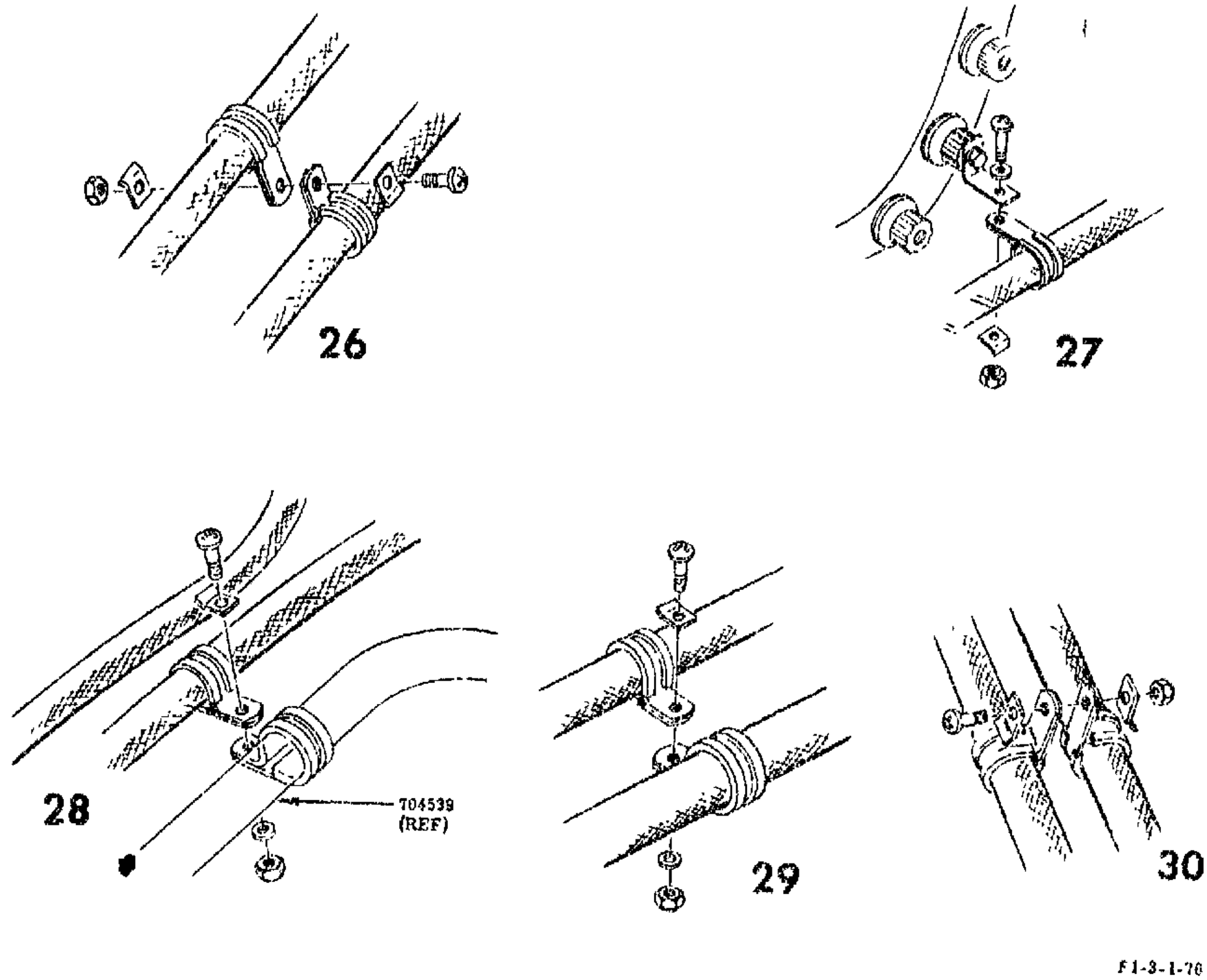


Figure 3-8. J18 and J20 Harness (Sheet 2 of 3)



Index No.	Name Attachin
1	J18 and harness
2	Electric terface tacle J1
2	Electric terface tacle J2
	Bolt
	Washe
	Washe
	Nut
3	Electric P30
	Boot
4	Electric P51
	Boot
5	Electric P52
	Boot
6	Electrica P75
	Boot
7	Electrica P78
	Boot
8	Electrica P128
	Boot
9	Clamp as
	Clamp
	Clamp
	Screw
	Washer
	Nut
10	Clamp as
	Clamp
	Screw
	Washer
	Nut
11	Clamp as
	Clamp
	Clamp
	Screw
	Spacer
	Washer
	Nut
12	Clamp as
	Clamp
	Screw
	Washer
	Nut

Figure 3-8. J18 and J20 Harness (Sheet 3 of 3)

F1-3-1-76

Index No.	Name and Attaching Parts	Part No.	Quantity
1	J18 and J20 harness	502944	1
2	Electrical interface receptacle J18	703937-111	1
2	Electrical interface receptacle J20	703937-91	1
	Bolt	RD114-4011-6414	8
	Washer	RD153-5002-0004	8
	Washer	RD153-1002-0004	8
	Nut	RD111-8003-1004	8
3	Electrical plug P30	502935-171	1
	Boot	19-501743-4	1
4	Electrical plug P51	502937-71	1
	Boot	19-501745-2	1
5	Electrical plug P52	502937-41	1
	Boot	19-501745-2	1
6	Electrical plug P75	502935-111	1
	Boot	19-501743-3	1
7	Electrical plug P78	502935-91	1
	Boot	19-501743-3	1
8	Electrical plug P128	502935-41	1
	Boot	19-501743-2	1
9	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0012	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
10	Clamp assembly		
	Clamp	RE127-2004-0014	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
11	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0011	1
	Screw	AN520C10R18	1
	Spacer	NAS43DD3-24	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
12	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
13	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
14	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0008	1
	Screw	AN520C10R12	1
	Nut	NAS679C3W	1
15	Clamp assembly		
	Clamp	RE127-2001-0045	1
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0012	2
	Screw	AN520C10R26	1
	Spacer	NAS43DD3-48	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
16	Clamp assembly		
	Clamp	RE127-2001-0045	1
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0012	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
17	Clamp assembly		
	Clamp	RE127-2001-0045	1
	Clamp	RE127-2004-0015	1
	Clamp	RE127-2005-0011	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
18	Clamp assembly		
	Clamp	RE127-2001-0045	1
	Clamp	RE127-2004-0007	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
19	Clamp assembly		
	Clamp	RE127-2004-0007	1
	Clamp	RE127-2005-0015	1
	Screw	AN520C10R8	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
20	Clamp assembly		
	Clamp	RE127-2004-0011	1
	Clamp	RE127-2004-0013	1
	Screw	AN520C10R22	1
	Spacer	NAS43DD3-40	1
	Nut	NAS679C3W	1

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Index No.	Name and Attaching Parts	Part No.	Quantity
13	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
14	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0008	1
	Screw	AN520C10R12	1
	Nut	NAS679C3W	1
15	Clamp assembly		
	Clamp	RE127-2001-0045	1
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0012	2
	Screw	AN520C10R26	1
	Spacer	NAS43DD3-48	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
16	Clamp assembly		
	Clamp	RE127-2001-0045	1
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0012	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
17	Clamp assembly		
	Clamp	RE127-2001-0045	1
	Clamp	RE127-2004-0015	1
	Clamp	RE127-2005-0011	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
18	Clamp assembly		
	Clamp	RE127-2001-0045	1
	Clamp	RE127-2004-0007	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
19	Clamp assembly		
	Clamp	RE127-2004-0007	1
	Clamp	RE127-2005-0015	1
	Screw	AN520C10R8	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
20	Clamp assembly		
	Clamp	RE127-2004-0011	1
	Clamp	RE127-2004-0013	1
	Screw	AN520C10R22	1
	Spacer	NAS43DD3-40	1
	Nut	NAS679C3W	1

Index No.	Name and Attaching Parts	Part No.	Quantity
21	Clamp assembly		
	Clamp	RE127-2004-0011	1
	Clamp	RE127-2005-0007	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
22	Clamp assembly		
	Clamp	RE127-2004-0011	1
	Screw	AN520C10R22	1
	Spacer	NAS43DD3-40	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
23	Clamp assembly		
	Clamp	RE127-2004-0011	2
	Screw	AN520C10R10	1
	Nut	NAS679C3W	1
24	Clamp assembly		
	Clamp	RE127-2004-0011	1
	Clamp	RE127-2004-0012	1
	Screw	AN520C10R10	1
	Nut	NAS679C3W	1
25	Clamp assembly		
	Clamp	RE127-2004-0008	1
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2005-0012	1
	Screw	AN520C10R14	1
	Nut	NAS679C3W	1
26	Clamp assembly		
	Clamp	RE127-2004-0008	1
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R12	1
	Nut	NAS679C3W	1
27	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
28	Clamp assembly		
	Clamp	RE127-2004-0018	1
	Clamp	RE127-2005-0012	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
29	Clamp assembly		
	Clamp	RE127-2004-0008	1
	Clamp	RE127-2005-0008	1
	Screw	AN520C10R14	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
30	Clamp assembly		
	Clamp	RE127-2004-0008	1
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R12	1
	Nut	NAS679C3W	1

3-24. J19 HARNESS.

3-25. REMOVING J19 HARNESS (See figure 3-9.)

a. Make sure that electrical power source is turned off.

WARNING

Disconnecting or connecting electrical connectors without turning off the power source can cause electrical arcing between connectors, resulting in serious injury or death to personnel and damage to equipment.

b. Disconnect electrical interface receptacle J19 (2) from interface panel.

c. Disconnect electrical plugs P50 (3) from redundant shutdown valve, and P56 (4) from hypergol manifold, as outlined in paragraph 3-14.

d. Remove harness support clamp assemblies (5) through (20), and carefully remove harness (1) from engine.

e. Install protective dust caps on electrical plugs and receptacle. Dust-cap requirements, by connector reference designation number, are listed in R-3896-4.

f. For servicing or maintenance, install dust caps fingertight on electrical connectors. If harness is to be stored or shipped, torque dust caps on electrical connectors. Dust-cap torque requirements, by connector number, are listed in figure 3-4.

g. If harness is to be transported to a repair area or stored, wrap harness with cushioning material to prevent possible damage. Wrap each individual electrical connector with cushioning material to prevent damage to connectors or other parts of harness.

3-26. INSTALLING J19 HARNESS. (See figure 3-9.)

a. Observe harness installation requirements outlined in paragraph 3-18.

b. Position harness on engine, routing electrical connectors to hypergol manifold and redundant shutdown valve connect points. Check breakout mold for proper location.

c. Connect electrical plugs P50 (3) and P56 (4) as outlined in paragraph 3-15 to redundant shutdown valve and hypergol manifold to prevent possible preloading of connectors.

d. Connect electrical interface receptacle J19 (2) to interface panel. Torque nuts to 70 ±5 in-lb.

e. Install harness support clamp assemblies (5) through (20) starting with clamp closest to center of harness and working toward receptacle and connectors. Make sure no excessive strain is applied to harness. Tighten harness support clamp screws sufficiently to prevent harness movement within clamp, yet not damage harness.

3-27. J142 CABLE.

3-28. REMOVING J142 CABLE. (See figure 3-10.)

a. Make sure that electrical power source is turned off.

WARNING

Disconnecting or connecting electrical connectors without turning off the power source can cause electrical arcing between connectors, resulting in serious injury or death to personnel and damage to equipment.

b. Disconnect electrical interface receptacle J142 (2) from interface panel.

c. Disconnect electrical plug P73 (3) from No. 1 thrust OK pressure switch (redesignated No. 2 switch on engines incorporating MD157 or MD158 change), as outlined in paragraph 3-14.

d. Remove cable support clamp assemblies (4) through (7). On engines not incorporating MD98 change, remove clamp assemblies (5) through (9). Carefully remove cable (1) from engine.

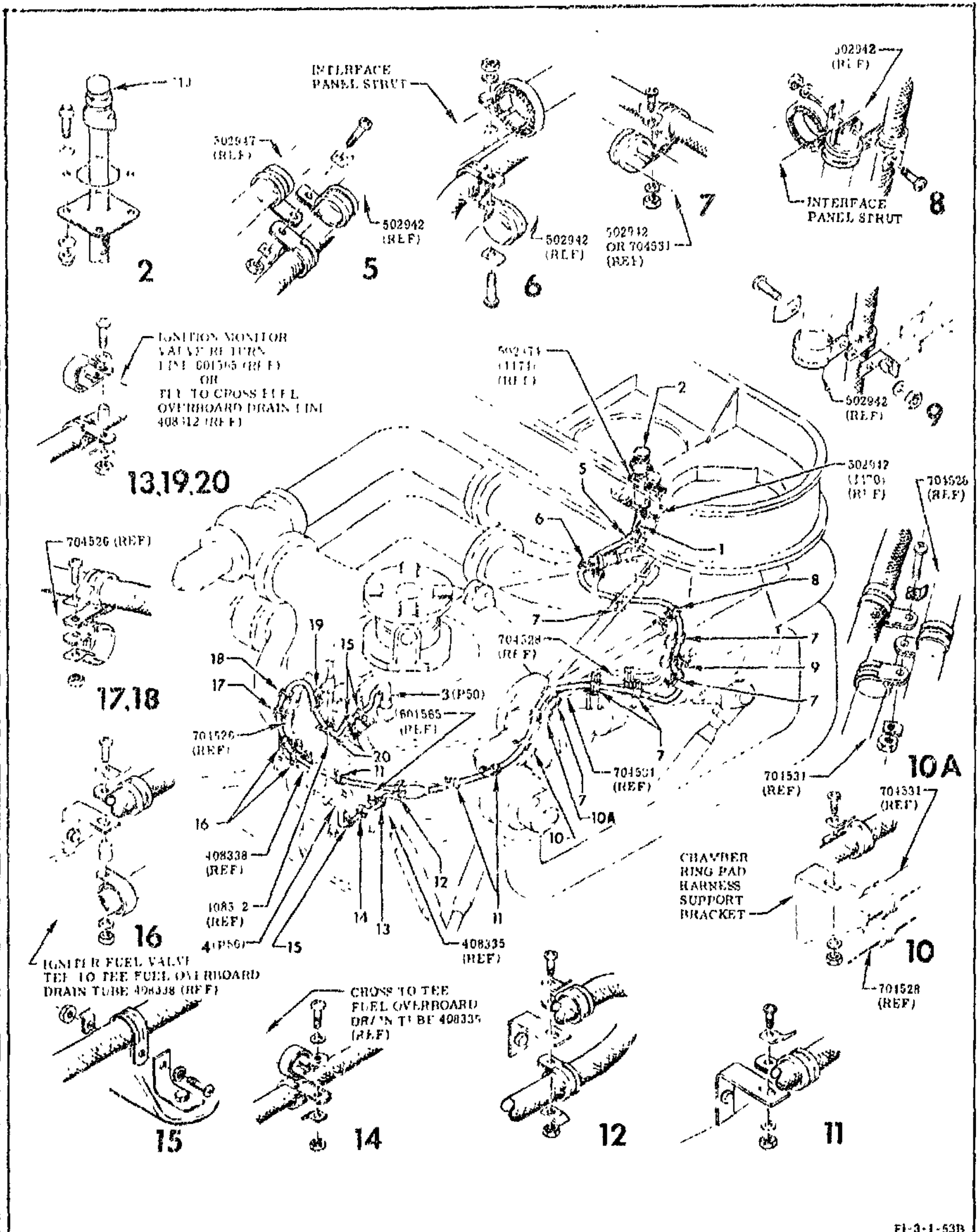


Figure 3-9. J19 Harness (Sheet 1 of 3)

Index No.	Name and Attaching Parts	Part No.	Quantity
1	J19 harness	502948-11	1
2	Electrical interface receptacle J19	703937-51	1
	Bolt	RD111-4011-6414	4
	Washer	RD153-5002-0004	4
	Washer	RD153-1002-0004	4
	Nut	RD114-8003-1004	4
3	Electrical plug P50	502937-91	1
	Boot	19-501745-3	1
4	Electrical plug P56	502937-91	1
	Boot	19-501745-3	1
5	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2004-0015	1
	Clamp	RE127-2005-0009	1
	Screw	AN520C10R12	1
	Nut	NAS679C3W	1
6	Clamp assembly		
	Clamp	RE127-2001-0026	1
	Clamp	RE127-2004-0015	1
	Clamp	RE127-2005-0009	1
	Screw	AN520C10R24	1
	Spacer	NAS43DD3-48	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
7	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2005-0015	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
8	Clamp assembly		
	Clamp	RE127-2001-0026	1
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2005-0015	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
9	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2005-0015	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
10	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
10A	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2004-0014	1
	Clamp	RE127-2005-0009	1
	Screw	AN520C10R12	1
	Nut	NAS679C3W	1
11	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
12	Clamp assembly		
	Clamp	RE127-2004-0008	1
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R10	1
	Nut	NAS679C3W	1
13	Clamp assembly		
	Clamp	RE127-2001-0008	1
	Clamp	RE127-2004-0008	1
	Screw	AN520C10R14	1
	Spacer	NAS43DD3-24	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
14	Clamp assembly		
	Clamp	RE127-2001-0006	1
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
15	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS699C3W	1
16	Clamp assembly		
	Clamp	RE127-2001-0008	1
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R17	1
	Spacer	NAS43HT3-24	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
17	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2004-0012	1
	Screw	AN520C10R10	1
	Nut	NAS679C3W	1
18	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2004-0010	1
	Screw	AN520C10R10	1
	Nut	NAS679C3W	1

Figure 3-9. J19 Harness (Sheet 2 of 3)

Index No.	Name and Attaching Parts	Part No.	Quantity
19	Clamp assembly		
	Clamp	RE127-2001-0008	1
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R16	1
	Spacer	NAS43DD3-24	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
20	Clamp assembly		
	Clamp	RE127-2001-0010	1
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R16	1
	Spacer	NAS43DD3-24	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1

Figure 3-9. J19 Harness (Sheet 3 of 3)

e. Install protective dust caps on electrical plug and receptacle. Dust-cap requirements, by connector reference designation number, are listed in R-3896-4.

f. For servicing or maintenance, install dust caps fingertight on electrical connectors. If cable is to be stored or shipped, torque dust caps on electrical connectors. Dust-cap torque requirements, by connector number, are listed in figure 3-4.

g. If cable is to be transported to a repair area or stored, wrap cable with cushioning material to prevent possible damage. Wrap each individual electrical connector with cushioning material to prevent damage to connectors or other parts of cable.

3-29. INSTALLING J142 CABLE. (See figure 3-10.)

a. Observe harness installation requirements outlined in paragraph 3-18.

b. Position cable on engine, routing electrical connector to connect point at No. 1 thrust OK pressure switch (redesignated No. 2 switch on engines incorporating MD157 or MD158 change).

c. Temporarily connect electrical plug P73 (3) fingertight to thrust OK pressure switch as outlined in paragraph 3-15 to prevent possible preloading of connector.

d. Connect electrical interface receptacle J142 (2) to interface panel. Torque nuts to 70 ±5 in-lb.

e. Install cable support clamp assemblies (4) through (7), starting with clamp assembly (4) and working toward electrical plug P73 (3), making sure no excessive strain is applied to cable. On engines not incorporating MD96 change, install cable support clamp assemblies (5) through (9), starting with clamp assembly (8) and working toward electrical plug P73 (3), making sure no excessive strain is applied to cable. Tighten cable support clamp screws sufficiently to prevent movement within clamp yet not damage cable.

3-30. J174 CABLE.

3-31. REMOVING J174 CABLE. (See figure 3-11.)

a. Make sure that electrical power source is turned off.

WARNING

Disconnecting or connecting electrical connectors without turning off the power source can cause electrical arcing between connectors, resulting in serious injury or death to personnel and damage to equipment.

b. Disconnect electrical interface receptacle J174 (2) from interface panel.

c. Disconnect electrical plug P74 (3) from No. 3 thrust OK pressure switch.

d. Remove harness support clamp assemblies (4) and (5), and carefully remove cable (1) from engine.

e. Install protective dust caps on electrical plug and receptacle. Dust-cap requirements, by connector reference designation number, are listed in R-3896-4.

f. For servicing or maintenance, install dust caps fingertight on electrical connectors. If cable is to be stored or shipped, torque dust caps on electrical connectors. Dust-cap torque requirement, by connector number, are listed in figure 3-4.

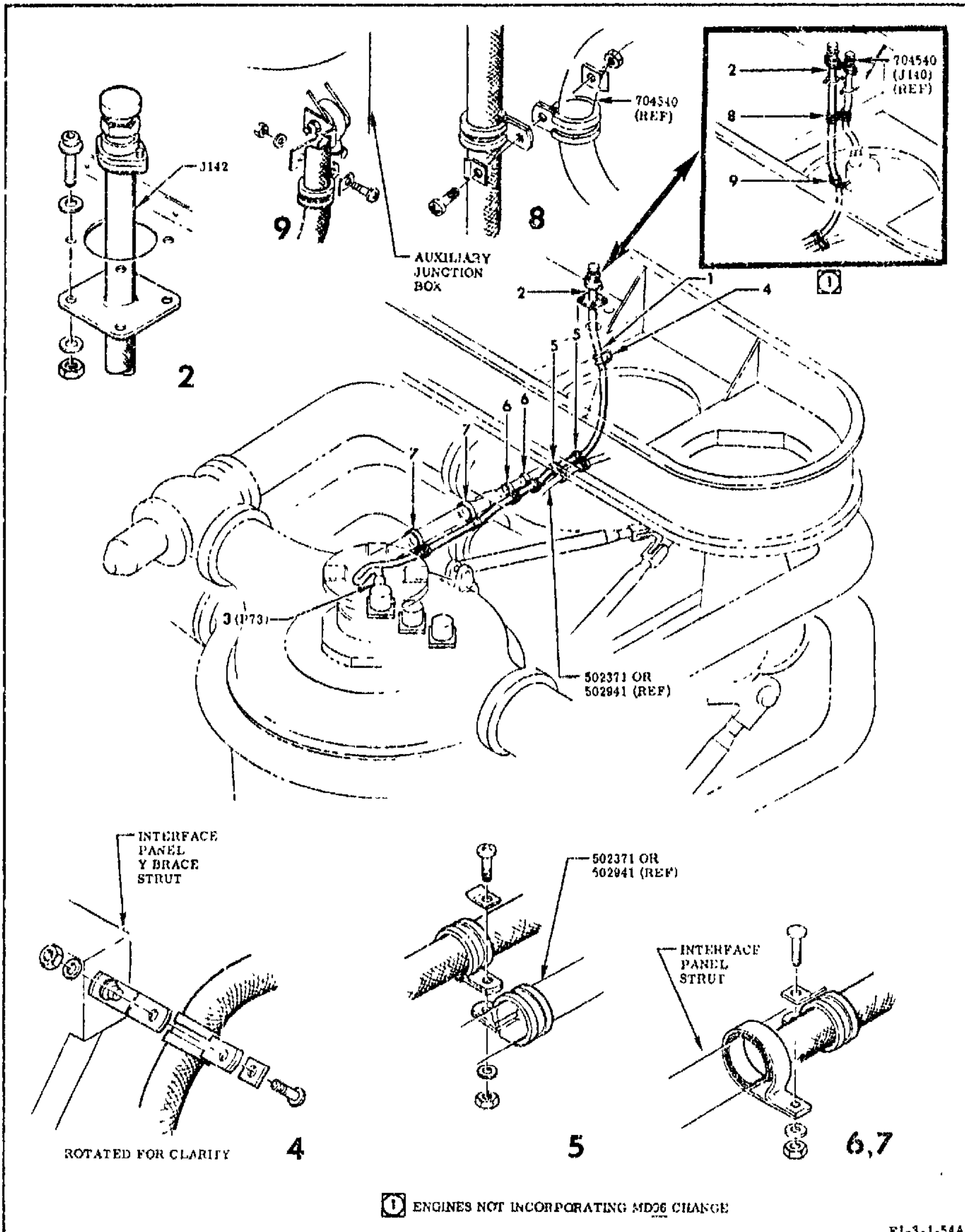


Figure 3-10. J142 Cable (Sheet 1 of 2)

Index No.	Name and Attaching Parts	Part No.	Quantity
1	J142 cable	502949	1
2	Electrical interface receptacle J142	703937-141	1
	Bolts	RD111-4011-6417	3
	Washer	RD153-5002-0004	3
	Washer	RD153-1002-0004	3
	Nut	RD114-8003-1004	3
3	Electrical plug P73	502937-91	1
	Boot	19-501745-3	1
4	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
	Bracket	RD127-9001-1220	1
	Bolt	RD111-4010-6409	1
	Washer	RD153-5002-0004	1
5	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2005-0009	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
6	Clamp assembly		
	Clamp	RE127-2001-0018	1
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
7	Clamp assembly		
	Clamp	RE127-2001-0026	1
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
8	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2004-0010	1
	Screw	AN520C10R12	1
	Nut	NAS679C3W	1
9	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1

Figure 3-10. J142 Cable (Sheet 2 of 2)

g. If cable is to be transported to a repair area or stored, wrap cable with cushioning material to prevent possible damage. Wrap each individual electrical connector with cushioning material to prevent damage to connectors or other parts of cable.

3-32. INSTALLING J174 CABLE. (See figure 3-11.)

a. Observe cable installation requirements outlined in paragraph 3-18.

b. Position cable on engine, routing electrical connector to connect point at No. 3 thrust OK pressure switch.

c. Connect electrical plug P74 (3), to No. 3 thrust pressure switch as outlined in paragraph 3-15 to prevent possible preloading of connector.

d. Connect electrical interface receptacle J174 (2) to interface panel. Torque nuts to 70 ±5 in-lb.

e. Install cable support clamp assemblies (4) and (5), making sure no excessive strain is applied to cable. Tighten cable support clamp screws sufficiently to prevent movement within clamp, yet not damage cable.

3-33. J800 HARNESS.

3-34. REMOVING J800 HARNESS. (See figure 3-12.)

a. Make sure that electrical power source is turned off.

WARNING

Disconnecting or connecting electrical connectors without turning off the power source can cause electrical arcing between connectors, resulting in serious injury or death to personnel and damage to equipment.

b. Disconnect electrical interface receptacle J800 (2) from interface panel.

c. Disconnect electrical plugs P85 (3), P86 (4), P87 (5), and P88 (6) from lower connector panel at turbopump as outlined in paragraph 3-14.

d. Remove harness support clamp assemblies (7), (8), and (9), and carefully remove harness (1) from engine.

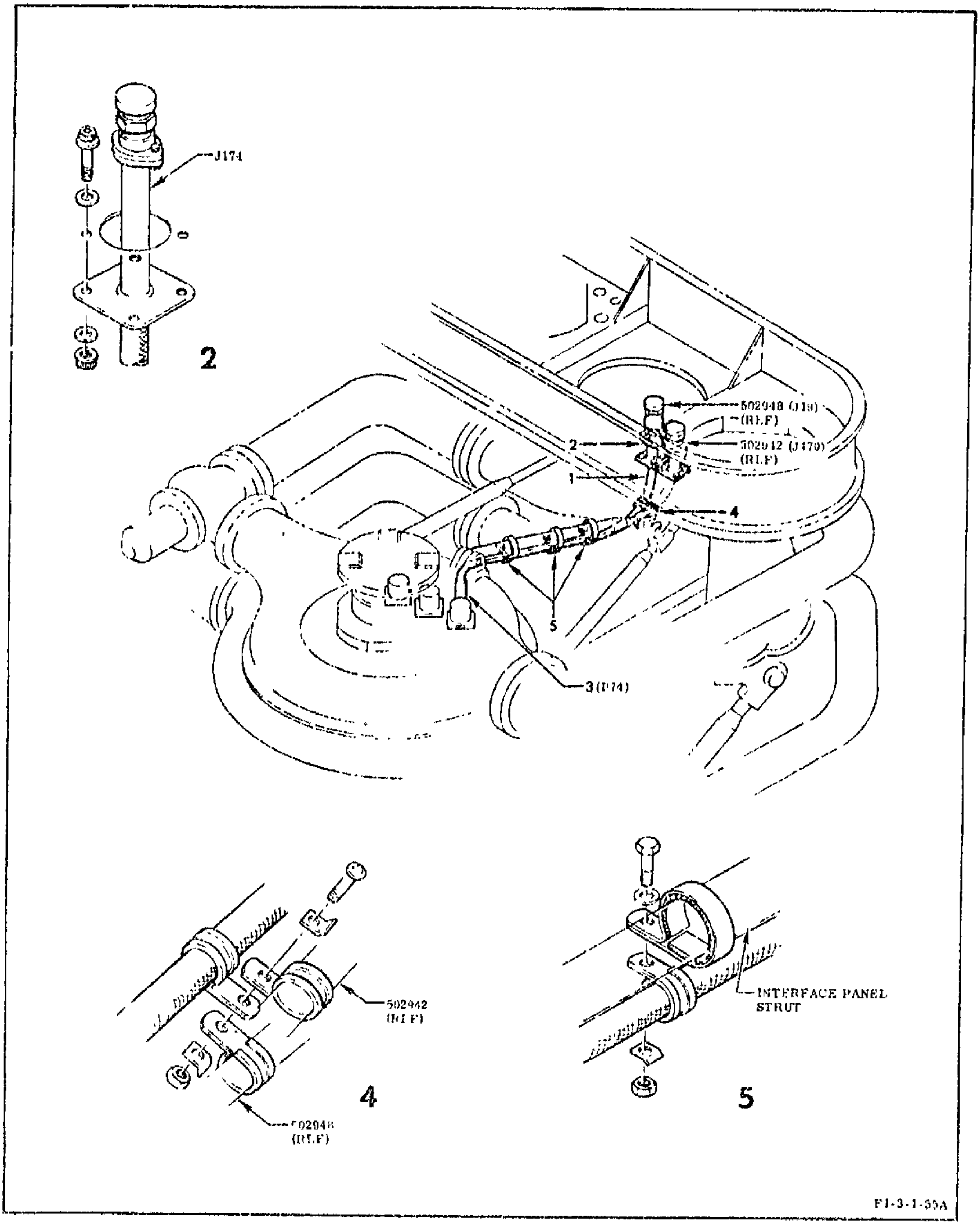


Figure 3-11. J174 Cable (Sheet 1 of 2)

Index No.	Name and Attaching Parts	Part No.	Quantity	Index No.	Name and Attaching Parts	Part No.	Quantity
1	J174 cable	502947	1	4	Clamp assembly		
2	Electrical interface receptacle J174	703937-131	1		Clamp	RE127-2004-0009	1
					Clamp	RE127-2004-0015	1
					Clamp	RE127-2005-0009	1
	Bolt	RD111-4011-6414	4		Screw	AN520C10R12	1
	Washer	RD153-5002-0004	4		Nut	NAS679C3W	1
	Washer	RD153-1002-0004	4	5	Clamp assembly		
	Nut	RD114-8003-1004	4		Clamp	RE127-2001-0026	1
3	Electrical plug P74	502937-91	1		Clamp	RE127-2004-0009	1
	Boot	19-501745-3	1		Screw	AN520C10R12	1
					Washer	LD153-0010-0007	1
					Nut	NAS679C3W	1

Figure 3-11. J174 Cable (Sheet 2 of 2)

e. Install protective dust caps on electrical plugs and receptacle. Dust-cap requirements, by connector reference designation number, are listed in R-3896-4.

f. For servicing or maintenance, install dust caps fingertight on electrical connectors. If harness is to be stored or shipped, torque dust caps on electrical connectors. Dust-cap torque requirements, by connector number, are listed in figure 3-4.

g. If harness is to be transported to a repair area or stored, wrap harness with cushioning material to prevent possible damage. Wrap each individual electrical connector with cushioning material to prevent damage to connectors or other parts of harness.

3-35. INSTALLING J800 HARNESS. (See figure 3-12.)

a. Observe harness installation requirements outlined in paragraph 3-18.

b. Position harness on engine, routing electrical connectors to respective connect points on lower connect panel at turbopump. Check breakout mold for proper location.

c. Connect electrical plugs P85 (3), P86 (4), P87 (5), and P88 (6), as outlined in paragraph 3-15, to their respective electrical receptacles on lower connector panel, to prevent possible preloading of connectors.

d. Connect electrical interface receptacle J800 (2) to interface panel. Check that connector ears of receptacle J800 are positioned parallel with interface panel. Torque nuts to 70 ±5 in-lb.

e. Install harness support clamp assemblies (7), (8), and (9), making sure no excessive strain is applied to harness. Tighten harness support clamp screws sufficiently to prevent harness movement within clamp, yet not damage harness.

3-36. FLIGHT INSTRUMENTATION HARNESSES AND CABLES (ENGINES INCORPORATING MD96 CHANGE.)

3-37. The following procedures outline the removal and reinstallation or replacement of the flight instrumentation electrical harnesses and cables. These procedures are applicable to an engine configuration incorporating MD96 change.

3-38. J100, J101, J102, AND J103 CABLES.

3-39. Because of the simplified configuration of interconnect cables J100, J101, J102, and J103 between the interface panel and the primary junction box, the removal and installation procedures for these cables are combined into one procedure.

3-40. REMOVING J100, J101, J102, AND J103 CABLES. (See figure 3-13.)

a. Make sure that electrical power source is turned off.

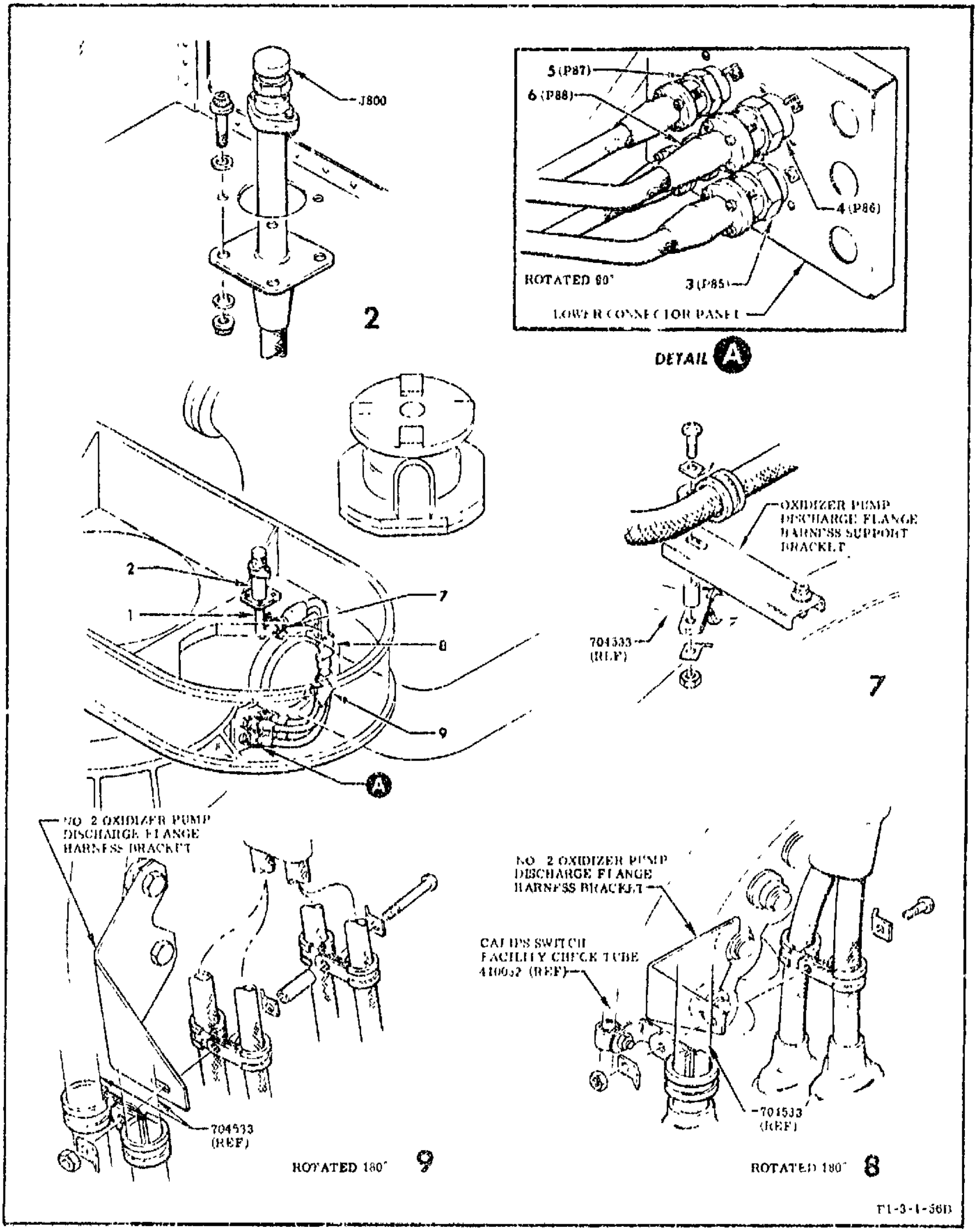


Figure 3-12. .800 Harness (Sheet 1 of 2)

Index No.	Name and Attaching Parts	Part No.	Quantity	Index No.	Name and Attaching Parts	Part No.	Quantity
1	J800 harness	502943	1	7	Clamp assembly		
2	Electrical interface receptacle J800	703937-11	1		Clamp	RE127-2004-0012	1
					Clamp	RE127-2004-0014	1
					Spacer	NAS43DD3-14	1
	Bolt	RD111-4011-6414	4		Screw	AN520C10R16	1
	Washer	RD153-5002-0004	4		Nut	NAS679C3W	1
	Washer	RD153-1002-0004	4	8	Clamp assembly		
	Nut	RD114-8003-1004	4		Clamp	RE127-2004-0010	1
3	Electrical plug P85	502935-31	1		Clamp	RE127-2004-0014	1
					Clamp	RE127-2005-0010	1
	Boot	19-501743-2	1		Screw	AN520C10R14	1
4	Electrical plug P86	502935-31	1		Nut	NAS679C3W	1
				9	Clamp assembly		
	Boot	19-501743-2	1		Clamp	RE127-2004-0007	2
5	Electrical plug P87	502935-11	1		Clamp	RE127-2004-0012	1
					Clamp	RE127-2005-0007	2
	Boot	19-501743-1	1		Clamp	RE127-2005-0012	1
6	Electrical plug P88	502935-11	1		Screw	AN520C10R30	1
					Spacer	NAS43DD3-40	1
	Boot	19-501743-1	1		Nut	NAS679C3W	1

Figure 3-12. J800 Harness (Sheet 2 of 2)

WARNING

Disconnecting or connecting electrical connectors without turning off the power source can cause electrical arcing between connectors, resulting in serious injury or death to personnel and damage to equipment.

b. If J100 (1) or J103 (10) cable is to be removed, remove cable support clamp assembly (13), if installed. (Clamp assembly is not required for reinstallation.)

c. Disconnect applicable electrical interface receptacle J100 (2), J101 (5), J102 (8), or J103 (11), from interface panel.

d. Disconnect applicable electrical plug, P108 (3), P109 (6), P110 (9), or P115 (12), from primary junction box, as outlined in paragraph 3-14, and carefully remove applicable cable from engine.

e. Install protective dust caps on electrical plugs and receptacles. Dust cap requirements, by connector reference designation number, are listed in R-3896-4.

f. For servicing or maintenance, install dust caps fingertight on electrical connectors. Dust cap torque requirements, by connector number, are listed in figure 3-4.

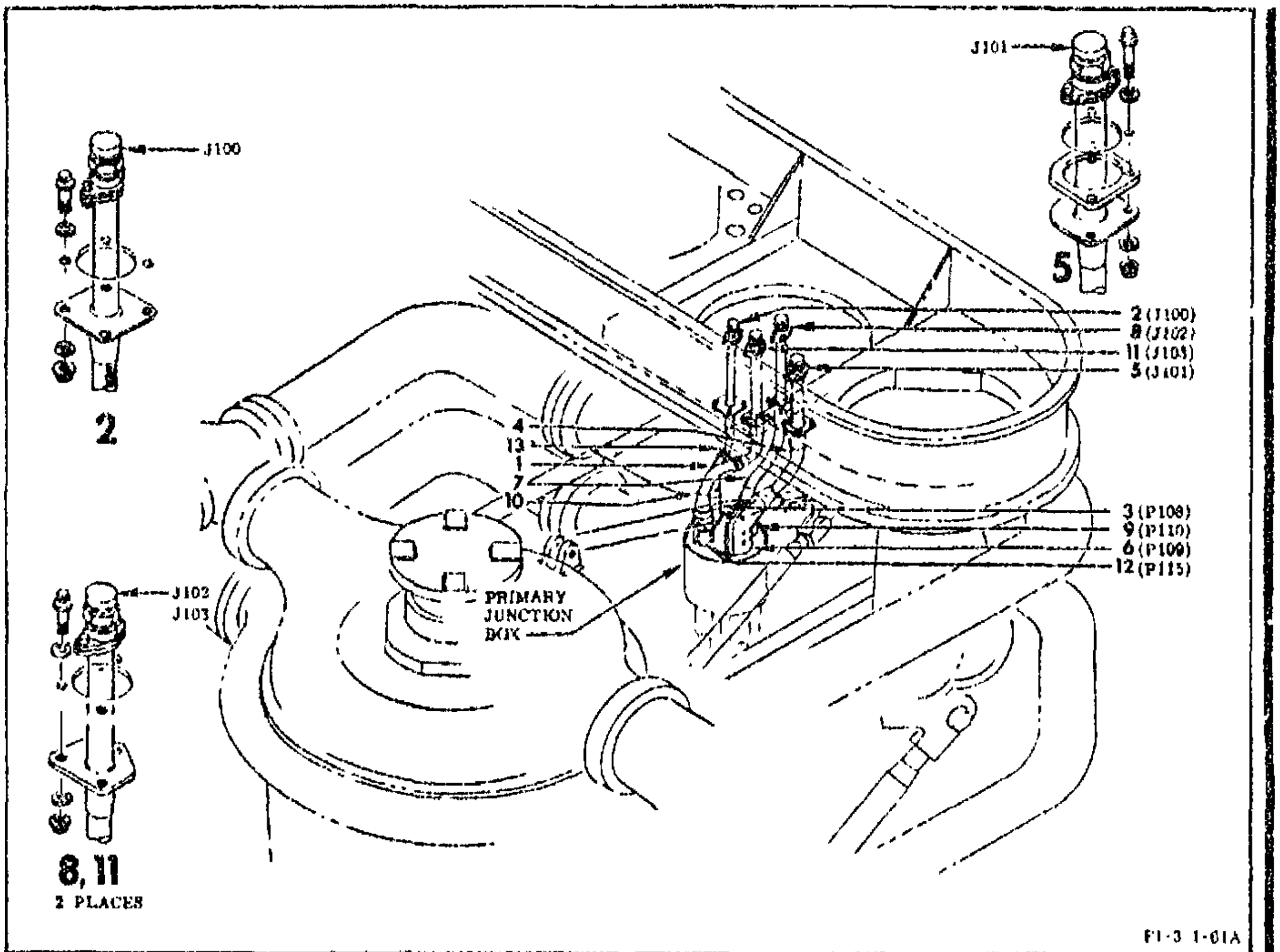
g. If cable is to be transported to a repair area or is to be stored, wrap cable with cushioning material to prevent possible damage. Wrap each individual electrical connector with cushioning material to prevent damage to connectors or other parts of the cable.

3-41. INSTALLING J100, J101, J102, AND J103 CABLES. (See figure 3-13.)

a. Observe cable installation requirements outlined in paragraph 3-18.

b. Position cable on engine, routing applicable electrical connectors to their respective connect points at interface panel and primary junction box.

c. Connect applicable electrical plug P108 (3), P109 (6), P110 (9), or P115 (12), fingertight as outlined in paragraph 3-15, to primary junction box to prevent possible preloading of connector.



Index No.	Name and Attaching Parts	Part No.	Quantity
1	J100 cable	704538	1
2	Electrical interface receptacle J100	703937-21	1
	Bolt	RD111-4011-6414	4
	Washer	RD153-1002-0004	4
	Washer	AS-30(a)	4
	Nut	RD114-8003-1004	4
3	Electrical plug P108	502935-211	1
	Boot	19-501743-5	1
4	J101 cable	704520	1
5	Electrical interface receptacle J101	703937-101	1
	Bolt	RD111-4011-6423	3
	Spacer	RD152-0003-0001	1
	Washer	RD153-1002-0004	3
	Washer	RD153-5002-0004	3
	Nut	RD114-8003-1004	3
6	Electrical plug P109	502937-611	1
	Boot	19-704105-1	1
7	J102 cable	704530	1
8	Electrical interface receptacle J102	703937-71	1
	Bolt	RD111-4011-6414	3
	Washer	RD153-1002-0004	3
	Washer	RD153-5002-0004	3
	Nut	RD114-8003-1004	3
9	Electrical plug P110	502935-351	1
	Boot	19-501743-7	1
10	J103 cable	704527	1
11	Electrical interface receptacle J103	703937-61	1
	Bolt	RD111-4011-6414	3
	Washer	RD153-1002-0004	3
	Washer	RD153-5002-0004	3
	Nut	RD114-8003-1004	3
12	Electrical plug P115	502935-341	1
	Boot	19-501743-7	1

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Figure 3-13. J100, J101, J102, and J103 Cables

d. Connect applicable interface receptacle, J100 (2), J101 (5), J102 (8), or J103 (11), to interface panel. Torque nuts to 70 ±5 in-lb.

e. Torque and safetywire electrical plug at primary junction box as outlined in paragraph 3-15.

3-42. J104 HARNESS.

3-43. REMOVING J104 HARNESS. (See figure 3-14.)

a. Make sure that electrical power source is turned off.

WARNING

Disconnecting or connecting electrical connectors without turning off the power source can cause electrical arcing between connectors, resulting in serious injury or death to personnel and damage to equipment.

b. Disconnect electrical interface receptacle J104 (2) from interface panel.

c. Disconnect electrical plugs P130 (3) as outlined in paragraph 3-14, at turbopump lower connector panel, and plug P132 (4) at oxidizer flowmeter.

d. Remove harness support clamp assemblies (5) through (10), and carefully remove harness (1) from engine.

e. Install protective dust caps on electrical plugs and receptacle. Dust-cap requirements, by connector reference designation number, are listed in R-3896-4.

f. For servicing or maintenance, install dust caps fingertight on electrical connectors. Dust-cap torque requirements, by connector number, are listed in figure 3-4.

g. If harness is to be transported to a repair area or stored, wrap harness with cushioning material to prevent possible damage. Wrap each individual electrical connector with cushioning material to prevent damage to connectors or other parts of the harness.

3-44. INSTALLING J104 HARNESS. (See figure 3-14.)

a. Observe harness installation requirements outlined in paragraph 3-18.

b. Position harness on engine, routing electrical plugs to their respective connect points at turbopump lower connector panel and oxidizer flowmeter. Check breakout mold for proper location.

c. Connect electrical plugs P130 (3) and P132 (4) fingertight as outlined in paragraph 3-15 to turbopump lower connector panel and oxidizer flowmeter to prevent possible preloading of connectors.

d. Connect electrical interface receptacle J104 (2) to interface panel. Torque nuts to 70 ±5 in-lb.

e. Install harness support clamp assemblies (5) through (10), starting with clamp assembly (5) and working toward electrical plugs P130 and P132, making sure no excessive strain is applied to harness. Tighten harness support clamp screws sufficiently to prevent harness movement within clamp, yet not damage harness.

f. Torque and safetywire electrical plugs P130 (3) and P132 (4) as outlined in paragraph 3-15.

3-45. J106 HARNESS.

3-46. REMOVING J106 HARNESS. (See figure 3-15.)

a. Make sure that electrical power source is turned off.

WARNING

Disconnecting or connecting electrical connectors without turning off the power source can cause electrical arcing between connectors, resulting in serious injury or death to personnel and damage to equipment.

b. On engines not incorporating MD87 change, disconnect electrical interface receptacle J104 (2) from interface panel.

c. On engines incorporating MD87 change, disconnect electrical interface receptacle J104 (3) from interface panel.

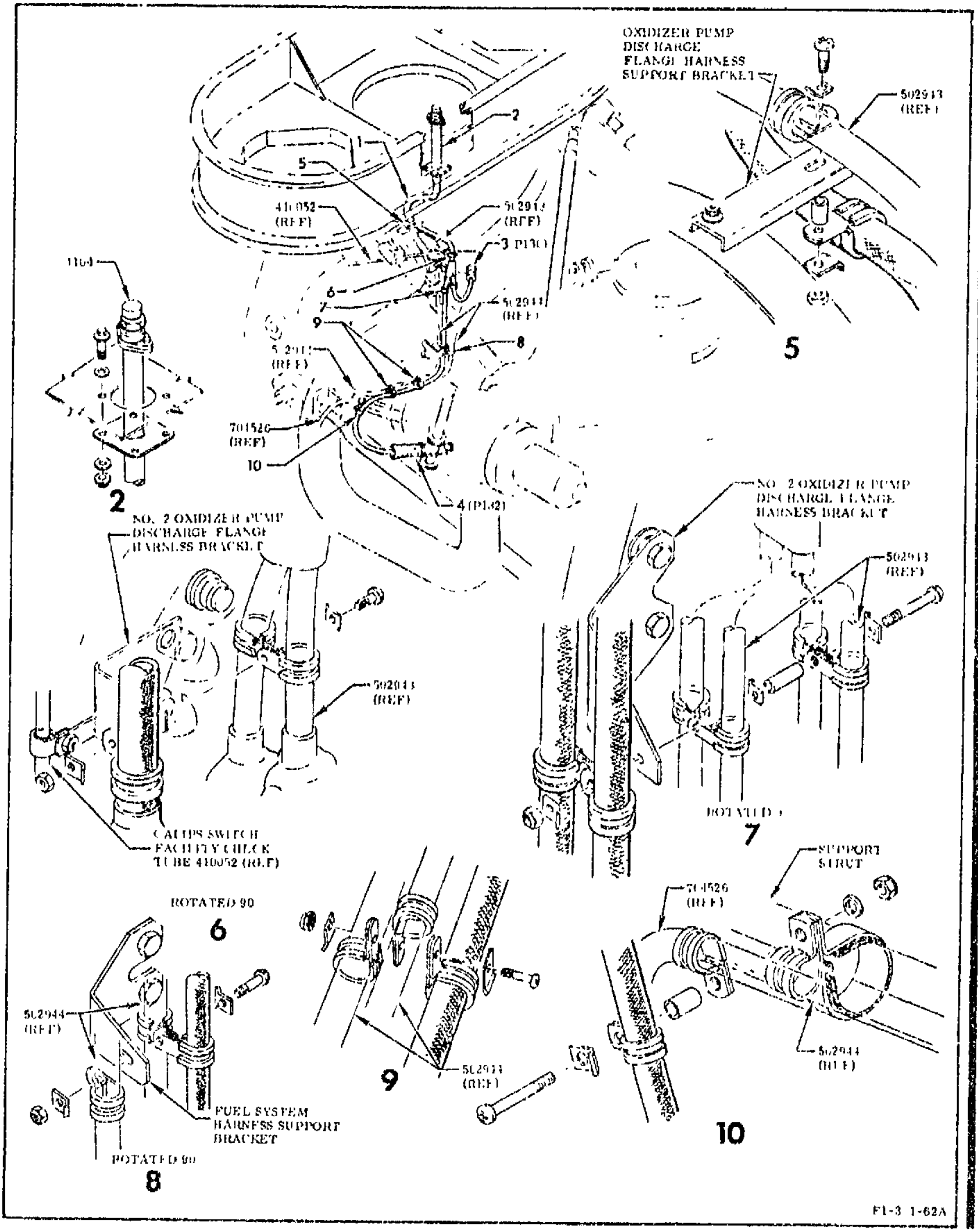


Figure 3-14. J104 Harness (Sheet 1 of 2)

Index No.	Name and Attaching Parts	Part No.	Quantity	Index No.	Name and Attaching Parts	Part No.	Quantity
1	J104 harness	704533	1	7	Clamp assembly		
2	Electrical interface receptacle J104	703937-31	1		Clamp	RE127-2004-0007	2
					Clamp	RE127-2004-0012	1
					Clamp	RE127-2005-0007	2
	Bolt	RD111-4011-6414	4		Clamp	RE127-2005-0012	1
	Washer	RD153-1002-0004	4		Screw	AN520C10R30	1
	Washer	RD153-5002-0004	4		Spacer	NAS43DD3-40	1
	Nut	RD114-8003-1004	4		Nut	NAS679C3W	1
3	Electrical plug P130	502935-131	1	8	Clamp assembly		
					Clamp	RE127-2004-0008	1
	Boot	19-501743-3	1		Clamp	RE127-2004-0009	1
4	Electrical plug P132	502935-91	1		Clamp	RE127-2005-0012	1
					Screw	AN520C10R14	1
	Boot	19-501743-3	1		Nut	NAS679C3W	1
5	Clamp assembly			9	Clamp assembly		
	Clamp	RE127-2004-0012	1		Clamp	RE127-2004-0012	1
	Clamp	RE127-2004-0014	1		Clamp	RE127-2004-0009	1
	Screw	AN520C10R16	1		Clamp	RE127-2005-0008	1
	Spacer	NAS43DD3-24	1		Screw	AN520C10R12	1
	Nut	NAS679C3W	1		Nut	NAS679C3W	1
6	Clamp assembly			10	Clamp assembly		
	Clamp	RE127-2004-0010	1		Clamp	RE127-2001-0045	1
	Clamp	RE127-2004-0014	1		Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0010	1		Clamp	RE127-2005-0012	2
	Screw	AN520C10R14	1		Screw	AN520C10R26	1
	Nut	NAS679C3W	1		Spacer	NAS43DD3-48	1
					Washer	LD153-0010-0007	1
					Nut	NAS679C3W	1

Figure 3-14. J104 Harness (Sheet 2 of 2)

d. Disconnect electrical plugs P134 (4), as outlined in paragraph 3-14, at turbopump upper connector panel, P137 (5) at boss on turbine manifold, and P138 (6) at CGT1 transducer mount bracket located on primary tube and outrigger mount shell.

e. On engines not incorporating MD87 change, remove harness support clamp assemblies (7) and (8), and on engines incorporating MD87 change, clamp assemblies (9) and (10).

f. Remove remaining harness support clamp assemblies (11) through (23), and carefully remove harness (1) from engine.

g. Install protective dust caps on electrical plugs and receptacle. Dust-cap requirements, by connector reference designation number, are listed in R-3896-4.

h. For servicing or maintenance, install dust caps fingertight on electrical connectors. Dust-cap torque requirements, by connector number, are listed in figure 3-4.

i. If harness is to be transported to a repair area or stored, wrap harness with cushioning material to prevent possible damage. Wrap each individual electrical connector with cushioning material to prevent damage to connectors or other parts of harness.

3-47. INSTALLING J106 HARNESS. (See figure 3-15.)

a. Observe harness installation requirements outlined in paragraph 3-18.

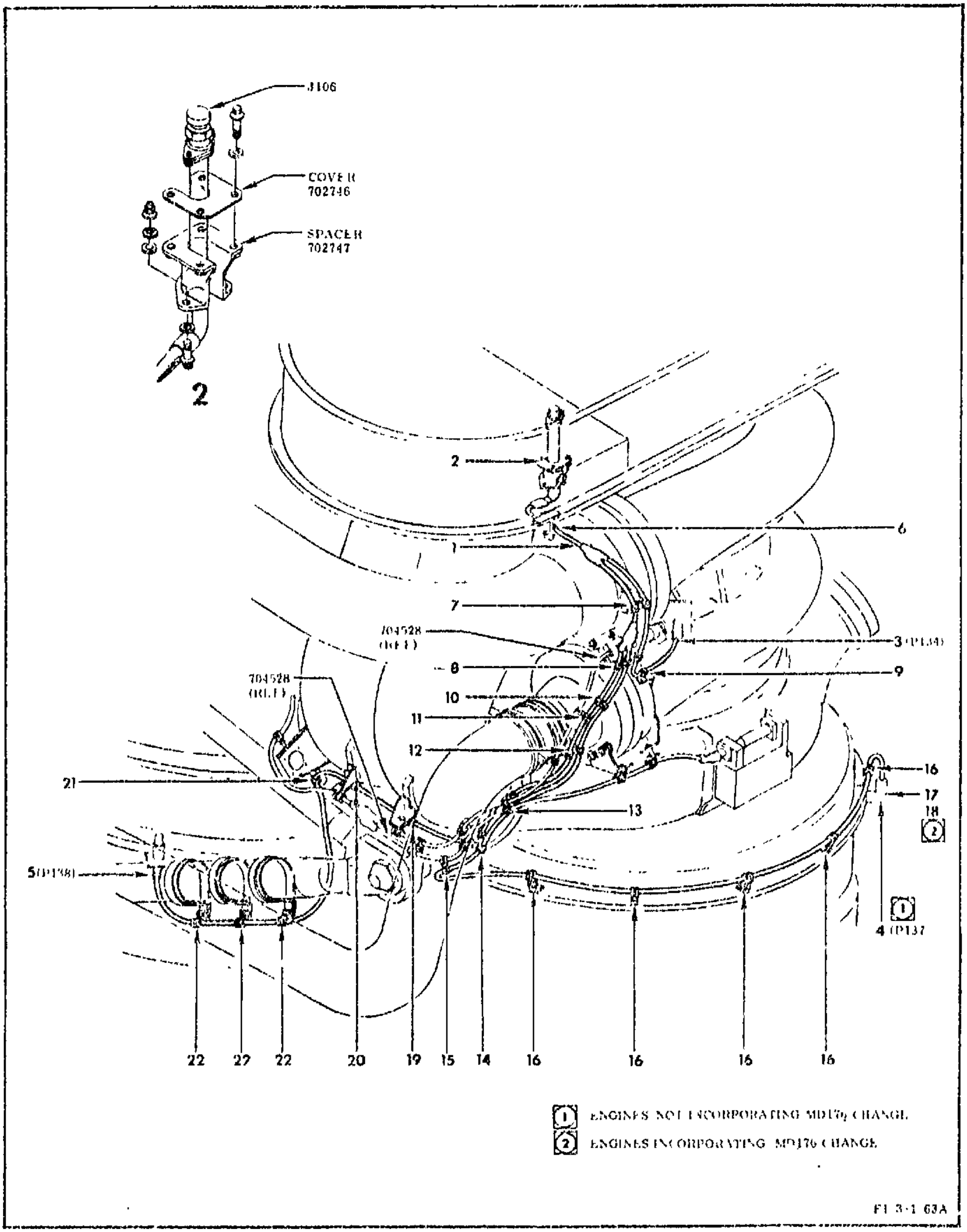


Figure 3-15. J106 Harness (Sheet 1 of 5)

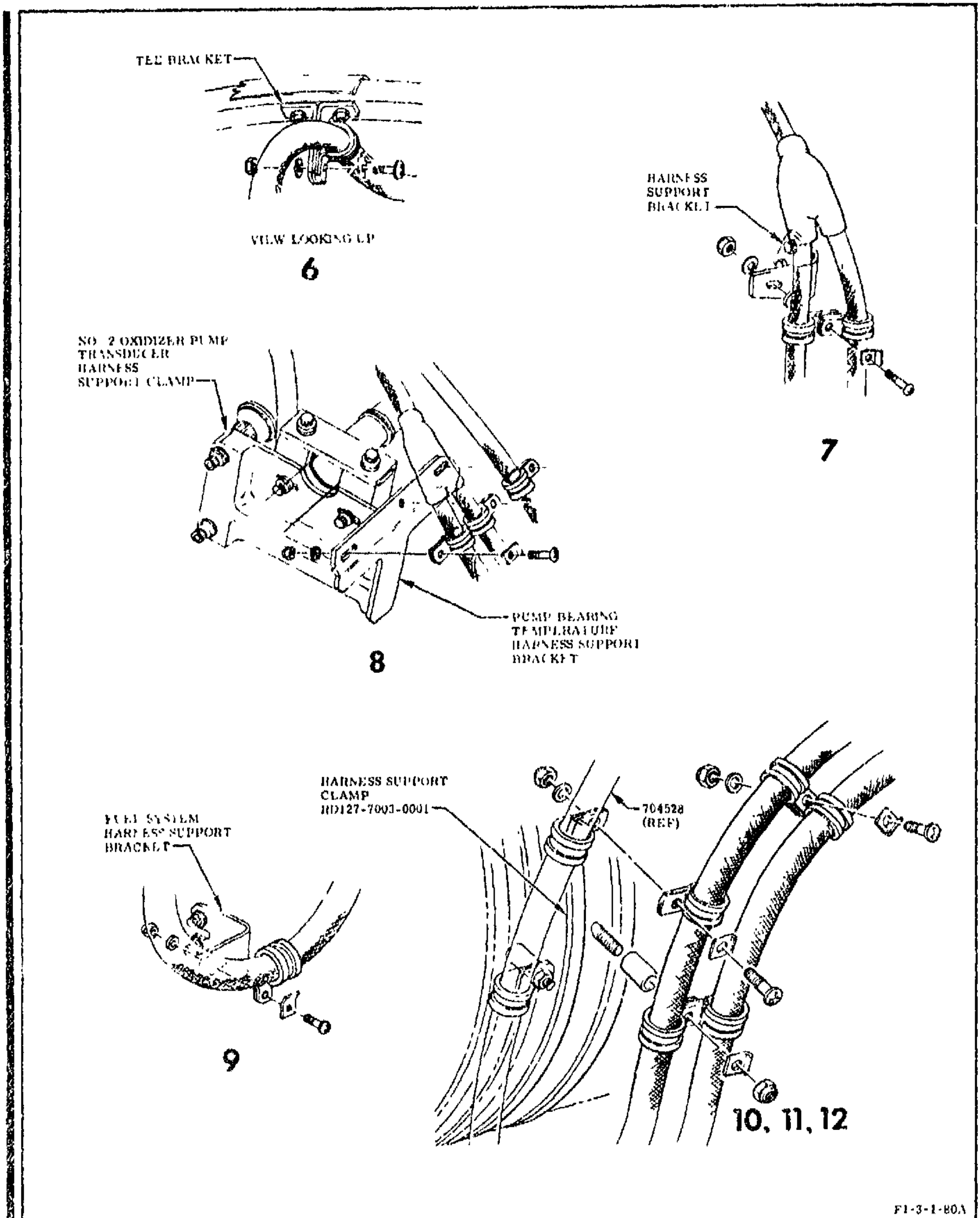


Figure 3-15. J106 Harness (Sheet 2 of 5)

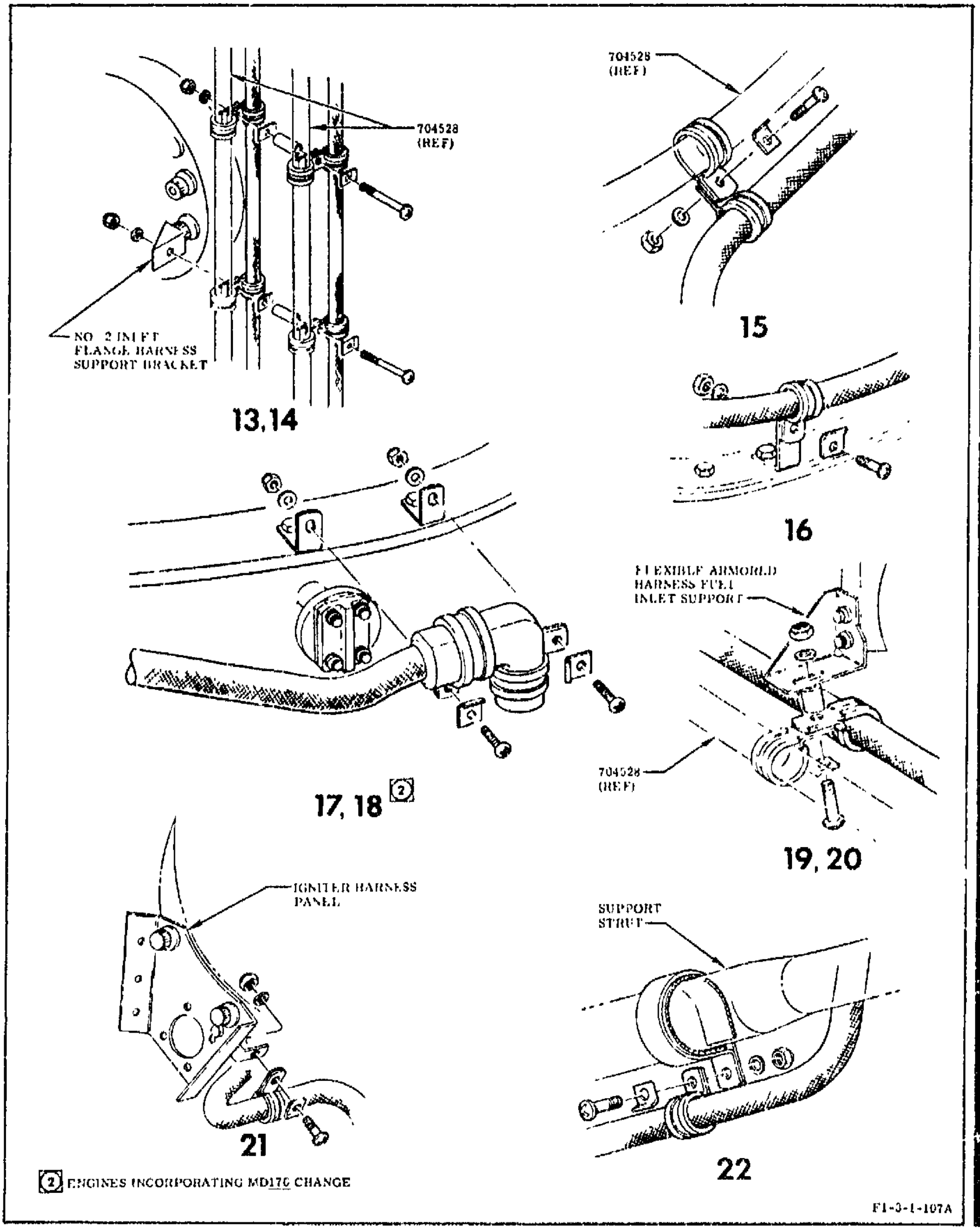


Figure 3-15. J106 Harness (Sheet 3 of 5)

Index No.	Name and Attaching Parts	Part No.	Quantity
1	J106 harness	704534-11	1
2	Electrical interface receptacle J106	703937-41	1
	Cover	702746	1
	Bolt	RD111-4011-6416	4
	Washer	RD153-5002-0004	4
	Spacer	702747	1
	Bolt	RD111-4011-6416	3
	Washer	RD153-1002-0004	6
	Washer	RD153-5002-0004	3
	Nut	RD114-3005-1004	3
3	Electrical plug P134	502935-41	1
	Boot	19-501743-2	1
4	Electrical plug P137	502937-631[(a)]	1
	Boot	19-501745-3	1
5	Electrical plug P138	502937-631	1
	Boot	19-501745-3	1
6	Clamp assembly		
	Clamp	RE127-2008-0015[(b)]	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
7	Clamp assembly		
	Clamp	RE127-2004-0010[(b)]	1
	Clamp	RE127-2005-0009[(b)]	1
	Screw	AN520C10R16	1
	Washer	LD153-0010-0007	1
	Washer	LD153-0010-0008	1
	Nut	NAS679C3W	1
8	Clamp assembly		
	Clamp	RE127-2004-0009	3
	Screw	AN520C10R10	3
	Washer	LD153-0010-0007	3
	Nut	NAS679C3W	3
9	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
10	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2005-0009	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
11	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0009	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
12	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2005-0009	1
	Clamp	RD127-7003-0001	1
	Spacer	NAS43DD3-16	1
	Nut	NAS679C3W	1
13	Clamp assembly		
	Clamp	RE127-2004-0009	2
	Clamp	RE127-2005-0012	2
	Screw	AN520C10R30	1
	Spacer	NAS43DD3-64	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
14	Clamp assembly		
	Clamp	RE127-2004-0009	2
	Clamp	RE172-2005-0012	2
	Screw	AN520C10R30	1
	Spacer	NAS43DD3-64	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
15	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2005-0012	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
16	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Screw	AN520C10R8	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
17[(b)]	Clamp assembly		
	Clamp	RE127-2004-0026	
	Screw	AN520C10R10	
	Washer	LD153-0010-0007	
	Nut	NAS679C3W	
18[(b)]	Clamp assembly		
	Clamp	RE127-2004-0021	
	Screw	AN520C10R10	
	Washer	LD153-0010-0007	
	Nut	NAS679C3W	

(a) Engines not incorporating MD176 change
(b) Engines incorporating MD176 change

Figure 3-15. J106 Harness (Sheet 4 of 5)

Index No.	Name and Attaching Parts	Part No.	Quantity	Index No.	Name and Attaching Parts	Part No.	Quantity
19	Clamp assembly			21	Clamp assembly		
	Clamp	RE127-2004-0012	1		Clamp	RE127-2004-0009	1
	Clamp	RE127-2005-0009	1		Screw	AN520C10R8	1
	Screw	AN520C10R16	1		Washer	LD153-0010-0007	1
	Spacer	NAS43DD3-16	1		Nut	NAS679C3W	1
	Washer	LD153-0010-0007	1	22	Clamp assembly		
	Nut	NAS679C3W	1		Clamp	RE127-2001-0043	1
20	Clamp assembly				Clamp	RE172-2004-0009	1
	Clamp	RE127-2004-0015	1		Screw	AN520C10R10	1
	Clamp	RE127-2005-0009	1		Washer	LD153-0010-0007	1
	Screw	AN520C10R16	1		Nut	NAS679C3W	1
	Spacer	NAS43DD3-16	1				
	Washer	LD153-0010-0007	1				
	Nut	NAS679C3W	1				

Figure 3-15. J106 Harness (Sheet 5 of 5)

b. Position harness on engine, routing electrical plugs to their respective connect points at turbopump upper connector panel, turbine manifold, and CGT1 transducer mount bracket. Check breakout molds for proper location.

c. Connect electrical plugs P134 (4) at turbopump upper connector panel, P137 (5) at boss on turbine manifold, and P138 (6) at CGT1 transducer mount bracket located on primary tube and outrigger mount shell fingertight as outlined in paragraph 3-15 to prevent possible preloading of connectors.

d. On engines not incorporating MD87 change, connect electrical interface receptacle J106 (2) to interface panel. Torque nuts to 70 ±5 in-lb.

e. On engines incorporating MD87 change, connect electrical receptacle J106 (3) to interface panel. Torque bolts that secure cover at forward side of panel and nuts that secure spacer at aft side of panel to 85 ±5 in-lb.

f. Install harness support clamp assemblies (11) through (23), starting with clamp assembly closest to center of harness and working toward receptacle and plugs. Make sure no excessive strain is applied to harness. Tighten harness support clamp screws sufficiently to prevent harness movement within clamp, yet not damage harness.

g. Torque and safetywire electrical plugs P134 (4), P137 (5), and P138 (6) as outlined in paragraph 3-15.

3-48. P111 HARNESS.

3-49. REMOVING P111 HARNESS. (See figure 3-16.)

a. Make sure that electrical power source is turned off.

WARNING

Disconnecting or connecting electrical connectors without turning off the power source can cause electrical arcing between connectors, resulting in serious injury or death to personnel and damage to equipment.

b. To facilitate removal of harness, disconnect primary junction box support harness support bracket (8) from primary/auxiliary junction box struts support and allow harness bundle to drop free.

CAUTION

Before disconnecting electrical plugs P119 (6) and P123 (7), the transducers must be disconnected or loosened from their respective attach bracket or adapter prior to disconnecting the harness to prevent damage to the harness or transducers.

c. Disconnect electrial plug P111 (2), as outlined in paragraph 3-14, from primary junction box.

d. Disconnect electrical plugs P116 (3), P117 (4), P118 (5), P119 (6), and P123 (7), as outlined in paragraph 3-16, from their respective transducers.

e. Before removing harness support clamp assembly (9), note position of clamp assembly (9) in relation to its distance from primary junction box.

NOTE

If the harness is to be replaced, noting the location of this clamp assembly is important, as it will facilitate the reinstallation of the new harness.

f. Remove harness support clamp assembly (9) from harness support bracket (8), and retain bracket for reinstallation.

g. Remove remaining harness support clamp assemblies (10) through (28), and carefully remove harness from engine.

h. Install protective dust caps on electrical plugs. Dust-cap requirements, by connector reference designation number, are listed in R-3896-4.

i. For servicing or maintenance, install dust caps fingertight on electrical connectors. Dust-cap torque requirements, by connector number, are listed in figure 3-4.

j. If harness is to be transported to a repair area or stored, wrap harness with cushioning material to prevent possible damage. Wrap each individual electrical connector with cushioning material to prevent damage to connectors or other parts of harness.

3-50. INSTALLING P111 HARNESS. (See figure 3-16.)

a. Observe harness installation requirements outlined in paragraph 3-18.

b. Position harness on engine, routing electrical plugs to their respective connect points at primary junction box and transducers. Check breakout molds for proper location.

c. Connect electrical plug P111 (2) (as outlined in paragraph 3-15) to primary junction box. Torque and safetywire plug, as outlined in paragraph 3-15.

CAUTION

Before connecting electrical plugs P119 (6) and P123 (7) to their respective transducers, transducers must be disconnected or loosened from their respective attach bracket or adapter prior to connecting the harness, to prevent damage to the harness or transducers.

d. Connect electrical plugs P116 (3), P117 (4), P118 (5), P119 (6), and P123 (7), as outlined in paragraphs 3-15 and 3-17. Torque and safetywire plugs, as outlined in paragraph 3-15.

e. Cross-torque nuts that secure gas generator chamber pressure transducer (P119) and thrust chamber combustion chamber pressure transducer (P123) to 125 ±10 in-lb.

f. Locate harness support clamp assembly (9) on harness in relation to its distance from primary junction box, as noted during removal of harness.

NOTE

The position of this clamp assembly is important, as its location directly affects the correct location of the other clamp assemblies.

g. Install harness support clamp assembly (9) on primary junction box support harness support bracket (8), which was removed as part of harness removal. . Tighten harness support clamp screws sufficiently to prevent harness movement within clamp, yet not damage harness.

h. Connect primary junction box support harness support bracket (8) to primary/auxiliary junction box struts support. Torque nuts to 125 ±5 in-lb.

i. Install remaining harness support clamp assemblies (10) through (28), starting with clamp assembly closest to center of harness and working toward clamp assembly (9) and electrical plugs. Make sure no excessive strain is applied to harness. Tighten harness support clamp screws sufficiently to prevent harness movement within clamp, yet not damage harness.

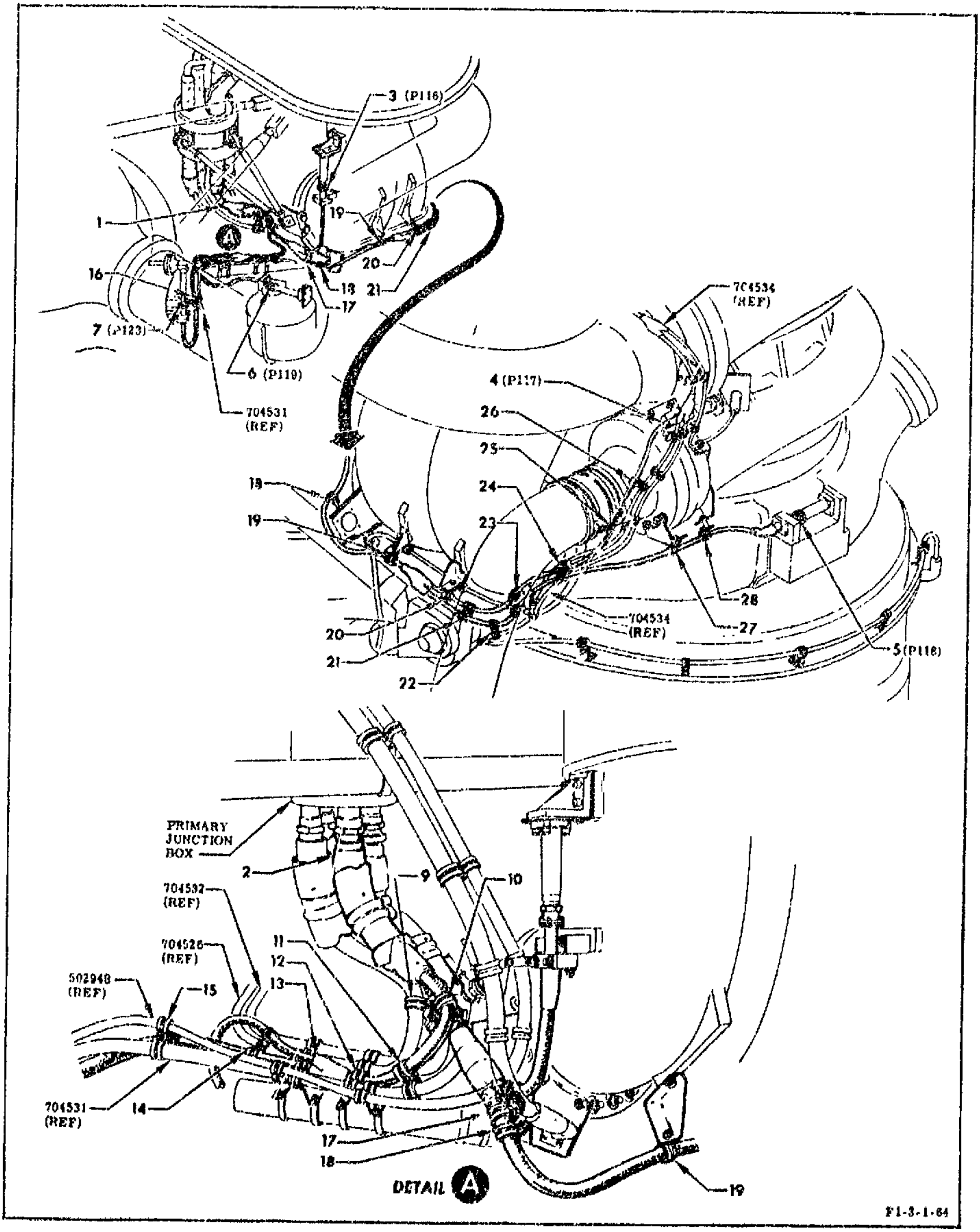


Figure 3-10. P111 Harness (Sheet 1 of 3)

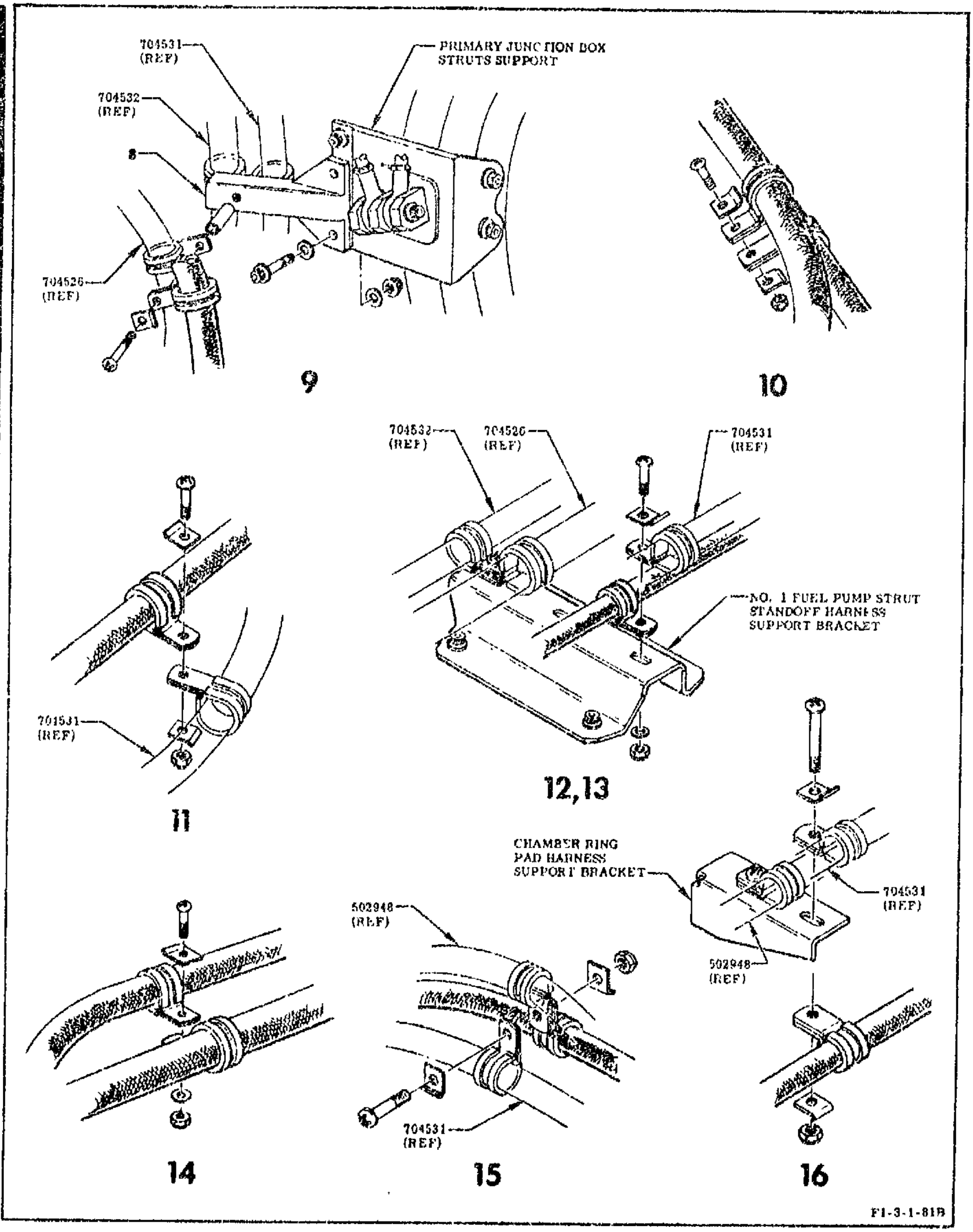
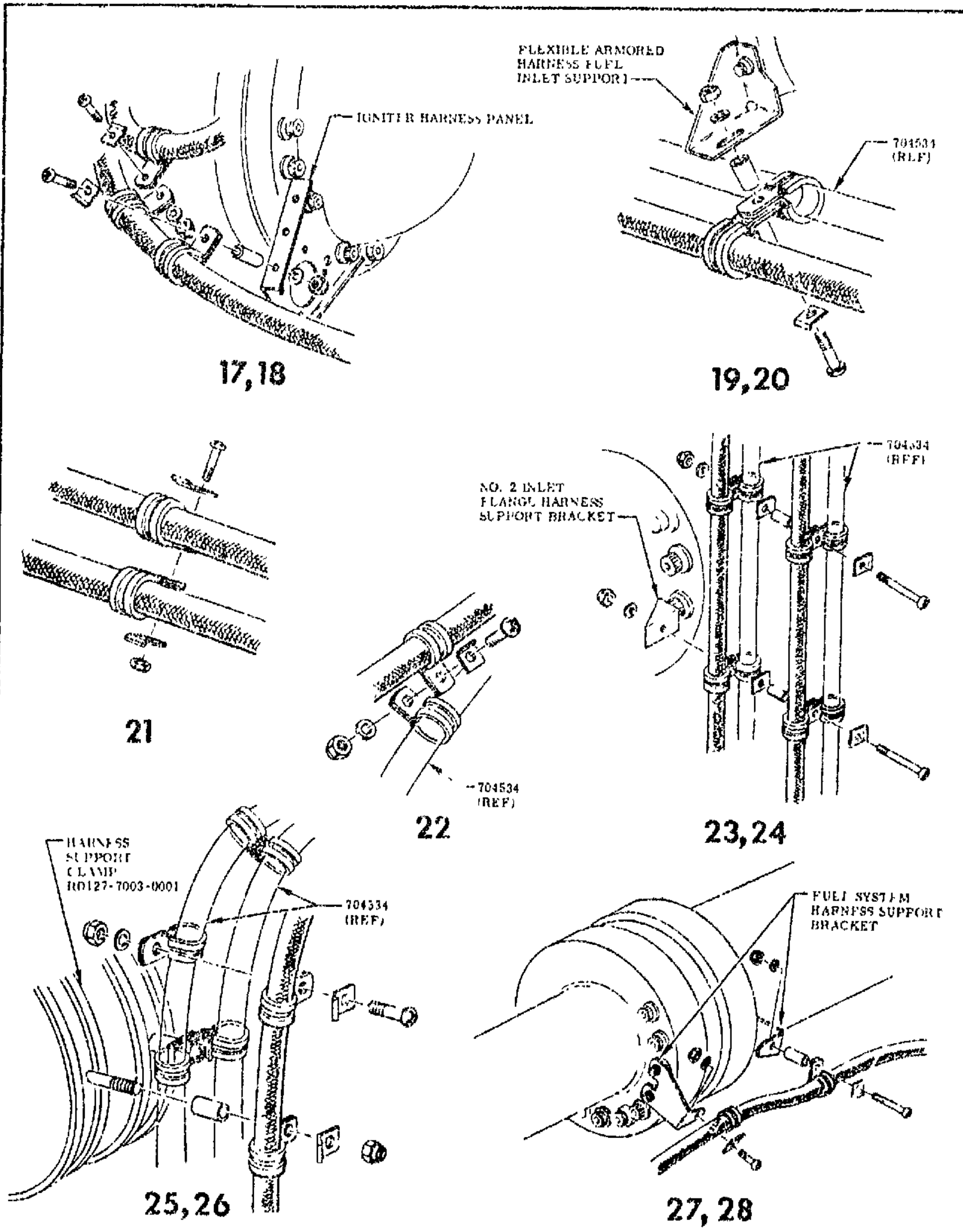


Figure 3-16. P111 Harness (Sheet 2 of 3)



Fi-3-1-82A

Index No.	Name and Attaching Parts
1	P111 harness
2	Electrical plug P111
	Boot
3	Electrical plug P116
	Harness support clamp
	B acket
	Bc t
	Washer
	Harness support block
	Clamp
	Bolt
	Washer
	Washer
	Nut
4	Electrical plug P117
	Harness support clamp
	Bolt
	Washer
	Harness support block
	Clamp
	Bolt
	Washer
	Washer
	Nut
5	Electrical plug P118
	Harness support clamp
	Bolt
	Washer
	Four-way valve
	Control line block
	Clamp
	Bolt
	Washer
	Washer
	Nut
6	Electrical plug P119
	Harness support clamp
	Bolt
	Washer

Index No.	Name and Attaching Parts	Part No.	Quantity
1	P111 harness	704528	1
2	Electrical plug P111	502935-481	1
	Boot	19-501743-9	
3	Electrical plug P116	704476	1
	Harness support clamp	703002	1
	Bracket	MS9102-33	1
	Bolt	RD111-4008-3405	2
	Washer	RD153-5002-0004	2
	Harness support block	703001	1
	Clamp	RE127-2001-0010	1
	Bolt	RD111-4011-6423	2
	Washer	RD153-1002-0004	2
	Washer	RD153-5002-0004	2
	Nut	RD114-8005-1004	2
4	Electrical plug P117	704476-21	1
	Harness support clamp	703002	1
	Bolt	RD111-4008-3405	2
	Washer	RD153-5002-0004	2
	Harness support block	703001	1
	Clamp	RE127-2002-0010	1
	Bolt	RD111-4011-6423	2
	Washer	RD153-1002-0004	2
	Washer	RD153-5002-0004	2
	Nut	RD114-8005-1004	2
5	Electrical plug P118	704476	1
	Harness support clamp	703002	1
	Bolt	RD111-4008-3405	2
	Washer	RD153-5002-0004	2
	Four-way valve	703017	1
	Control line block		
	Clamp	RE127-2002-0010	1
	Bolt	RD111-4011-6417	2
	Washer	RD153-1002-0004	2
	Washer	RD153-5002-0004	2
	Nut	RD114-8005-1004	2
6	Electrical plug P119	502937-601	1
	Harness support clamp	703925	1
	Bolt	RD111-4008-3405	2
	Washer	RD153-5002-0004	2

Index No.	Name and Attaching Parts	Part No.	Quantity
	Harness support block	703911	1
	Clamp	RE127-2002-0006	1
	Bolt	RD111-4011-6423	2
	Washer	RD153-1002-0004	2
	Washer	RD153-5002-0004	2
	Nut	RD114-8005-1004	2
7	Electrical plug P123	704476	1
	Harness support clamp	703002	1
	Bolt	RD111-4008-3405	2
	Washer	RD153-5002-0004	2
	Harness support block	703001	1
	Clamp	RE127-2002-0010	1
	Bolt	RD111-4011-6425	2
	Washer	RD153-1002-0004	2
	Washer	RD153-5002-0004	2
	Nut	RD114-8005-1004	2
8	Primary junction box support harness support bracket	703902	1
	Bolt	RD111-4011-6422	2
	Washer	RD153-1002-0004	2
	Washer	RD153-5002-0004	2
	Nut	RD114-8005-1004	2
9	Clamp assembly		
	Clamp	RE127-2004-0015	1
	Clamp	RE127-2005-0018	1
	Screw	AN520C10R16	1
	Spacer	NAS43DD3-24	1
10	Clamp assembly		
	Clamp	RE127-2004-0015	1
	Clamp	RE127-2004-0018	1
	Screw	AN520C10R10	1
	Nut	NAS679C3W	1
11	Clamp assembly		
	Clamp	RE127-2004-0015	2
	Screw	AN520C10R10	1
	Nut	NAS679C3W	1
12	Clamp assembly		
	Clamp	RE127-2004-0016	1
	Clamp	RE127-2005-0014	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
13	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0018	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1

Index No.	Name and Attaching Parts	Part No
14	Clamp assembly	
	Clamp	RE127-20
	Clamp	RE127-20
	Screw	AN520C10
	Washer	LD153-00
	Nut	NAS679C3
15	Clamp assembly	
	Clamp	RE127-20
	Clamp	RE127-20
	Clamp	RE127-20
	Screw	AN520C10
	Nut	NAS679C3
16	Clamp assembly	
	Clamp	RE127-20
	Clamp	RE127-20
	Screw	AN520C10
	Nut	NAS679C3
17	Clamp assembly	
	Clamp	RE127-20
	Clamp	RE127-20
	Screw	AN520C10
	Washer	LD153-00
	Nut	NAS679C3
18	Clamp assembly	
	Clamp	RE127-20
	Screw	AN520C10
	Spacer	NAS43DD
	Washer	LD153-00
	Nut	NAS679C3
19	Clamp assembly	
	Clamp	RE127-20
	Clamp	RE127-20
	Screw	AN520C10
	Spacer	NAS43DD3
	Washer	LD153-00
	Nut	NAS679C3
20	Clamp assembly	
	Clamp	RE127-20
	Clamp	RE127-20
	Screw	AN520C10
	Spacer	NAS43DD3
	Washer	LD153-00
	Nut	NAS679C3
21	Clamp assembly	
	Clamp	RE127-20
	Screw	AN520C10
	Nut	NAS679C3
22	Clamp assembly	
	Clamp	RE127-20
	Clamp	RE127-20
	Screw	AN520C10
	Washer	LD153-00
	Nut	NAS679C3

Figure

rt No.	Quantity
911	1
27-2002-0006	1
11-4011-6422	2
53-1002-0004	2
53-5002-0004	2
14-8005-1004	2
76	1
002	1
11-4008-3405	2
53-5002-0004	2
001	1
27-2002-0010	1
11-4011-6425	2
53-1002-0004	2
53-5002-0004	2
14-8005-1004	2
02	1
11-4011-6422	2
53-1002-0004	2
53-5002-0004	2
14-8005-1004	2
27-2004-0015	1
27-2005-0018	1
20C10R16	1
43DD3-24	1
27-2004-0015	1
27-2004-0018	1
20C10R10	1
679C3W	1
27-2004-0015	2
20C10R10	1
679C3W	1
27-2004-0016	1
27-2005-0014	1
20C10R12	1
53-0010-0007	1
679C3W	1
27-2004-0012	1
27-2005-0018	1
20C10R12	1
53-0010-0007	1
679C3W	1

Index No.	Name and Attaching Parts	Part No.	Quantity
14	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0015	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
15	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2004-0014	1
	Clamp	RE127-2005-0009	1
	Screw	AN520C10R12	1
	Nut	NAS679C3W	1
16	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2004-0015	1
	Screw	AN520C10R12	1
	Nut	NAS679C3W	1
17	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0014	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
18	Clamp assembly		
	Clamp	RE127-2004-0014	1
	Screw	AN520C10R20	1
	Spacer	NAS43DD3-48	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
19	Clamp assembly		
	Clamp	RE127-2004-0015	1
	Clamp	RE127-2005-0009	1
	Screw	AN520C10R16	1
	Spacer	NAS43DD3-16	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
20	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0009	1
	Screw	AN520C10R16	1
	Spacer	NAS43DD3-16	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
21	Clamp assembly		
	Clamp	RE127-2004-0012	2
	Screw	AN520C10R12	1
	Nut	NAS679C3W	1
22	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2005-0012	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1

Index No.	Name and Attaching Parts	Part No.	Quantity
23	Clamp assembly		
	Clamp	RE127-2004-0009	2
	Clamp	RE127-2005-0012	2
	Screw	AN520C10R30	1
	Spacer	NAS43DD3-64	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
24	Clamp assembly		
	Clamp	RE127-2004-0009	2
	Clamp	RE127-2005-0012	2
	Screw	AN520C10R30	1
	Spacer	NAS43DD3-64	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
25	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RD127-7003-0001	1
	Spacer	NAS43DD3-16	1
	Nut	NAS679C3W	1
26	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0009	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
27	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
28	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Screw	AN520C10R20	1
	Spacer	NAS43DD3-40	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1

Figure 3-16. P111 Harness (Sheet 3 of 3)

3-51. P112 HARNESS

3-52. REMOVING P112 HARNESS. (See figure 3-17.)

a. Make sure that electrical power source is turned off.

WARNING

Disconnecting or connecting electrical connectors without turning off the power source can cause electrical arcing between connectors, resulting in serious injury or death to personnel and damage to equipment.

b. To facilitate removal of harness, disconnect primary junction box support harness support bracket (6) from primary/auxiliary junction box struts support and allow harness bundle to drop free.

c. Disconnect electrical plug P112 (2) as outlined in paragraph 3-14 from primary junction box.

d. Disconnect electrical plugs P120 (3), P121 (4), and P122 (5) as outlined in paragraph 3-16 from their respective transducers.

e. Before removing harness support clamp assembly (7), note position of clamp assembly (7) in relation to its distance from primary junction box.

NOTE

If the harness is to be replaced, noting the location of this clamp assembly is important, as it will facilitate the reinstallation of the new harness.

f. Remove harness support clamp assembly (7) from harness support bracket (6), and retain bracket for reinstallation.

g. Remove remaining harness support clamp assemblies (8) through (23) and carefully remove harness from engine.

h. Install protective dust caps on electrical plugs. Dust-cap requirements, by connector reference designation number, are listed in R-3896-4.

i. For servicing or maintenance, install dust caps fingertight on electrical connectors. Dust-cap requirements, by connector number, are listed in figure 3-4.

j. If harness is to be transported to a repair area or is to be stored, wrap harness with cushioning material to prevent possible damage. Wrap each individual electrical connector with cushioning material to prevent damage to connectors or other parts of harness.

3-53. INSTALLING P112 HARNESS. (See figure 3-17.)

a. Observe harness installation requirements outlined in paragraph 3-18.

b. Position harness on engine, routing electrical plugs to their respective connect points at primary junction box and transducers. Check breakout molds for proper location.

c. Connect electrical plug P112 (2) to primary junction box fingertight as outlined in paragraph 3-15.

d. Connect electrical plugs P120 (3), P121 (4), and P112 (5) fingertight as outlined in paragraphs 3-15 and 3-17 to their respective transducers.

e. Locate harness support clamp assembly (7) on harness in relation to its distance from primary junction box, as noted during removal of harness

NOTE

The position of this clamp assembly is important, as its location directly affects the correct location of the other clamp assemblies.

f. Install harness support clamp assembly (7) on primary junction box support harness support bracket (6) that was removed as part of harness removal. Tighten harness support clamp screw sufficiently to prevent harness movement within clamp and yet not damage harness.

g. Connect primary junction box support harness support bracket (6) to primary/auxiliary junction box struts support. Torque nuts to 125 ±5 in-lb.

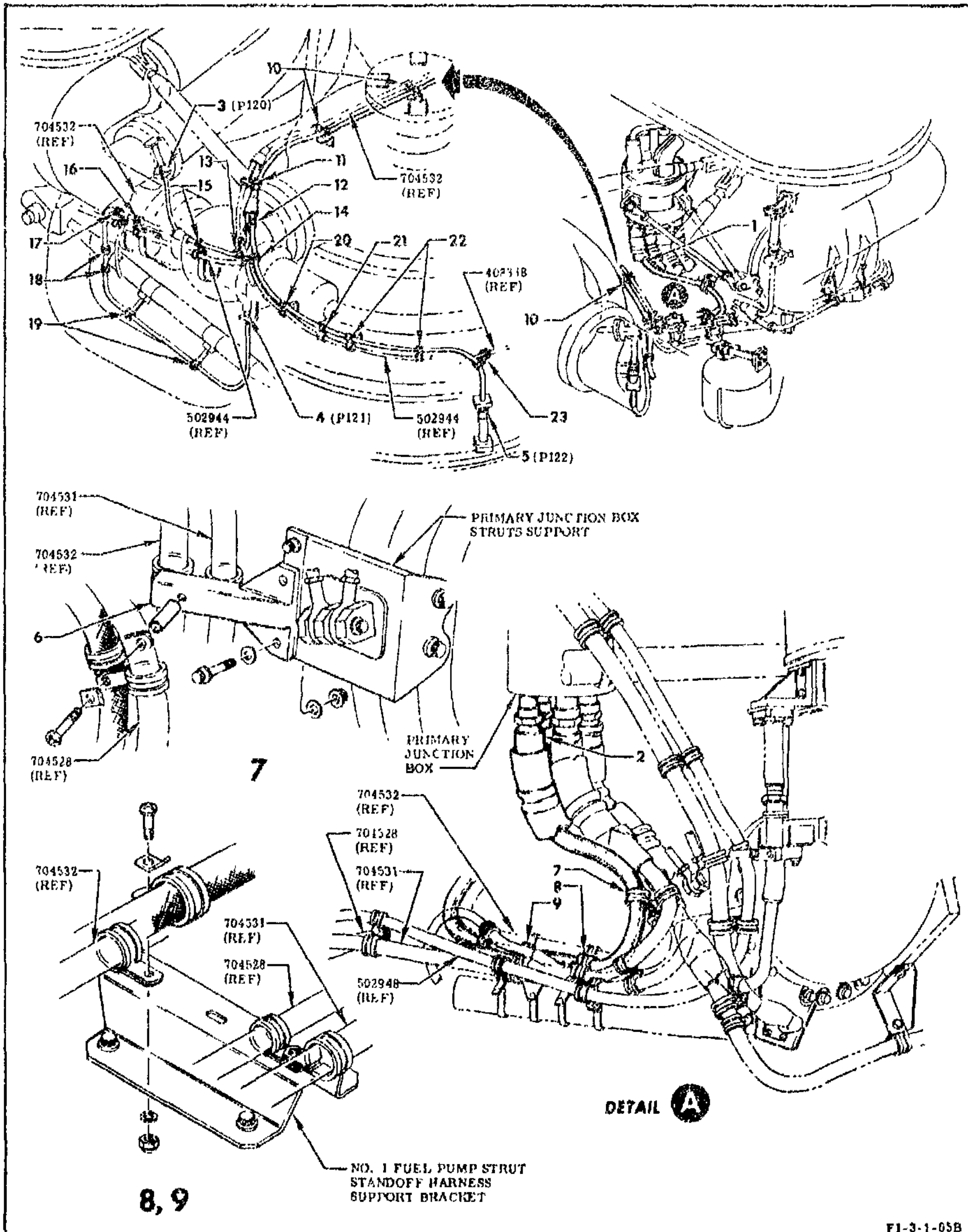


Figure 3-17. P112 Harness (Sheet 1 of 4)

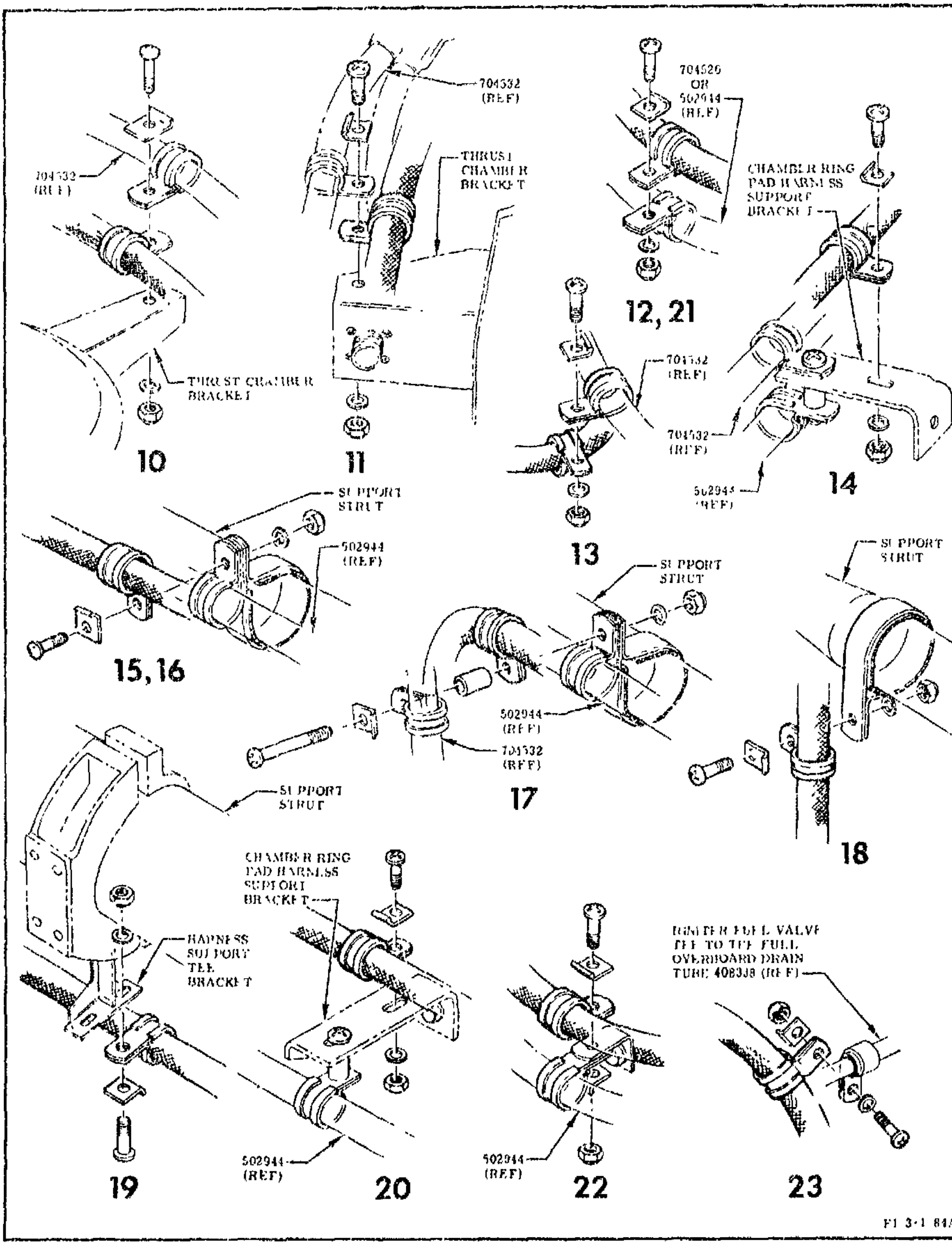


Figure 3-17. P112 Harness (Sheet 2 of 4)

Index No.	Name and Attaching Parts	Part No.	Quantity
1	P112 harness	704526	1
2	Electrical plug P112	502935-421	1
	Boot	19-501743-8	1
3	Electrical plug P120	704476	1
	Harness support clamp	703002	1
	Bolt	RD111-4008-3405	2
	Washer	RD153-5002-0004	2
	Harness support block	703001	1
	Clamp	RE127-2001-0010	1
	Bolt	RD111-4011-6423	2
	Washer	RD153-1002-0004	2
	Washer	RD153-5002-0004	2
	Nut	RD114-8005-1004	2
4	Electrical plug P121	704476	1
	Harness support clamp	703002	1
	Bolt	RD111-4008-3405	2
	Washer	RD153-5002-0004	2
	Harness transducer support	704503	1
	Clamp	RE127-2002-0010	1
	Bolt	RD111-4009-0614	2
	Washer	RD153-1002-0006	2
	Washer	RD153-5002-0006	2
	Nut	RD114-8005-1006	2
5	Electrical plug P122	704476	1
	Harness support clamp	703002	1
	Clamp	RE127-2002-0010	1
	Bolt	RD111-4008-3405	2
	Washer	RD153-5002-0004	2
	Harness support block	703001	1
	Bolt	RD111-4011-6423	2
	Washer	RD153-1002-0004	2
	Washer	RD153-5002-0004	2
	Nut	RD114-8005-1004	2
6	Primary junction box support harness support bracket	703902	1
	Bolt	RD111-4011-6422	2
	Washer	RD153-1002-0004	2
	Washer	RD153-5002-0004	2
	Nut	RD114-8005-1004	2

Index No.	Name and Attaching Parts	Part No.	Quantity
7	Clamp assembly		
	Clamp	RE127-2004-0015	1
	Clamp	RE127-2005-0018	1
	Screw	AN520C10R16	1
	Spacer	NAS43DD3-24	1
8	Clamp assembly		
	Clamp	RE127-2004-0017	1
	Clamp	RE127-2005-0015	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
9	Clamp assembly		
	Clamp	RE127-2004-0018	1
	Clamp	RE127-2005-0015	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
10	Clamp assembly		
	Clamp	RE127-2004-0016	1
	Clamp	RE127-2005-0017	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
11	Clamp assembly		
	Clamp	RE127-2004-0016	1
	Clamp	RE127-2005-0013	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
12	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2004-0013	1
	Screw	AN520C10R10	1
	Nut	NAS679C3W	1
13	Clamp assembly		
	Clamp	RE127-2004-0015	1
	Clamp	RE127-2005-0012	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
14	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
15	Clamp assembly		
	Clamp	RE127-2001-0045	1
	Clamp	RE127-2004-0015	1
	Clamp	RE127-2005-0011	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1

Figure 3-17. P112 Harness (Sheet 3 of 4)

Index No.	Name and Attaching Parts	Part No.	Quantity
16	Clamp assembly		
	Clamp	RE127-2001-0045	1
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0012	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
17	Clamp assembly		
	Clamp	RE127-2001-0045	1
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0012	2
	Screw	AN520C10R26	1
	Spacer	NAS43DD3-48	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
18	Clamp assembly		
	Clamp	RE127-2001-0045	1
	Clamp	RE127-2004-0012	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
19	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
20	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
21	Clamp assembly		
	Clamp	RE127-2004-0011	2
	Screw	AN520C10R10	1
	Nut	NAS679C3W	1
22	Clamp assembly		
	Clamp	RE127-2004-0011	1
	Clamp	RE127-2004-0012	1
	Screw	AN520C10R10	1
	Nut	NAS679C3W	1
23	Clamp assembly		
	Clamp	RE127-2001-0008	1
	Clamp	RE127-2004-0012	1
	Screw	AN520C10R10	1
	Nut	NAS679C3W	1
	Washer	LD153-0010-0007	1

Figure 3-17. P112 Harness (Sheet 4 of 4)

h. Install remaining harness support clamp assemblies (8) through (23), starting with clamp assembly closest to center of harness and working toward junction box and electrical plugs. Make sure no excessive strain is applied to harness. Tighten harness support clamp screws sufficiently to prevent harness movement within clamp and yet not damage harness.

i. Torque and safetywire electrical plugs P112 (2), P120 (3), P121 (4), and P122 (5) as outlined in paragraph 3-15.

3-54. P113 HARNESS.

3-55. REMOVING P113 HARNESS. (See figure 3-18.)

a. Make sure that electrical power source is turned off.

WARNING

Disconnecting or connecting electrical connectors without turning off the power source can cause electrical arcing between connectors, resulting in serious injury or death to personnel and damage to equipment.

b. To facilitate removal of harness, disconnect primary junction box support harness support bracket (6) from primary/auxiliary junction box struts support and allow harness bundle to drop free.

c. Disconnect electrical plug P113 (2), as outlined in paragraph 3-14, from primary junction box.

d. Disconnect electrical plugs P53 (3), P70 (4), and P76 (5), as outlined in paragraph 3-14, from gas generator, No. 1 oxidizer valve, and No. 1 fuel valve.

e. Before removing harness support clamp assembly (7), note position of clamp assembly (7) in relation to its distance from primary junction box.

NOTE

If the harness is to be replaced, noting the location of this clamp assembly is important, as it will facilitate the reinstallation of the new harness.

f. Remove harness support clamp assembly (7) from harness support bracket (6), and retain bracket for reinstallation.

g. Remove remaining harness support clamp assemblies (8) through (21), and carefully remove harness from engine.

h. Install protective dust caps on electrical plugs. Dust-cap requirements, by connector reference designation number, are listed in R-3896-4.

i. For servicing or maintenance, install dust caps fingertight on electrical connectors. Dust-cap requirements, by connector number, are listed in figure 3-4.

j. If harness is to be transported to a repair area or is to be stored, wrap harness with cushioning material to prevent possible damage. Wrap each individual electrical connector with cushioning material to prevent damage to connectors or other parts of harness.

3-56. INSTALLING P113 HARNESS. (See figure 3-18.)

a. Observe harness installation requirements outlined in paragraph 3-18.

b. Position harness on engine, routing electrical plugs to their respective connect points at primary junction box, gas generator, No. 1 oxidizer valve, and No. 1 fuel valve. Check breakout molds for proper location.

c. Connect electrical plug P113 (2) to primary junction box fingertight as outlined in paragraph 3-15.

d. Connect electrical plugs P53 (3), P70 (4), and P76 (5) fingertight as outlined in paragraph 3-15 to gas generator, No. 1 oxidizer valve, and No. 1 fuel valve.

e. Locate harness support clamp assembly (7) on harness in relation to its distance from primary junction box, as noted during removal of harness.

NOTE

The position of this clamp assembly is important, as its location directly affects the correct location of the other clamp assemblies.

f. Install harness support clamp assembly (7) on primary junction box support harness support bracket (6) which was removed as part of harness removal. Tighten harness support clamp screw sufficiently to prevent harness movement within clamp and yet not damage harness.

g. Connect primary junction box support harness support bracket (6) to primary/auxiliary junction box struts support. Torque nuts to 125 ±5 in-lb.

h. Install remaining harness support clamp assemblies (8) through (21), starting with clamp assembly closest to center of harness and working toward junction box and electrical plugs. Make sure no excessive strain is applied to harness. Tighten harness support clamp screws sufficiently to prevent harness movement within clamp and yet not damage harness.

i. Torque and safetywire electrical plugs P113 (2), P53 (3), P70 (4), and P76 (5) as outlined in paragraph 3-15.

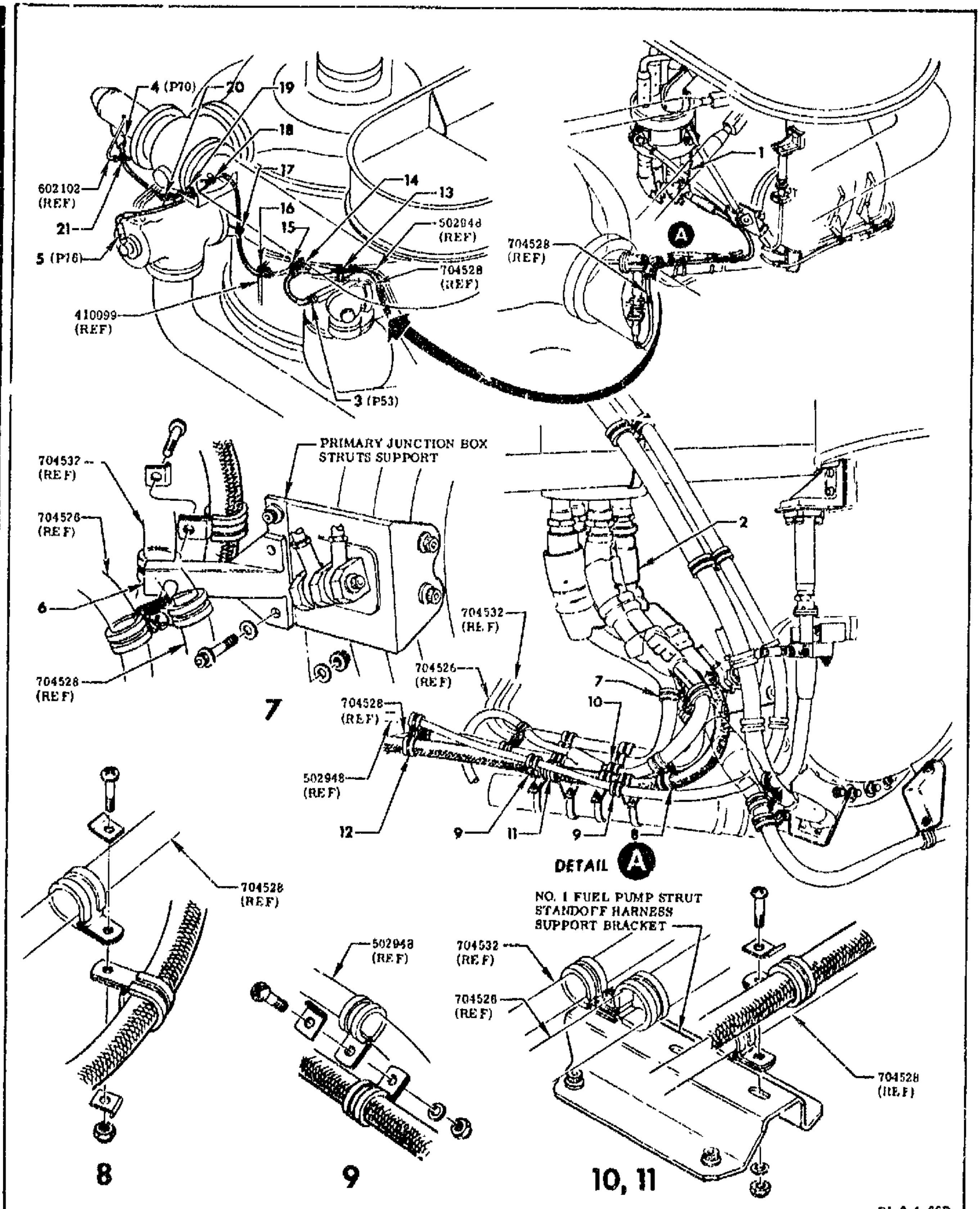


Figure 3-18. P113 Harness (Sheet 1 of 3)

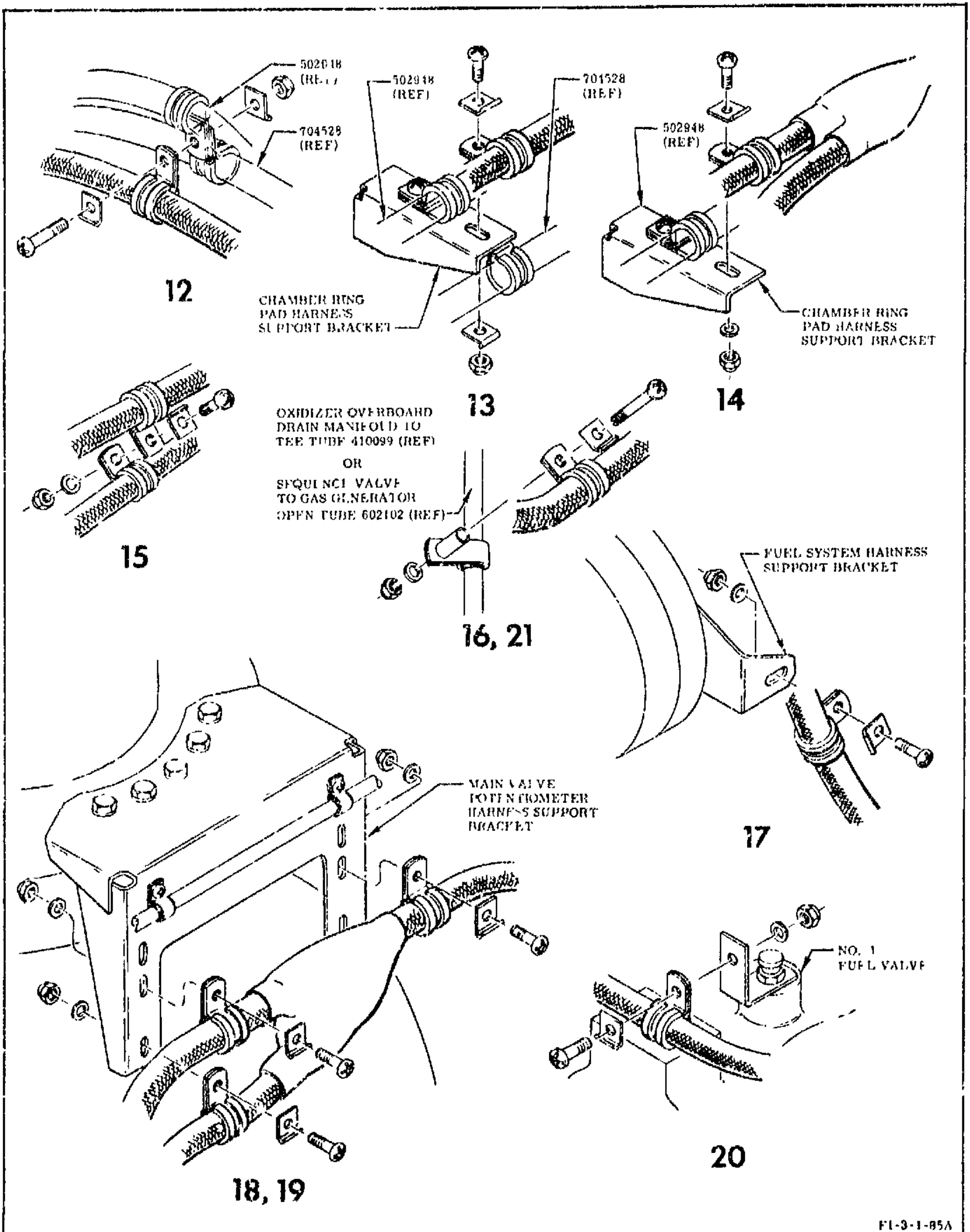


Figure 3-18. P113 Harness (Sheet 2 of 3)

Index No.	Name and Attaching Parts	Part No.	Quantity
1	P113 Harness	704531	1
2	Electrical plug P113	502936-341	1
	Boot	19-501743-7	1
3	Electrical plug P53	502937-91	1
	Boot	19-501745-3	1
4	Electrical plug P70	502935-171	1
	Boot	19-501743-4	1
5	Electrical plug P76	502937-171	1
	Boot	19-501745-4	1
6	Primary junction box support harness support bracket	703902	
	Bolt	RD111-4011-6422	2
	Washer	RD153-1002-0004	2
	Washer	RD153-5002-0004	2
	Nut	RD114-8005-1004	2
7	Clamp assembly		
	Clamp	RE127-2004-0015	1
	Clamp	RE127-2005-0016	1
	Screw	AN520C10R16	1
8	Clamp assembly		
	Clamp	RE127-2004-0015	2
	Screw	AN520C10R10	1
	Nut	NAS679C3W	1
9	Clamp assembly		
	Clamp	RE127-2004-0009	1
	Clamp	RE127-2005-0015	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
10	Clamp assembly		
	Clamp	RE127-2004-0016	1
	Clamp	RE127-2005-0014	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
11	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2005-0018	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
12	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2004-0014	1
	Clamp	RE127-2005-0009	1
	Screw	AN520C10R12	1
	Nut	NAS679C3W	1
13	Clamp assembly		
	Clamp	RE127-2004-0012	1
	Clamp	RE127-2004-0015	1
	Screw	AN520C10R12	1
	Nut	NAS679C3W	1
14	Clamp assembly		
	Clamp	RE127-2004-0016	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
15	Clamp assembly		
	Clamp	RE127-2004-0016	1
	Clamp	RE127-2005-0009	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
16	Clamp assembly		
	Clamp	RE127-2001-0006	1
	Clamp	RE127-2004-0013	1
	Screw	AN520C10R18	1
	Spacer	NAS43DD3-32	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
17	Clamp assembly		
	Clamp	RE127-2004-0013	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
18	Clamp assembly		
	Clamp	RE127-2004-0013	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
19	Clamp assembly		
	Clamp	RE127-2004-0011	2
	Screw	AN520C10R10	2
	Washer	LD153-0010-0007	2
	Nut	NAS679C3W	2
20	Clamp assembly		
	Clamp	RE127-2004-0011	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
21	Clamp assembly		
	Clamp	RE127-2001-0006	1
	Clamp	RE127-2004-0011	1
	Screw	AN520C10R18	1
	Spacer	NAS43DD3-32	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1

Figure 3-18. P113 Harness (Sheet 3 of 3)

3-57. P114 HARNESS.

3-58. REMOVING P114 HARNESS. (See figure 3-19.)

a. Make sure that electrical power source is turned off.

WARNING

Disconnecting or connecting electrical connectors without turning off the power source can cause electrical arcing between connectors, resulting in serious injury or death to personnel and damage to equipment.

b. To facilitate removal of harness, disconnect primary junction box support harness support bracket (6) from primary/auxiliary junction box struts support and allow harness bundle to drop free.

c. Disconnect electrical plug P114 (2), as outlined in paragraph 3-14, from primary junction box.

d. Disconnect electrical plugs P71 (3), and P77 (4), as outlined in paragraph 3-14, from No. 2 oxidizer valve and No. 2 fuel valve.

e. Disconnect electrical receptacle J128 (5) from thrust chamber mount bracket.

f. Before removing harness support clamp assembly (7), note position of clamp assembly (7) in relation to its distance from primary junction box.

NOTE

If the harness is to be replaced, noting the location of this clamp assembly is important, as it will facilitate the reinstallation of the new harness.

g. Remove harness support clamp assembly (7) from harness support bracket (6), and retain bracket for reinstallation.

h. Remove remaining harness support clamp assemblies (8) through (18), and carefully remove harness from engine.

i. Install protective dust caps on electrical plugs. Dust-cap requirements, by connector reference designation number, are listed in R-3896-4.

j. For servicing or maintenance, install dust caps fingertight on electrical connectors. Dust-cap requirements, by connector number, are listed in figure 3-4.

k. If harness is to be transported to a repair area or stored, wrap harness with cushioning material to prevent possible damage. Wrap each individual electrical connector with cushioning material to prevent damage to connectors or other parts of harness.

3-59. INSTALLING P114 HARNESS. (See figure 3-19.)

a. Observe harness installation requirements outlined in paragraph 3-18.

b. Position harness on engine, routing electrical plugs and receptacle to their respective connect points at primary junction box, No. 2 oxidizer valve, No. 2 fuel valve, and thrust chamber mount bracket. Check breakout molds for proper location.

c. Connect electrical plug P114 (2) to primary junction box fingertight as outlined in paragraph 3-15.

d. Connect electrical plugs P71 (3) and P77 (4) fingertight, as outlined in paragraph 3-15, to No. 2 oxidizer valve and No. 2 fuel valve.

e. Connect electrical receptacle J128 (5) to thrust chamber mount bracket. Torque nuts to 10-12 in-lb.

f. Locate harness support clamp assembly (7) on harness in relation to its distance from primary junction box, as noted during removal of harness.

NOTE

The position of clamp assembly (7) is important, since its location directly affects the correct location of the other clamp assemblies.

g. Install harness support clamp assembly (7) on primary junction box support harness support bracket (6) that was removed as part of harness removal. Tighten harness support clamp screw sufficiently to prevent harness movement within clamp and yet not damage harness.

h. Connect primary junction box support harness support bracket (6) to primary/auxiliary junction box struts support. Torque nuts to 125 ±5 in-lb.

i. Install remaining harness support clamp assemblies (8) through (18), starting with clamp assembly closest to center of harness and working toward junction box and electrical plugs Make sure no excessive strain is applied to harness. Tighten harness support clamp screws sufficiently to prevent harness movement within clamp and yet not damage harness.

j. Torque and safetywire electrical plugs P114 (2), P71 (3), and P77 (4) as outlined in paragraph 3-15.

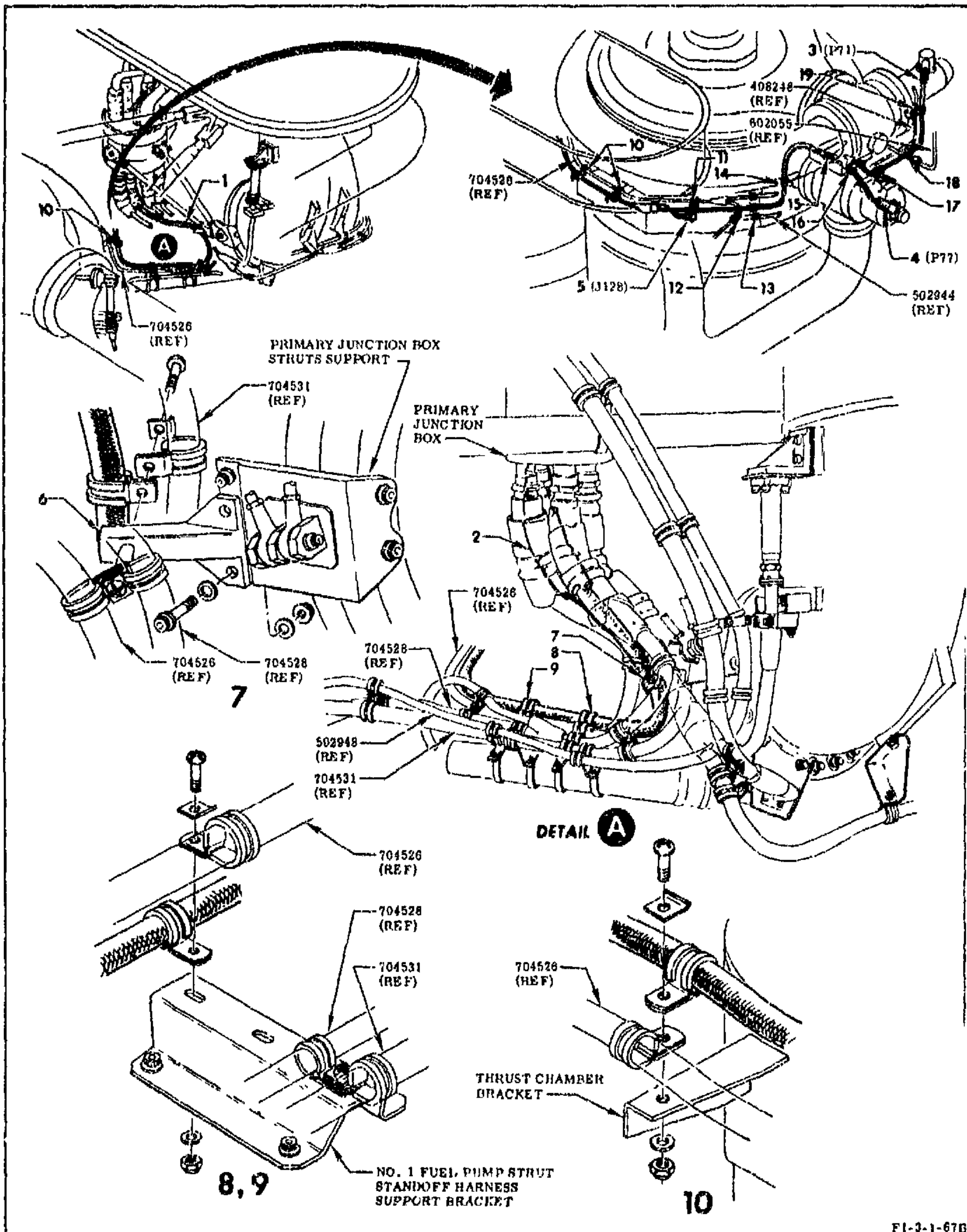


Figure 3-19. P114 Harness (Sheet 1 of 3)

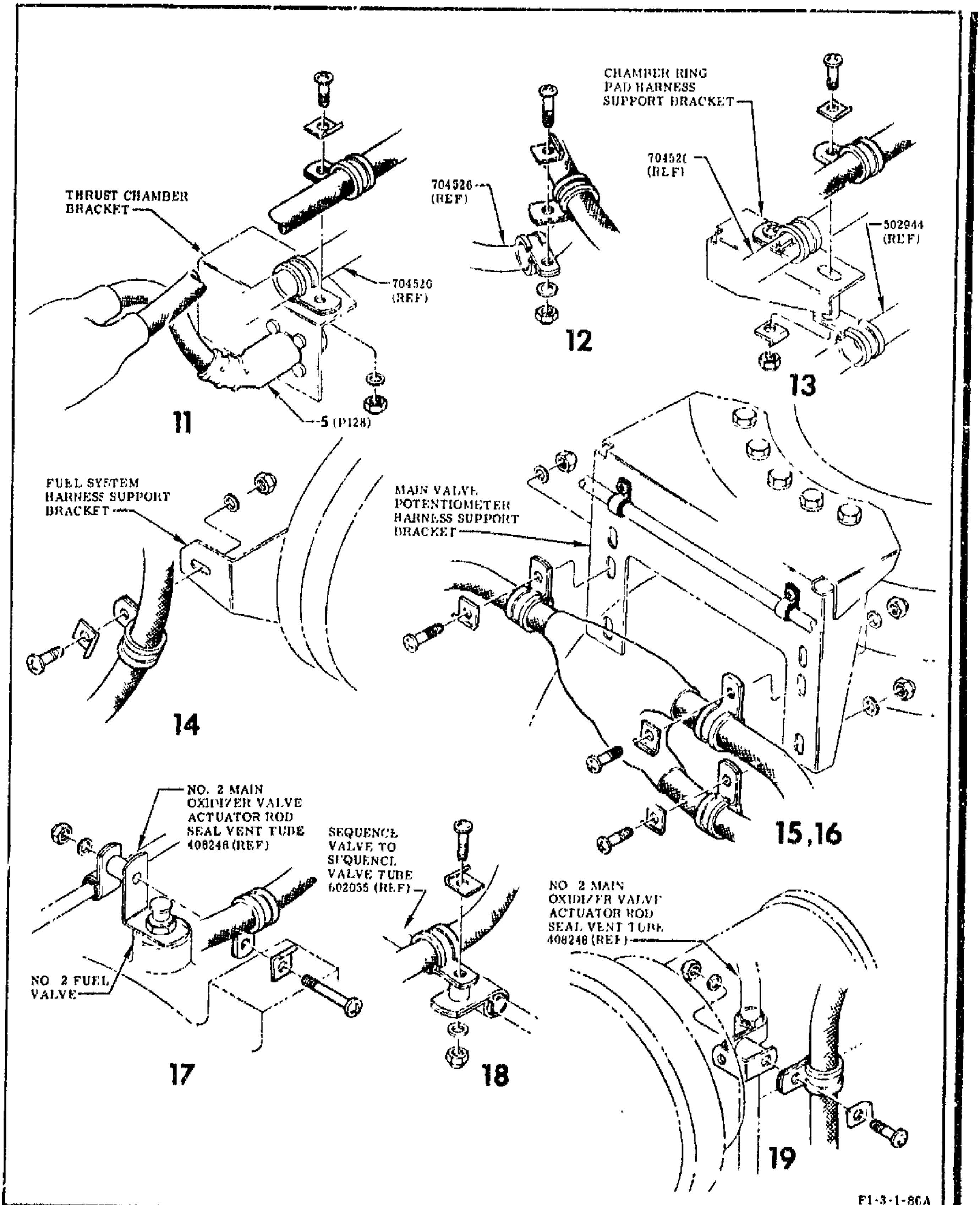


Figure 3-19. P114 Harness (Sheet 2 of 3)

Index No.	Name and Attaching Parts	Part No.	Quantity
1	P114 harness	704532	1
2	Electrical plug P114	502935-301	1
	Boot	19-501743-6	1
3	Electrical plug P71	502935-171	1
	Boot	19-501743-4	1
4	Electrical plug P77	502935-171	1
	Boot	19-501743-4	1
5	Electrical receptacle J128	502936-41	1
	Boot	19-501743-12	1
	Screw	AN515C4R7	4
	Washer	LD153-0010-0001	4
	Nut	NAS679C04W	4
6	Primary junction box support harness support bracket	703902	1
	Bolt	RD111-4011-0422	2
	Washer	RD153-1002-0004	2
	Washer	RD153-5002-0004	2
	Nut	RD114-8005-1004	2
7	Clamp assembly		
	Clamp	RE127-2004-0015	1
	Clamp	RE127-2005-0016	1
	Screw	AN520C10R16	1
8	Clamp assembly		
	Clamp	RE127-2004-0017	1
	Clamp	RE127-2005-0015	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
9	Clamp assembly		
	Clamp	RE127-2004-0018	1
	Clamp	RE127-2005-0015	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
10	Clamp assembly		
	Clamp	RE127-2004-0016	1
	Clamp	RE127-2005-0017	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
11	Clamp assembly		
	Clamp	RE127-2004-0016	1
	Clamp	RE127-2005-0013	1
	Screw	AN520C10R12	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
12	Clamp assembly		
	Clamp	RE127-2004-0015	1
	Clamp	RE127-2005-0012	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
13	Clamp assembly		
	Clamp	RE127-2004-0011	1
	Clamp	RE127-2004-0013	1
	Screw	AN520C10R22	1
	Spacer	NAS43DD3-40	1
	Nut	NAS679C3W	1
14	Clamp assembly		
	Clamp	RE127-2004-0013	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
15	Clamp assembly		
	Clamp	RE127-2004-0013	1
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
16	Clamp assembly		
	Clamp	RE127-2004-0011	2
	Screw	AN520C10R10	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
17	Clamp assembly		
	Clamp	RE127-2004-0011	1
	Clamp	RE127-2001-0002 (b)	1
	Screw	AN520C10R10 (a)	1
	Screw	AN520C10R16 (b)	1
	Spacer	NAS43DD3-24 (b)	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
18	Clamp assembly		
	Clamp	RE127-2001-0006	1
	Clamp	RE127-2004-0011	1
	Screw	AN520C10R16	1
	Spacer	NAS43DD3-24	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1
19	Clamp assembly		
	Clamp	RE127-2004-0011	1
	Clamp	RE127-2001-0002 (b)	1
	Screw	AN520C10R8 (a)	1
	Screw	AN520C10R16 (b)	1
	Spacer	NAS43DD3-24 (b)	1
	Washer	LD153-0010-0007	1
	Nut	NAS679C3W	1

(a) Engines not incorporating MD162 or MD163 change
(b) Engines incorporating MD162 or MD163 change

Figure 3-10. P114 Harness (Sheet 3 of 3)

3-60. QUICK-DISCONNECTS AND ADAPTERS.

3-61. This procedure contains instructions for installing quick-disconnects and adapters. Figure 3-20 shows the various quick-disconnect installations for both the flanged and threaded type of quick-disconnects and adapters. Location, type, lubricant, seal data, and torque requirements for quick-disconnects are listed in figure 3-21. The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne). Specified lubricating procedures (methods) are outlined in section I.

3-62. INSTALLING FLANGED-TYPE QUICK-DISCONNECTS AND ADAPTERS. (See figure 3-20.)

a. For quick-disconnects installed with a flanged adapter, install adapter with seal plates. Torque attach bolts to applicable torque value, and safetywire. Torque requirements for adapter attach bolts are listed in figure 3-21.

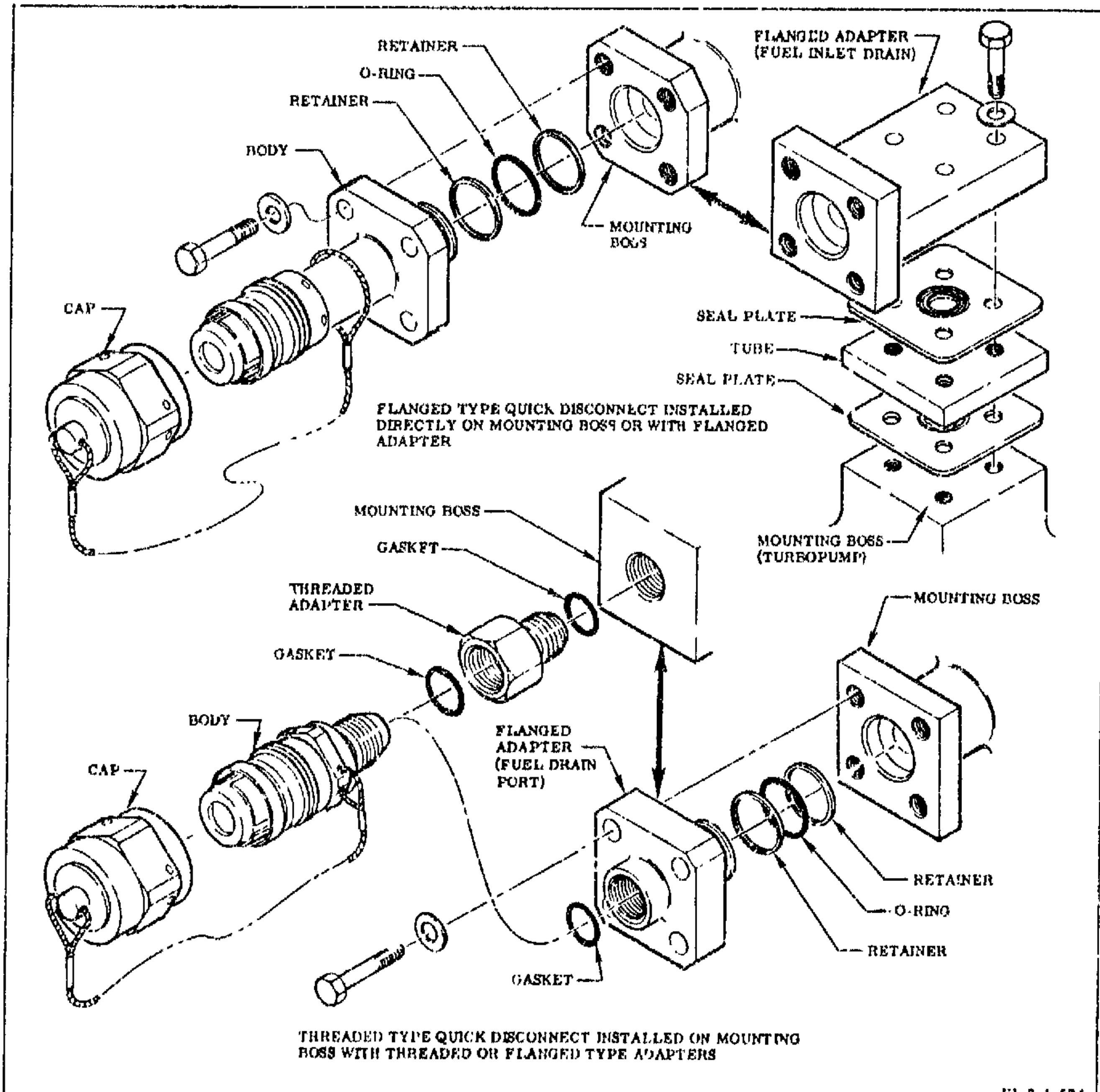


Figure 3-20. Quick-Disconnects and Adapters

Location	Quick-Disconnect Part Number NA5-260079-	Type	Seals	Seal Lubrication	Adapter Torque	Quick-Disconnect Body Torque	Cap Torque[a]
No. 1 and No. 2 fuel inlet elbow drains	-T3	Flanged	O-ring RD262-4006-0121 Retainer MS28774-023	(b)	Flanged-type adapter. Torque attach bolts to 40-50 in-lb.	Torque attach bolts to 40-50 in-lb.	70-75 ft-lb
No. 1 and No. 2 fuel high-pressure duct drains	-T2	Flanged	O-ring RD262-4006-0018 Retainer MS28774-018	(b)		Torque attach bolts to 43 ±3 in-lb.	30-40 ft-lb
No. 1 and No. 2 fuel manifold inlet drains	-T1	Threaded	Gasket RD262-3001-0006 O-ring RD262-4006-0121 Retainer MS28774-121	(b)	Flanged-type adapter. Torque attach bolts to 75 ±5 in-lb.	135 ±15 in-lb[b]	30-40 ft-lb
No. 1 and No. 2 fuel valve purge	-T7	Flanged	O-ring RD262-4006-0018 Retainer MS28774-018	(b)		Torque attach bolts to 35 ±2 in-lb.	30-40 ft-lb
Bearing coolant control valve preservative inlet	-T6	Flanged	O-ring RD262-4006-0018 Retainer MS28774-018	(b)		Torque attach bolts to 40-50 in-lb.	30-40 ft-lb
Engine control valve supply tube drain	-T2	Flanged	O-ring RD262-4006-0018 Retainer MS28774-018	(b)		Torque attach bolts to 80 ±5 in-lb.	30-40 ft-lb
Checkout valve engine return hose drain	-T2	Flanged	O-ring RD262-4006-0018 Retainer MS28774-018	(b)		Torque attach bolts to 45 ±5 in-lb.	30-40 ft-lb

(a) When removing or installing quick-disconnect cap, quick-disconnect body must not be allowed to turn.
(b) Use lubricant grease RB0140-012 (Rocketdyne) on seals and/or threads.

Figure 3-21. Requirements for Installing Quick-Disconnects (Sheet 1 of 2)

Location	Quick-Disconnect Part Number NA5-260079-	Type	Seals	Seal Lubrication	Adapter Torque	Quick-Disconnect Body Torque	Cap Torque[a]
Actuator return line drain	-T2	Flanged	O-ring RD262-4006-0018 Retainer MS28774-018	(b)		Torque attach bolts to 45 ±5 in-lb.	30-40 ft-lb
Hypergol manifold drain	-T4	Flanged	O-ring RD262-4006-0012 Retainer MS28774-012	(b)		Torque attach bolts to 27-33 in-lb.	30-40 ft-lb
Hypergol manifold purge	-T7	Flanged	O-ring RD262-4006-0018 Retainer MS28774-018	(b)		Torque attach bolts to 72-88 in-lb.	30-40 ft-lb
Ignition monitor valve drain	-T2	Flanged	O-ring RD262-4006-0018 Retainer MS28774-018	(b)		Torque attach bolts to 75 ±5 in-lb.	30-40 ft-lb
Gas generator ball valve fuel drain	308206	Threaded	Gasket RD262-3001-0004 Gasket RD262-3001-0006	(b)	220 ±10 in-lb	220 ±10 in-lb	220 ±10 in-lb

(a) When removing or installing quick-disconnect cap, quick-disconnect body must not be allowed to turn.
(b) Use lubricant grease RB0140-012 (Rocketdyne) on seals and/or threads.

Figure 3-21. Requirements for Installing Quick-Disconnects (Sheet 2 of 2)

b. Lubricate (Method J) quick-disconnect O-ring and install quick-disconnect body with O-ring and retainers to mounting boss or flanged adapter. Torque attach bolts to applicable torque value, and safetywire. Torque requirements for quick-disconnect attach bolts are listed in figure 3-21.

c. Install cap on quick-disconnect body and torque to applicable torque value. Torque requirements for quick-disconnect caps are listed in figure 3-21.

3-63. INSTALLING THREADED-TYPE QUICK-DISCONNECTS AND ADAPTERS. (See figure 3-20.)

a. For quick-disconnects installed with a threaded adapter, lubricate (Method A) adapter. Lubricate (Method J) gasket, and install adapter with gasket into port. Torque adapter to applicable torque value. Torque requirements for threaded adapters are listed in figure 3-21.

CAUTION

Overtorque applied to a threaded adapter can result in damage to parts.

b. For quick-disconnects installed with a flanged adapter, lubricate (Method J) adapter gasket, and install adapter with gasket on mounting boss. Torque adapter attach bolts to applicable torque value, and safetywire. Torque requirements for adapter attach bolts are listed in figure 3-21.

CAUTION

When installing the quick-disconnect body into a threaded adapter, counter-torque must be applied to the adapter, or damage to parts can result.

c. Lubricate (Method A) quick-disconnect. Lubricate (Method J) gasket. Install quick-disconnect body with gasket on adapter. Torque quick-disconnect body to applicable torque. Torque requirements for quick-disconnects are listed in figure 3-21.

d. Install cap on quick-disconnect body and torque to applicable value. Torque requirements for quick-disconnect caps are listed in figure 3-21.

3-64. <u>FLIGHT INSTRUMENTATION PRESSURE TRANSDUCERS.</u>

3-65. REMOVING FLIGHT INSTRUMENTATION PRESSURE TRANSDUCERS. (See figure 3-22.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

CAUTION

When removing gas generator chamber pressure transducer P119 or thrust chamber combustion chamber pressure transducer P123, the transducer must be disconnected or loosened from the bracket or adapter prior to disconnecting the harness, to prevent damage to the harness or transducer.

b. Disconnect transducer harness plug as outlined in paragraph 3-16.

c. Remove transducer (1) and seal (2).

3-66. INSTALLING FLIGHT INSTRUMENTATION PRESSURE TRANSDUCERS. (See figure 3-22.)

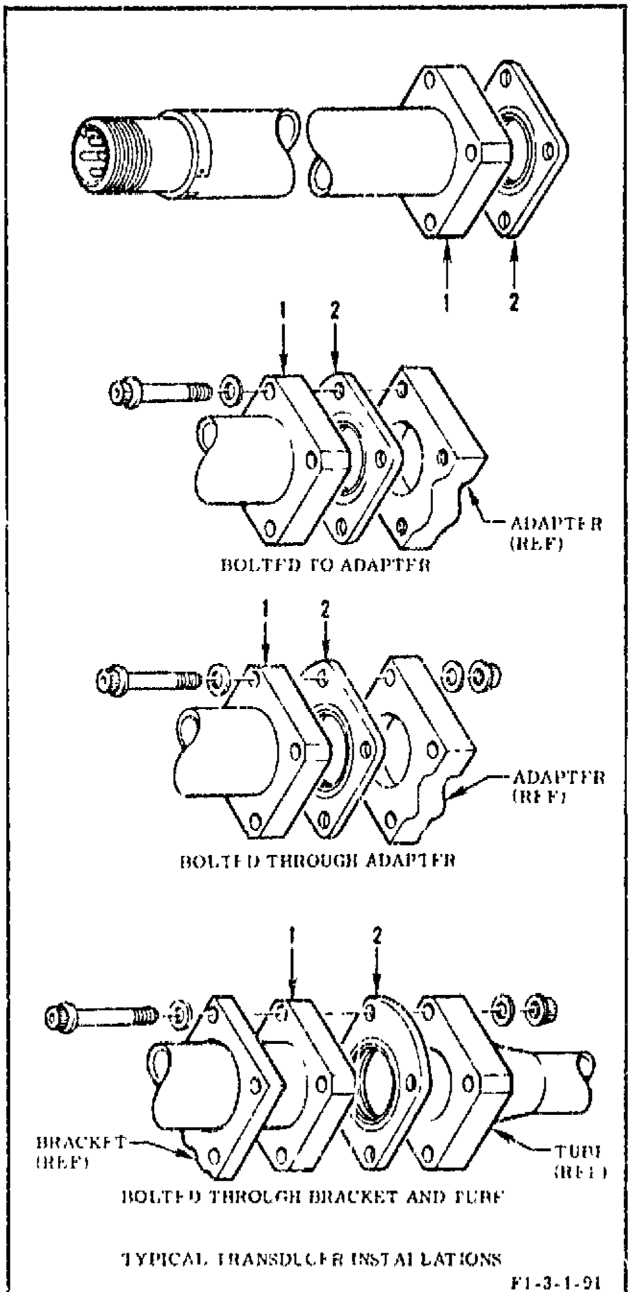
a. If installing a replacement transducer, verify that transducer preinstallation test outlined in section I has been performed.

aA. Observe safety, and contamination and damage prevention requirements outlined in section I.

CAUTION

When installing gas generator chamber pressure transducer P119 or thrust chamber combustion chamber pressure transducer P123, the transducer must remain loose until after the harness plug is fully mated and torqued to prevent damage to harness and transducer.

b. Install transducer (1) and seal plate (2) to adapter or tube. Position transducer to match keyway of harness plug. Cross-torque fasteners for applicable installation using torquing procedure outlined in section I as follows: transducer bolted to adapter, 45 ±5 in-lb; transducer bolted through adapter, bracket, and tube flange, 70 ±5 in-lb, except gas generator chamber pressure transducer P119 and thrust chamber combustion chamber pressure transducer P123, which are torqued to 125 ±10 in-lb.



1 Transducer 2 Seal

Figure 3-22. Flight Instrumentation Pressure Transducers

c. Connect electrical plug of instrumentation harness using method outlined in paragraph 3-17.

d. If applicable, cross-torque nuts that secure P119 and P123 to 125 ±10 in-lb after instrumentation harness plug is fully mated and torqued.

e. Refer to section IV for post-maintenance test requirements.

3-67. FLIGHT INSTRUMENTATION TEMPERATURE TRANSDUCERS.

3-68. TURBINE INLET MANIFOLD TEMPERATURE TRANSDUCER.

3-69. This procedure is applicable to engines incorporating MD149 change and not incorporating MD176 change.

3-70. REMOVING TURBINE INLET MANIFOLD TEMPERATURE TRANSDUCER. (See figure 3-23.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove boot (1), and disconnect connector P137 (2) using method outlined in paragraph 3-14.

c. Remove transducer mounting bolts and nuts.

CAUTION

Step d is performed only to free the transducer in the boss. No attempt shall be made to free the transducer from the boss by continuously rotating the transducer because damage to the copper rings will result.

d. Free transducer (3) by rotating transducer a few degrees in mounting boss using a suitable open-end wrench on transducer flange.

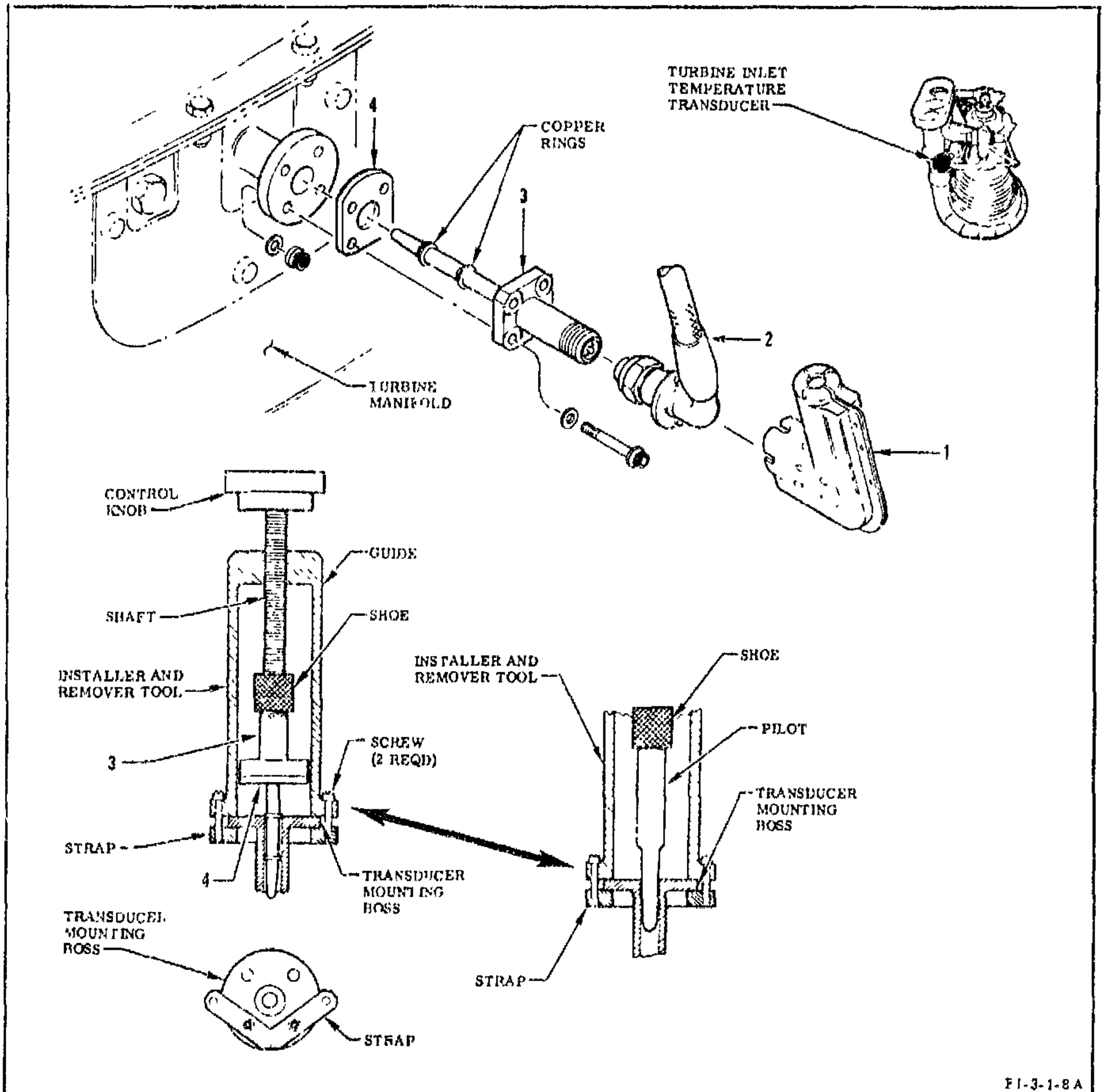
e. Remove transducer (3, using installer and remover kit G2038, or equivalent, as follows:

(1) Position strap of tool on underside of transducer mounting boss with roll pins of strap in boss mounting holes.

(2) Place guide of tool on face of mounting boss, and install two screws through guide into strap. Tighten screws until strap and guide come in contact with mounting boss.

NOTE

A floating action is required between the strap, the guide, and the mounting boss.



1	Boot	3	Transducer
2	Connector	4	Seal

Figure 3-23. Turbine Inlet Manifold Temperature Transducer

(3) Adjust control knob and shoe of tool until shoe is mated with transducer electrical receptacle. Fully screw shoe of tool onto electrical receptacle of transducer.

(4) Tighten two screws that secure guide of tool to strap.

(5) Turn control knob counterclockwise, and pull transducer (3) free of mounting boss.

f. Remove seal (4) and disconnect transducer from tool. Install protective cap RD265-6002-3002 on transducer electrical receptacle.

g. Disengage tool from transducer mounting boss.

h. Return removed transducer to Rocketdyne.

NOTE

Once a transducer has been removed for any reason, the copper rings must be re-formed before reinstallation, since the diameter of the copper rings has been reduced to a point where an interference fit in the mounting boss cannot be maintained.

3-71. INSTALLING TURBINE INLET MANIFOLD TEMPERATURE TRANSDUCER. (See figure 3-23.)

a. If installing a replacement transducer, verify that transducer preinstallation test outlined in section I has been performed.

aA. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. If engine has been hot fired, clean carbon from transducer mounting boss. Clean bore using reamer from kit G2038. Use care to prevent removal of parent material.

c. Make sure transducer is in a serviceable condition and copper rings have been re-formed.

NOTE

Transducers that have been refurbished and have had the copper rings re-formed may exhibit minor imperfections in the copper rings due to reswaging of the copper. These minor imperfections due to reswaging are considered acceptable.

d. Install transducer using installer and remover kit G2038, or equivalent, as follows:

(1) Fully screw pilot into shoe of tool.

(2) Position strap of tool on underside of transducer mounting boss with roll pins in boss mounting holes.

(3) Place guide of tool on face of mounting boss and install two ND112-0001-0511 screws through guide into strap. Tighten screws until strap and guide come in contact with mounting boss.

NOTE

A floating action is required between the strap, the guide, and the mounting boss.

(4) Turn control knob of tool clockwise and insert pilot into mounting boss as far as it will go. (Pilot will be inserted approximately 1.25 inches into boss.) Do not overtorque control knob.

CAUTION

The guide must be free to float, allowing it to seek axial alinement with the boss.

(5) Tighten 2 screws securing guide of tool to strap.

(6) Turn control knob counterclockwise, and pull free of mounting boss; then disconnect pilot from tool.

(7) Fully screw transducer electrical receptacle into shoe of tool. Make sure receptacle keyway is positioned for subsequent connecting of connector (2).

(8) Place seal (4) on transducer stem.

(9) Turn control knob clockwise, and gently insert transducer into mounting boss, visually checking copper ring fit into boss. Press transducer into place until seal (4) and transducer (3) are flush with mounting boss face.

(10) Disconnect and remove tool.

e. Secure transducer to mounting boss as follows:

(1) Cross-torque bolts to 130 ±5 in-lb.

(2) After all bolts are torqued to 130 ±5 in-lb, decrease torque on each bolt to 50 ±5 in-lb; then final-torque bolts to 70 ±5 in-lb.

f. Connect connector (2) as outlined in paragraph 3-15.

g. Refer to section IV for post-maintenance test requirements.

3-72. ENVIRONMENTAL TEMPERATURE TRANSDUCER.

3-73. The environmental temperature transducer is located on the No. 1 side of the engine and is attached to a bracket on the aft tooling ring of the thrust chamber.

3-74. REMOVING ENVIRONMENTAL TEMPERATURE TRANSDUCER.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect connector from transducer using procedure outlined in paragraph 3-14.

c. Remove transducer from bracket.

3-75. INSTALLING ENVIRONMENTAL TEMPERATURE TRANSDUCER.

a. If installing a replacement transducer, verify that transducer preinstallation test outlined in section I has been performed.

aA. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install transducer in bracket with receptacle positioned to match keyway of harness connector. Cross-torque nuts to 70 ±5 in-lb.

c. Install connector using procedure outlined in paragraph 3-15.

d. Refer to section IV for post-maintenance test requirements.

3-75A. OXIDIZER PUMP BEARING TEMPERATURE TRANSDUCER NO. 1.

3-75B. The transducer is located on the turbopump. The electrical receptacle (J134) of the transducer is attached to the upper connector panel on the No. 1 side of the turbopump.

3-75C. REMOVING OXIDIZER PUMP BEARING TEMPERATURE TRANSDUCER NO. 1.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

aA. Note position of keyway of receptacle J134, and disconnect receptacle from panel.

b. Disconnect transducer at probe and by unscrewing transducer retainer, remove transducer and packing.

3-75D. INSTALLING OXIDIZER PUMP BEARING TEMPERATURE TRANSDUCER NO. 1.

a. If installing a replacement transducer, verify that transducer preinstallation tests outlined in section I have been performed.

aA. Observe safety, and contamination and damage prevention requirements outlined in section I.

aB. Lubricate (Method J) packing with lubricant grease RB0140-012 (Rocketdyne) and install packing on retainer of transducer.

aC. Install probe end of transducer in pump housing; then position transducer receptacle at panel to locate keyway in required position.

b. Torque retainer to 80-90 in-lb.

c. Attach receptacle at panel and install lug at attaching screw. Torque nuts to 3.5 to 4.5 in-lb.

3-76. TEMPERATURE TRANSDUCERS (ENGINES NOT INCORPORATING MD96 CHANGE).

3-77. This procedure applies to the following flight instrumentation temperature transducers:

a. No. 2 fuel pump inlet temperature transducer located on No. 2 fuel inlet elbow.

b. Heat exchanger oxidizer inlet temperature transducer located on heat exchanger check valve.

c. Heat exchanger GOX outlet temperature transducer located on heat exchanger GOX duct (heat exchanger end).

d. Heat exchanger helium outlet temperature transducer located on heat exchanger helium return duct (heat exchanger end).

3-78. REMOVING TEMPERATURE TRANSDUCERS (ENGINES NOT INCORPORATING MD96 CHANGE).

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect connector from transducer using procedure outlined in paragraph 3-14.

c. Remove transducer and seal.

3-79. INSTALLING TEMPERATURE TRANSDUCERS (ENGINES NOT INCORPORATING MD96 CHANGE).

a. If installing a replacement transducer, verify that transducer preinstallation test outlined in section I has been performed.

aA. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install seal and transducer with transducer positioned to match keyway of connector. Cross-torque bolts to 45 ±5 in-lb. Safetywire bolts.

c. Install connector using procedure outlined in paragraph 3-15.

d. Refer to section IV for post-maintenance test requirements.

3-80. PRIMARY JUNCTION BOX.

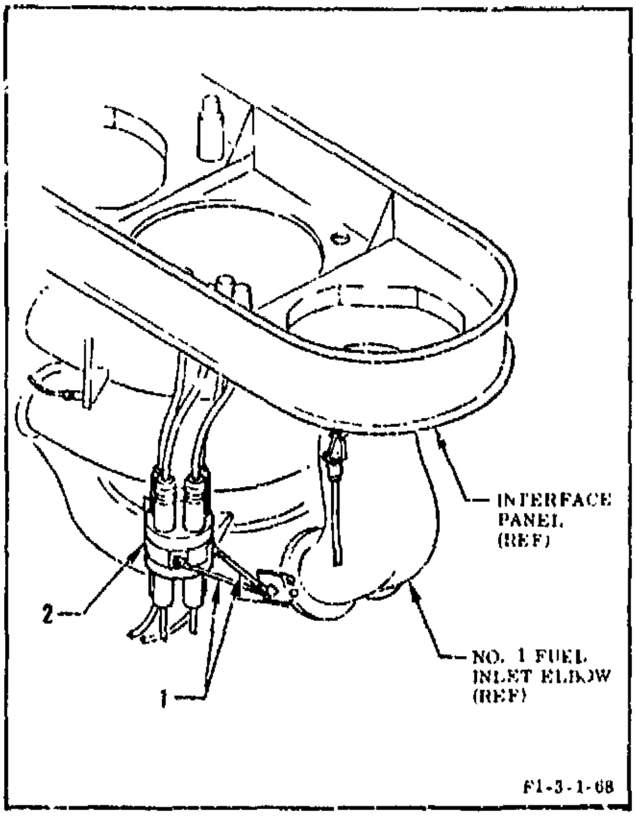
3-81. REMOVING PRIMARY JUNCTION BOX. (See figure 3-24.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect connectors as outlined in paragraph 3-14.

c. Remove struts (1). Do not disturb adjusted lengths of struts.

d. Disconnect junction box (2) from turbopump flange.



1 Strut 2 Junction box

Figure 3-24. Primary Junction Box

3-82. INSTALLING PRIMARY JUNCTION BOX. (See figure 3-24.)

a. If installing a replacement junction box, verify that junction box preinstallation tests outlined in section I have been performed.

aA. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Attach junction box (2) to turbopump flange. Torque bolts to 70 ±5 in-lb. Safetywire bolts.

c. Install struts (1). Torque nuts to 150 ±10 in-lb. If strut lengths require adjusting, torque checknuts to 100 ±5 in-lb. Safetywire checknuts.

d. Install connectors as outlined in paragraph 3-15.

e. Refer to section IV for post-maintenance test requirements.

3-83. <u>OXIDIZER FLOWMETER.</u>

3-84. REMOVING OXIDIZER FLOWMETER. (See figure 3-25.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Slide boot (1) back from plug (2), and disconnect plug as outlined in paragraph 3-14.

c. Remove attaching hardware, and carefully remove seals (3, 4) and flowmeter (5).

3-85. INSTALLING OXIDIZER FLOWMETER. (See figure 3-25.)

a. If installing a replacement flowmeter, verify that flowmeter preinstallation test outlined in section I has been performed.

aA. Observe safety, and contamination and damage prevention requirements outlined in section I.

WARNING

The use of contaminated parts in a liquid oxygen or indirect liquid oxygen system can cause an explosion resulting in injury to personnel and damage to equipment.

CAUTION

If the flowmeter has been subjected to solvent cleaning, the flowmeter must be inspected for residual chlorinate solvent as outlined in section I. Residual solvents within the flowmeter can cause corrosion.

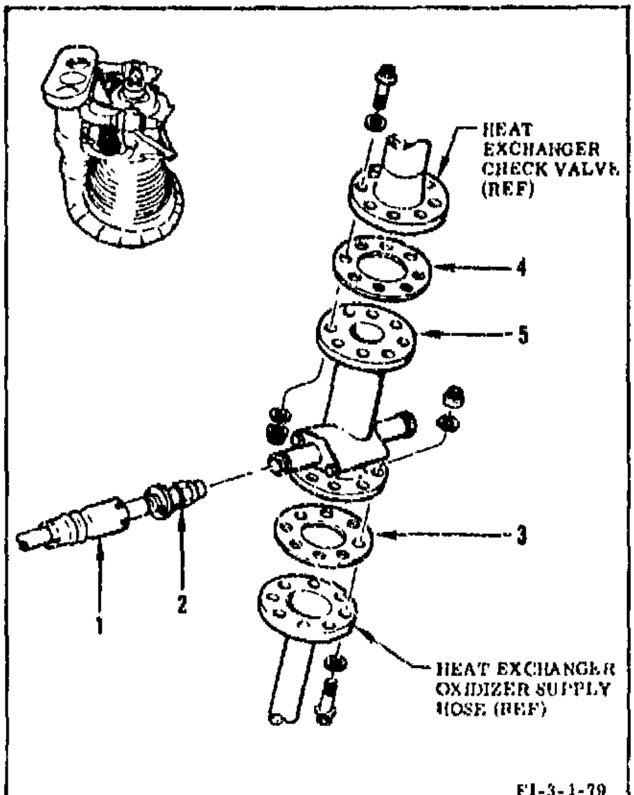
b. Make sure parts are clean for use in liquid oxygen service.

c. Carefully install seals (3, 4) and flowmeter (5). Make sure transducer is positioned to allow connector (2) to be connected.

d. Cross-torque nuts to 255 ±15 in-lb using torque method outlined in section I.

e. Connect plug (2) as outlined in paragraph 3-15.

f. Refer to section IV for post-maintenance test requirements.



1	Boot	4	Seal
2	Plug	5	Oxidizer flowmeter
3	Seal		

Figure 3-25. Oxidizer Flowmeter

3-86. HEAT EXCHANGER CHECK VALVE.

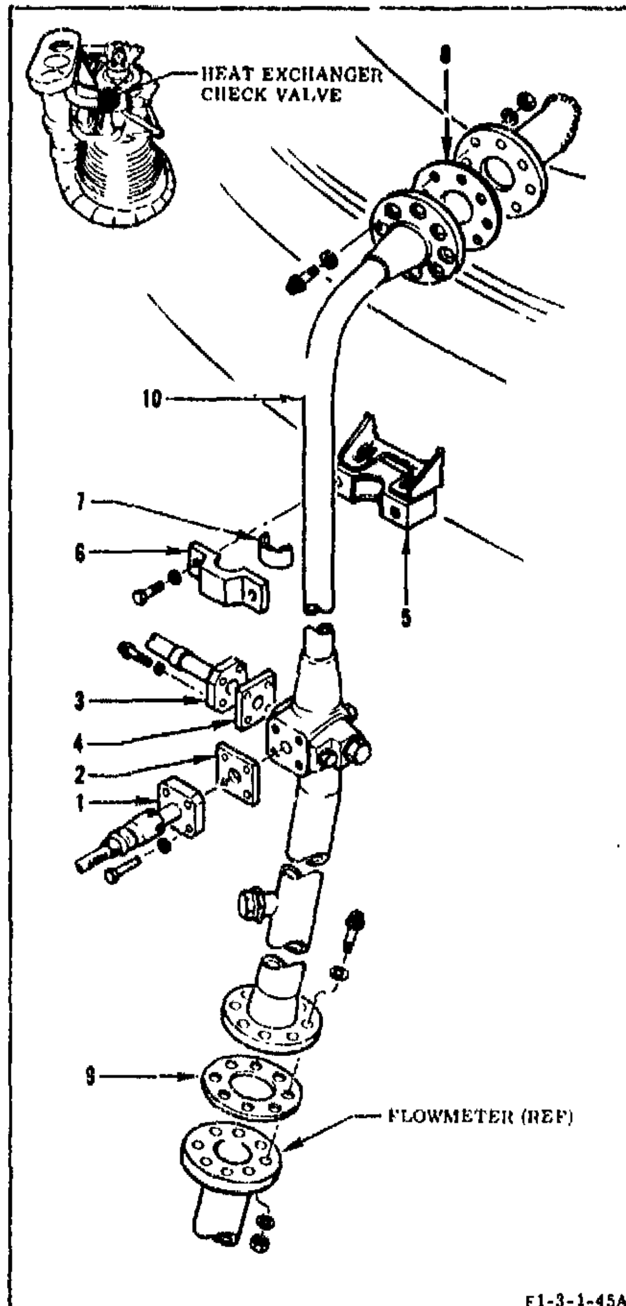
3-87. REMOVING HEAT EXCHANGER CHECK VALVE. (See figure 3-26.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. On engines not incorporating MD96 change, remove transducer (1), seal (2), tube (3), and seal (4).

c. Remove cover (6) and, if necessary, remove liners (7).

d. Disconnect flanges, and remove seals (8, 9) and valve (10).



1	Transducer[a]	6	Cover
2	Seal[a]	7	Liners
3	Tube[a]	8	Seal
4	Seal[a]	9	Seal
5	Block	10	Check valve

(a) Engines not incorporating MD96 change

Figure 3-26. Heat Exchanger Check Valve

3-88. INSTALLING HEAT EXCHANGER CHECK VALVE. (See figure 3-26.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

WARNING

The use of contaminated parts in a liquid oxygen or indirect liquid oxygen system can cause an explosion resulting in injury to personnel and damage to equipment.

CAUTION

If the heat exchanger check valve has been subjected to solvent cleaning, the valve must be inspected for residual halogenated solvents as outlined in section I. Residual solvents within the heat exchanger check valve can cause corrosion.

b. Make sure that parts are cleaned for liquid oxygen service and that covers are not removed until parts are ready for installation.

c. Install liners (7), if necessary, and position check valve (10) in place using seals (8, 9). Cross-torque nuts to 255 ±5 in-lb using torque method outlined in section I.

d. If necessary, adjust block (5) to valve (10). Torque nuts to 125 ±5 in-lb.

e. Install cover (6), and cross-torque bolts to 12 ±2 in-lb using torque method outlined in section I.

NOTE

Steps f through i apply to engines not incorporating MD96 change.

f. Install seal (4) and tube (3).

g. Install seal (2) and transducer (1).

h. Cross-torque bolts for tube (3) and transducer (1) to 45 ±5 in-lb using torque method outlined in section I.

i. Safetywire all bolts not secured by nuts, using method outlined in section I.

j. Refer to section IV for post-maintenance test requirements.

3-89. WRAP-AROUND DUCTS AND HOSES.

3-90. Tools required consist of alinement tool T-5041233 and support T-5046440, or equivalent.

3-91. REMOVING WRAP-AROUND DUCTS AND HOSES. (See figure 3-27.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

aA. Disassemble the following thermal insulation brackets, as required, to provide clearance for removing wrap-around ducts. Refer to R-3896-6.

(1) Helium supply, helium return, and GOX wrap-around ducts: bracket 145188 and tie rod 145305.

(2) Hydraulic supply and hydraulic return wrap-around ducts: bracket 145290.

CAUTION

Extreme care must be used when removing the gimbal jointed ducts. The unattached ends must be supported to prevent damage to the gimbal joints and braided sections.

b. Remove covers (2, 4, 6, 9) or cover (15) and clips (16, 17), as necessary, to remove duct or ducts.

c. Remove support tool T-5046440, and disconnect applicable ducts or hoses at engine connection.

3-92. INSTALLING WRAP-AROUND DUCTS AND HOSES.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

CAUTION

Extreme care must be used when installing the gimbal jointed ducts. The unattached ends must be supported to prevent damage to the gimbals and braided sections.

b. Install pad K2297-2 in cradle of existing engine bracket for duct (1).

c. Install duct (1) and secure to engine line using seal 406349, 6 bolts RD111-4011-6527, 6 washers RD153-5002-0005, 6 washers RD153-1002-0005, and 6 nuts RD114-8005-1005. Torque nuts to 265 ±5 in-lb.

d. Install pad K2297-2 in cover 651298 (2). Install cover and secure with 4 bolts RD111-1009-0417 and 4 washers LD153-0013-0002. Torque bolts to 35 ±2 in-lb. Safetywire bolts.

e. Install pad K2297-6 in cradle of existing engine bracket for helium return duct (3).

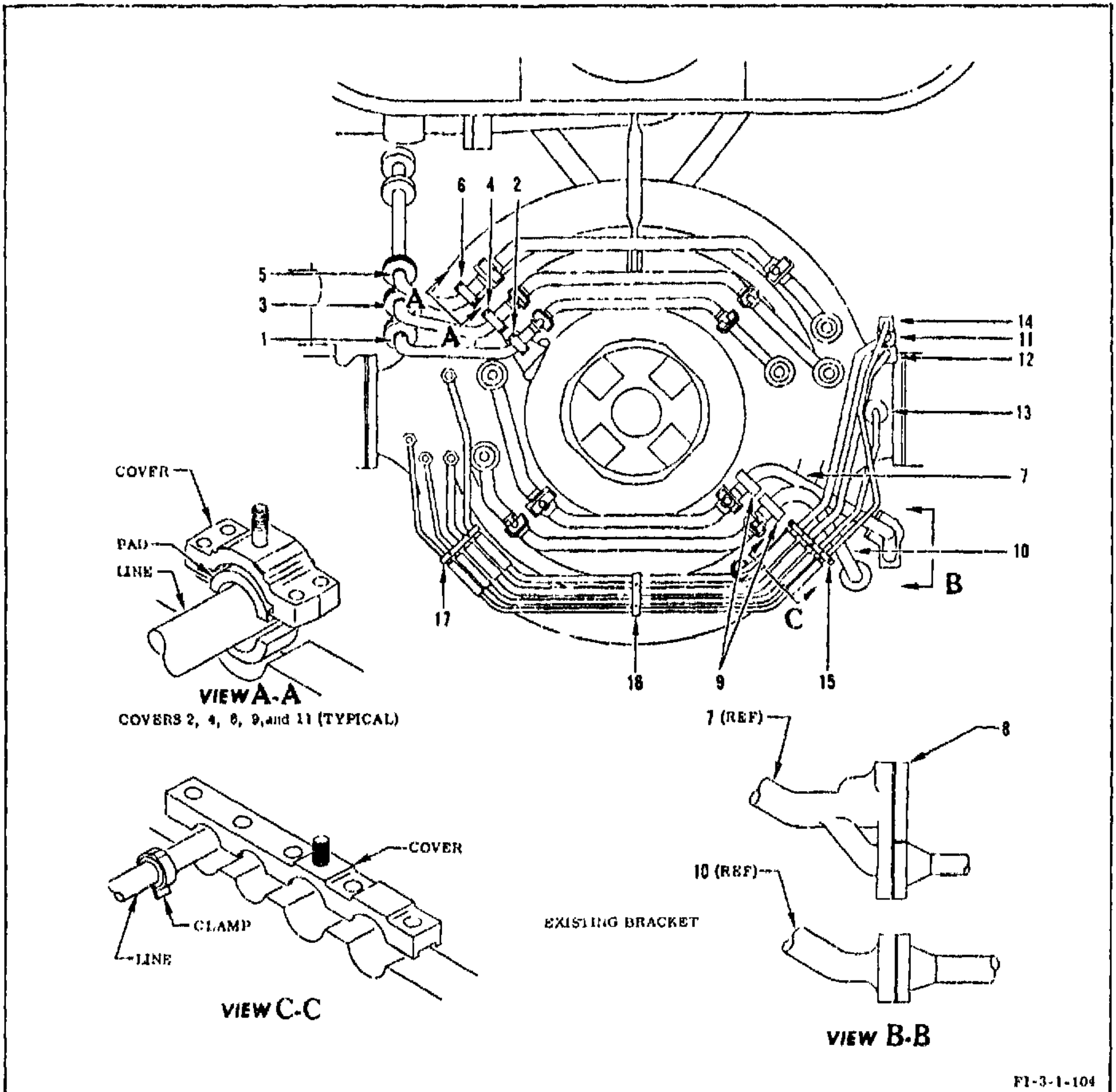
f. Install duct (3) and secure to engine line using seal 406350 (engines not incorporating MD187 change) or seal 409895 (engines incorporating MD187 change) and 8 bolts RD111-4011-6527, 8 washers RD153-5002-0005, 8 washers RD153-1002-0005, and 8 nuts RD114-8005-1005. Torque nuts to 265 ±10 in-lb.

g. Install pad K2297-6 in cover 651296 (4). Install cover and secure with 4 bolts RD111-1009-0417 and 4 washers LD153-0013-0002. Torque bolts to 35 ±2 in-lb. Safetywire bolts.

h. Install pad K2297-6 in cradle of existing engine bracket for GOX return duct (5).

i. Install duct (5) and secure to engine line using seal 406350 (engines not incorporating MD186 change) or seal 409895 (engines incorporating MD186 change) and 8 bolts RD111-4011-6527, 8 washers RD153-5002-0005, 8 washers RD153-1002-0005, and 8 nuts RD114-8005-1005. Torque nuts to 265 ±10 in.-lb.

j. Install support tool T-5046440, or equivalent, to support duct (1, 3, 5).



1 Helium supply wrap-around duct
2 Cover
3 Helium return wrap-around duct
4 Cover
5 GOX wrap-around duct
6 Cover
7 Hydraulic supply wrap-around duct
8 Cover
9 Cover
10 Hydraulic return wrap-around duct
11 Oxidizer dome purge wrap-around hose
12 Turbopump oxidizer seal purge wrap-around hose
13 Prefill wrap-around hose
14 Cocoon purge wrap-around hose
15 Cover
16 Clip
17 Clip

Figure 3-27. Wrap-Around Ducts and Hoses

k. Install pad K2297-6 in cover 651296 (6). Install cover and secure with 4 bolts RD111-1009-0417 and 4 washers LD153-0013-0002. Torque bolts to 35 ±2 in-lb. Safetywire bolts.

l. Install pad K2297-4 in cradle of existing engine bracket.

m. Install duct (7) and secure to engine line using seal 19-406332-19, 4 bolts RD111-4010-6418, and 4 washers RD153-5002-0004. Torque bolts to 80 ±5 in-lb. Safetywire bolts.

n. Secure duct to engine bracket using 3 bolts RD111-4008-0508 and 3 washers RD153-5002-0005. Torque bolts to 90 ±5 in-lb. Safetywire bolts.

o. Install cover 651292 (8) using seal 19-408758-3, 8 bolts RD111-4010-6519, and 8 washers RD153-5002-0005. Torque bolts to 225 ±15 in-lb. Safetywire bolts.

p. Install pad K2202-4 in cover 651297 (9). Install cover and secure with 4 bolts RD111-1009-0417 and 4 washers LD153-0013-0002. Torque bolts to 35 ±2 in-lb. Safetywire bolts.

q. Install pad K2297-4 in cradle of existing engine bracket.

r. Install hydraulic return duct (10) and secure to engine line using seal 19-406338-2, 6 bolts RD111-4011-6428, 6 washers RD153-5002-0004, 6 washers RD153-1002-0004, and 6 nuts RD114-8005-1004. Torque nuts to 125 ±5 in-lb.

s. Install pad K2297-4 in cover 651297 (9). Install cover and secure with 4 bolts RD111-1009-0417 and 4 washers LD153-0013-0002. Torque bolts to 35 ±2 in-lb. Safetywire bolts.

t. Install support tool T-5046440, or equivalent, to support unattached ends of lines (11 through 14) as lines are installed.

u. Install hose (11) and secure to engine line using seal 19-406332-15, 4 bolts RD111-1010-6424, 4 washers LD153-0013-0002, 4 washers RD153-1002-0004, and 4 nuts RD114-8003-1004. Torque nuts to 75 ±5 in-lb.

v. Install hose (12) and secure to engine line using seal 19-406332-15, 4 bolts RD111-1010-6424, 4 washers LD153-0013-0002, 4 washers RD153-1002-0004, and 4 nuts RD114-8003-1004. Torque nuts to 75 ±5 in-lb.

w. Remove cover at prefill check valve located on fuel inlet manifold (No. 1 side) and install hose (13) using existing seal and cover attaching hardware, consisting of seal 19-408751-1, bolts RD111-1010-6427, washers RD153-5002-0004 and RD153-1002-0004, and nuts RD114-8005-1004. Torque nuts to 100 ±10 in-lb.

x. Install hose (14) and secure to engine line using seal 19-406332-23, 4 bolts RD111-1010-6424, 4 washers LD153-0013-0002, 4 washers RD153-1002-0004, and 4 nuts RD114-8003-1004. Torque nuts to 75 ±5 in-lb.

y. Install 2 clamps RE127-2003-0006 and 2 clamps RE127-2003-0010 on hoses (11, 12, 13) in preparation for installation of cover (15).

z. Install cover 651578 (15) using 5 bolts RD111-1009-0414 and 5 washers LD153-0013-0002. Torque bolts to 20 ±2 in-lb. Safetywire bolts.

aa. Install clips 308437 (16) and 308649 (17) using 2 screws AN520C10R18, 2 screws AN520C10R14, 8 washers LD153-0010-0008, and 4 nuts NAS679C3W. Alternately torque nuts for each clip to 5 (+5, -0) in-lb.

ab. Check alinement of wrap-around ducts (paragraph 3-93).

ac. Reinstall applicable thermal insulation brackets removed in paragraph 3-91. Refer to R-3896-6.

3-93. CHECKING ALINEMENT OF WRAP-AROUND DUCTS.

3-94. This procedure verifies proper positioning of hydraulic and pressurization system wrap-around ducts. Tools required consist of alinement tool T-5041233.

a. Install alinement tool T-5041233 on No. 1 actuator end of gimbal bearing shaft. Make sure that conical alinement pin is in shaft countersink, rectangular key is in shaft locking plug, and tool magnet is pressed firmly against end of shaft.

b. Look through tool sight glass and, keeping sight glass fore and aft hairlines alined, verify that yoke-to-retaining pin-centers of ducts (7, 10, figure 3-27) are between hairlines of sight glass. If pin centers are outside of hairlines, adjust lines laterally as outlined in paragraph 3-95. Make sure lines are seated in cradles of hydraulic customer-connect ducts support bracket. If ducts are not seated, adjust ducts vertically as outlined in paragraph 3-96.

c. Install alinement tool T-5041233 to side opposite No. 1 actuator end of gimbal bearing shaft. Make sure conical alinement pin is in shaft countersink, rectangular key is in shaft locking plug, and tool magnet is pressed against end of shaft.

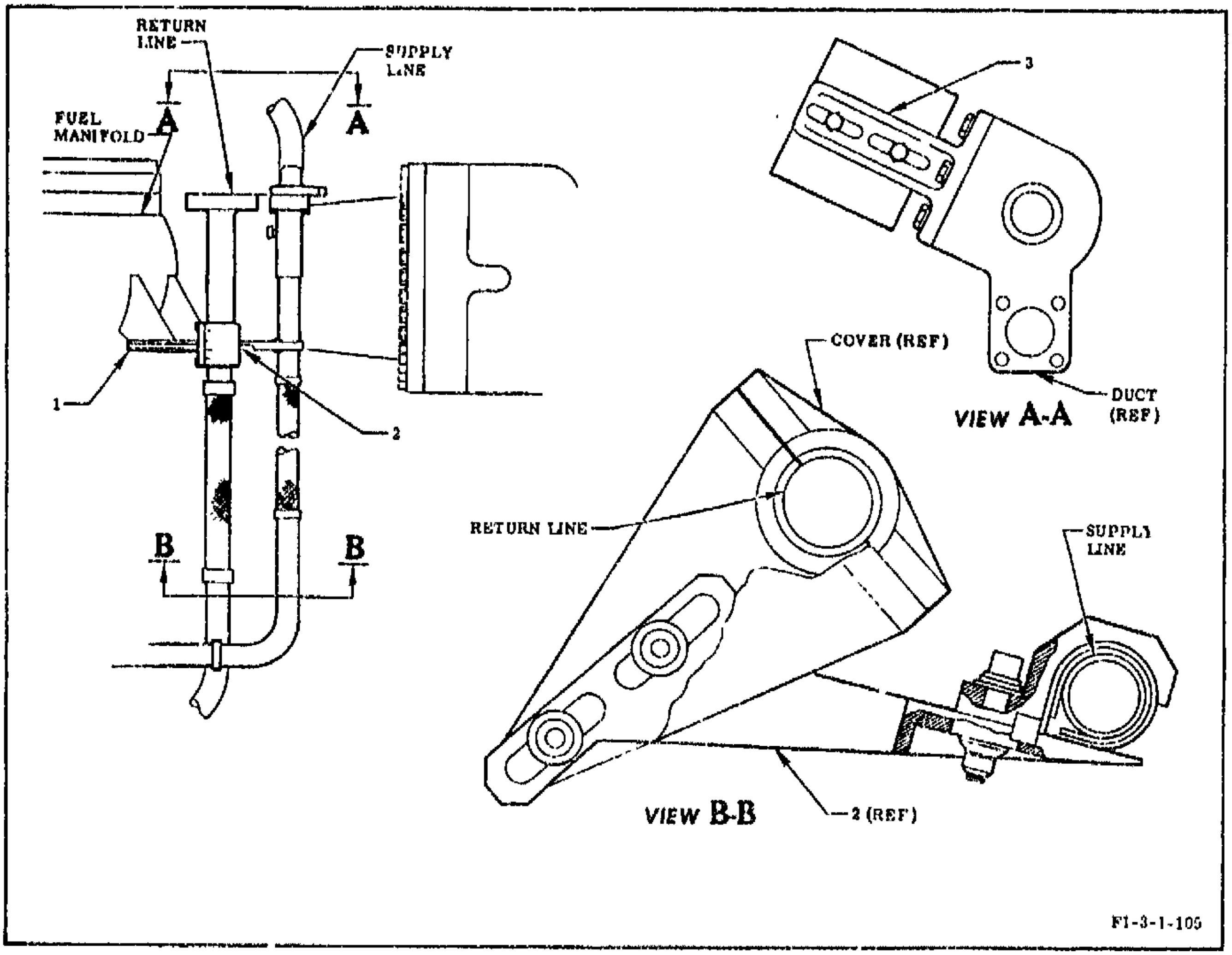
d. Look through tool sight glass and, keeping sight glass fore and aft hairlines alined, verify that yoke-to-retaining-pin centers of ducts (1, 3, 5, figure 3-27) are between hairlines of sight glass. If pin centers are outside of hairlines, laterally adjust ducts outlined in paragraph 3-97. Make sure ducts are seated in cradles of heat exchanger customer-connect bracket. If ducts are not seated, vertically adjust ducts as outlined in paragraph 3-98.

3-95. LATERAL ADJUSTMENT OF HYDRAULIC WRAP-AROUND DUCTS. This procedure adjusts the hydraulic wrap-around ducts to aline the pin centers of the hydraulic duct gimbal sections within the hairlines of alinement tool T-5041233. (See figure 3-28.)

a. Loosen attaching bolts of brackets (1, 2) and support (3).

b. Loosen bolts that secure wrap-around duct covers at hydraulic customer-connect duct support bracket.

c. Loosen forward joints of ducts, if connected, and aline ducts until pin centers of duct gimbals are within hairlines of alinement tool T-5041233.



1 Bracket 2 Bracket 3 Support

Figure 3-28. Adjusting Hydraulic Wrap-Around Ducts

d. Torque fasteners at forward joints of ducts, if connected.

e. Torque nuts that secure brackets (1, 2) to 110 ±10 in-lb.

f. Torque nuts that secure support (3) to 90 ±5 in-lb.

g. Torque wrap-around duct cover bolts to 35 ±2 in-lb.

3-96. VERTICAL ADJUSTMENT OF HYDRAULIC WRAP-AROUND DUCTS. This procedure positions the hydraulic wrap-around ducts in the cradles of the support bracket by adjusting the ducts in the engine y-axis. (See figure 3-28.)

a. Loosen clamp and cover that secure engine supply and return ducts to brackets (1, 2).

b. Loosen bolts that secure support (3) to duct.

c. Loosen forward joints of ducts, if connected.

d. Loosen covers that secure wrap-around ducts to hydraulic customer-connect duct-support bracket.

e. Adjust location of engine ducts (y-axis) until wrap-around ducts seat in cradle of support bracket.

f. Make sure gimbal joint pin centers are alined within hairlines of alinement tool T-5041233.

g. Torque fasteners at forward joints of ducts, if connected.

h. Torque cover bolts to 35 ±2 in-lb.

i. Torque cover bolts to support (3) to 30 ±2 in-lb.

j. Torque nut that secures clamp for duct (7) to 40 ±5 in-lb.

3-97. LATERAL ADJUSTMENT OF PRESSURIZATION WRAP-AROUND DUCTS. This procedure adjusts the pressurization ducts to aline pin centers of the pressurization duct gimbal sections within the hairlines of the alinement tool T-5041233. (See figure 3-29.)

NOTE

The pressurization ducts (1, 3, 5, figure 3-27) are adjusted simultaneously since they are supported by one bracket.

a. Disconnect bracket (1, figure 3-29) from support (2).

NOTE

Pressurization ducts must not be disconnected from bracket.

b. Loosen bolts that secure bracket (3) to support.

c. Loosen forward joints of ducts, if connected.

d. Loosen pressurization duct dome bracket covers. Aline gimbal joint pin centers of ducts within hairlines of alinement tool; then torque fasteners at forward joints of ducts, if connected, and torque bolts for duct covers at dome support brackets to 34 ±3 in-lb.

e. Torque nuts that secure bracket (3) to support to 130 ±10 in-lb.

f. Disconnect block (4) and support (5).

g. Loosen strap (6) and bracket (7); then move support (2) to aline with bracket (1).

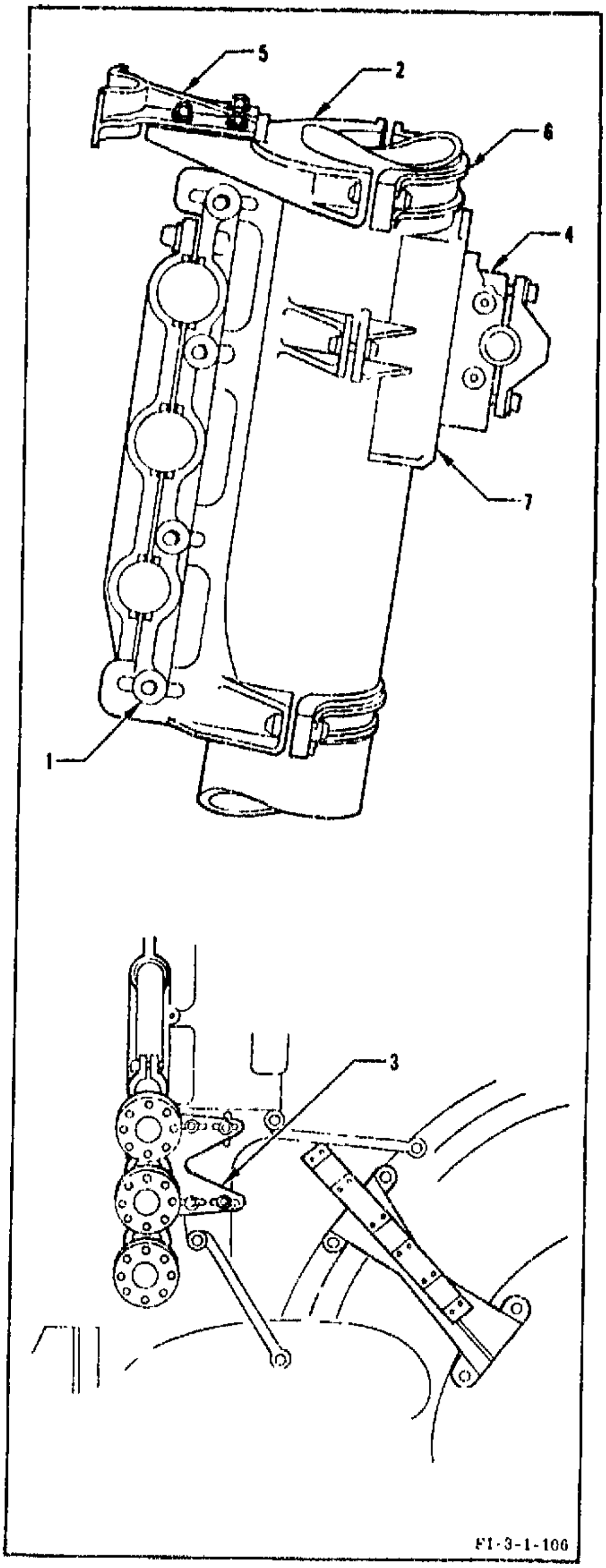
NOTE

Bracket (1) and pressurization duct gimbal joints must not be removed.

h. Secure bracket (1) to support (2) by torquing nuts to 100 ±10 in-lb.

i. Adjust block (4) along duct, and torque nuts to 125 ±10 in-lb. Torque cover bolts to 12 ±2 in-lb.

j. Adjust support (5) to hose, and torque nuts to 125 ±10 in-lb.



1 Bracket
2 Support
3 Bracket
4 Block
5 Support
6 Strap
7 Bracket

Figure 3-29. Adjusting Pressurization Wrap-Around Ducts

3-98. VERTICAL ADJUSTMENT OF PRESSURIZATION WRAP-AROUND DUCTS. This procedure positions the pressurization ducts in the cradles of the heat exchanger ducts support bracket by adjusting the ducts in the engine y-axis. (See figure 3-29.)

a. Loosen 2 covers that secure heat exchanger ducts to brackets on No. 2 side of engine.

b. Loosen 3 covers that secure ducts to heat exchanger ducts support bracket.

c. Make sure forward joints of ducts are secure.

d. Adjust ducts longitudinally to seat in cradles of heat exchanger ducts support bracket, and torque bolts of 3 covers to 35 ±2 in-lb. Pin centers of gimbals must remain in the alined position, as determined with alinement tool T-5041233.

e. Torque bolts of 2 covers that secure heat exchanger ducts to brackets on No. 2 side of engine to 25 ±5 in-lb. Safetywire bolts.

3-98A. <u>HEAT EXCHANGER AND TURBOPUMP TURBINE.</u>

3-98B. This procedure disconnects and connects the heat exchanger at the turbopump turbine to permit use of the torque bar on the second-stage turbine wheel during turbopump maintenance.

3-98C. DISCONNECTING HEAT EXCHANGER FROM TURBOPUMP TURBINE. (See figure 3-30.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect hose (1) and remove seal plate (2).

c. If static firing instrumentation is installed, remove tube (3) and seals (4).

d. Measure and record extension of heat exchanger lines from a fixed point adjacent to cover (24) to line flanges.

e. Loosen cover (24).

f. Remove cover (28) and liners (29).

g. Mark location of joints for coupling (39), remove coupling, and position shield (40) on heat exchanger.

h. Loosen all fasteners at heat exchanger to turbine flange.

i. Replace one flange fastener at centerline of flange adjacent to thrust chamber with an extra-length bolt, washers, and nut; tighten nut. The bolt must be of sufficient threaded length so that the nut can be adjusted to hold the flanges together and to allow the flanges to separate 2-1/2 inches when the nut is backed off.

j. Replace a flange fastener on either side of outer centerline of flange with two additional bolts, washers, and nuts as specified in step i. Locate and adjust fasteners to support flange without interfering with torque bar installation.

CAUTION

Deflection of the gimbal joints or flexible sections of the heat exchanger ducts and hoses in excess of 10 degrees from a null position is not allowed. Damage to the gimbal bellows or flexible sections of the ducts and hoses may occur.

k. Remove remaining flange fasteners; then back off nuts of extra-length bolts to separate flanges. Observe gimbal joints and flexible section of ducts and hoses for deflection. Where deflection will exceed 10 degrees before sufficient gap is obtained to install torque bar, the affected ducts or hoses must be disconnected.

NOTE

If the gap does not permit installation of the torque bar, the heat exchanger and heat exchanger ducts and hoses must be disconnected and supported and/or removed as outlined in paragraph 3-99.

l. Position seal (42) on heat exchanger flange, to protect flange sealing surface.

m. Using heavy gage, commercial grade plastic sheet, cover heat exchanger inlet and secure sheeting to heat exchanger exterior with pressure-sensitive tape RB0195-002 (Rocketdyne), or equivalent.

3-98D. CONNECTING HEAT EXCHANGER TO TURBOPUMP TURBINE. (See figure 3-30.) Specified lubricating procedures (methods) are outlined in section I.

a. Carefully remove plastic sheet from heat exchanger inlet flange.

b. Support flanges of heat exchanger to maintain gap between flanges, and replace seal (42). Reinstall extra-length bolts, washers, and nuts.

c. Cross-torque nuts on extra-length bolts until flange fasteners can be installed. Replace extra-length bolts with flange fasteners, and cross-torque nuts to 130-140 in-lb.

d. Install shield (40) with cutout positioned at instrumentation ports of heat exchanger and joints of coupling (39) located at position marked during removal. Incrementally torque coupling fasteners to 90 ±5 in-lb.

e. If static firing instrumentation is installed, lubricate (Method G) tube (3) with thread compound C-5A (Felt Products); install seals (4) and tube. Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nut.

f. Install seal plate (2) and hose (1). Cross-torque bolts to 45 ±5 in-lb. Safetywire bolts.

NOTE

If the heat exchanger ducts or hoses were disconnected, they must be installed as outlined in paragraph 3-102.

- Steps g and h apply if heat exchanger ducts and hoses were not disconnected and the wrap-around lines are installed.
- Steps i through k apply if heat exchanger ducts and hoses were not disconnected and the wrap-around lines are not installed.

g. Adjust extension of ducts (30, 32, 34) to position recorded during removal. Tighten bolts for cover (24) to retain ducts in place.

h. Install cover (28) and liners (29). Torque bolts for cover (24) to 25 ±5 in-lb. Torque bolts for cover (28) to 40 ±2 in-lb. Safetywire bolts.

i. Install flange alinement tool T-5039437 to interfaces of ducts (30, 32, 34), to radially position duct flanges.

j. Adjust extension of ducts (30, 32, 34) to position recorded during removal and tighten bolts for cover (24), to retain ducts in place.

k. Install cover (28) and liners (29). Torque bolts for cover (28) to 40 ±2 in-lb. Safetywire bolts and remove tool.

l. Refer to section IV for post-maintenance test requirements specified for heat exchanger and heat exchanger ducts and hoses.

3-99. HEAT EXCHANGER AND HEAT EXCHANGER DUCTS AND HOSES.

3-100. Equipment required consists of sling 9024925-11 from Component Handling Fixture Set G4068, seal alinement tools T-5044716 and T-5044717, and flange alinement tool T-5039437.

3-101. REMOVING HEAT EXCHANGER AND HEAT EXCHANGER DUCTS AND HOSES. (See figure 3-30.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. If heat exchanger is to be removed, disconnect hose (1) and remove seal plate (2), and disconnect tube (3) and remove seal (4).

c. If heat exchanger is to be replaced, remove union (5) and seal (6).

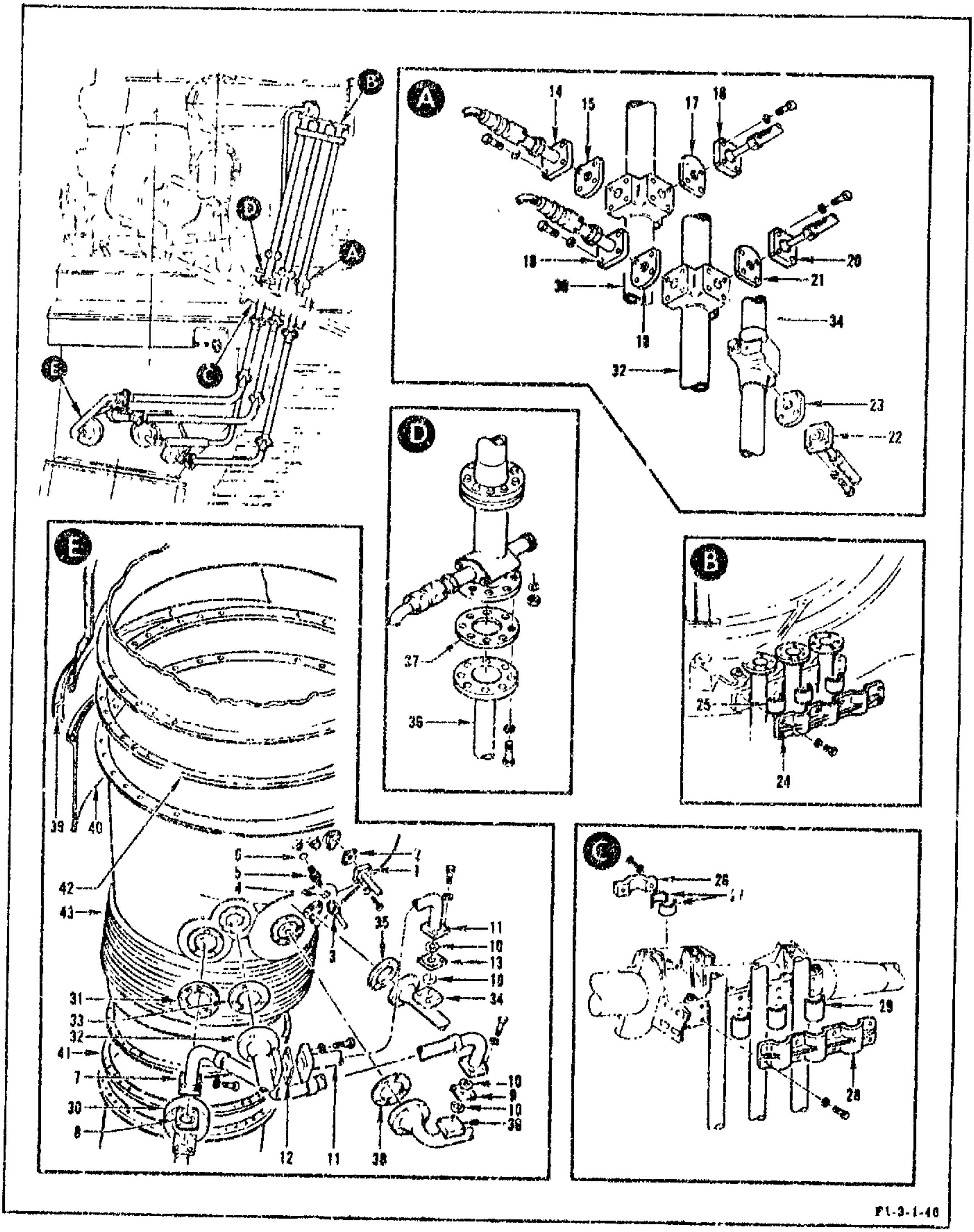


Figure 3-30. Heat Exchanger and Heat Exchanger Ducts and Hoses (Sheet 1 of 2)

1	Hose	12	Seal	23[a]	Seal	34	Duct
2	Seal plate	13	Orifice plate	24	Cover	35	Seal
3	Tube	14	Transducer[a]	25	Liner	36	Hose
4	Seal	15	Seal[a]	26	Cover	37	Seal
5	Union	16	Hose[a]	27	Liner	38	Seal
6	Seal	17	Seal[a]	28	Cover	39	Coupling
7	Hose	18	Transducer[a]	29	Liner	40	Shield
8	Seal	19	Seal[a]	30	Duct	41	Seal
9	Orifice plate	20	Hose[a]	31	Seal	42	Seal
10	Seal	21	Seal[a]	32	Duct	43	Heat exchanger
11	Hose	22	Hose[a]	33	Seal		

(a) Engines not incorporating MD96 change

Figure 3-30. Heat Exchanger and Heat Exchanger Ducts and Hoses (Sheet 2 of 2)

NOTE

Steps d through l remove heat exchanger ducts. Prior to performing step d, wrap-around lines connected to the heat exchanger ducts must be disconnected at the heat exchanger duct flanges as outlined in paragraph 3-91.

CAUTION

Extreme care must be used when removing flexible instrumentation hoses to prevent excessive bending and resultant bulging of the braid. Excessive bends are those having a permanent set with a radius of less than 3 inches in a free state.

d. Remove hose (7), seal (8), orifice plate (9), and seals (10). Note position of orifice plate, and record serial number for reinstallation.

dA. Lubricate (Method A) duct (30) and hose (36) bypass flange closure fasteners with lubricant grease RB0140-012 (Rocketdyne).

e. Remove hose (11), seal (12), orifice plate (13), and seals (10). Note position of orifice plate, and record serial number for reinstallation.

eA. Lubricate (Method A) ducts (32, 34) bypass flange closure fasteners with lubricant grease RB0140-012 (Rocketdyne).

f. On engines not incorporating MD96 change, remove instrumentation parts (14 through 23).

g. Measure and record extension of heat exchanger ducts (30, 32, 34) from flange interfaces to forward side of cover (24).

h. Supporting heat exchanger lines, remove bracket covers (24, 26, 28). Do not remove liners (25, 27, 29) unless they require replacement.

i. Remove duct (30) and seal (31).

j. Remove duct (32) and seal (33).

k. Remove duct (34) and seal (35).

l. Disconnect hose (36) from transducer, and remove seal (37); then disconnect hose at heat exchanger, and remove seal (38).

NOTE

Steps m through r remove the heat exchanger.

m. Remove coupling (39), and slide shield (40) over heat exchanger.

n. Install sling 9024925-11 on heat exchanger. (See figure 3-31.)

CAUTION

The heat exchanger weighs approximately 823 pounds.

o. Supporting heat exchanger, disconnect heat exchanger at exhaust manifold and remove seal (41, figure 3-30). Heat exchanger bellows may retract when disconnected.

p. Disconnect heat exchanger at inlet end, and remove seal (42).

q. Use extreme care to prevent damage to flanges, and remove heat exchanger from engine.

r. Remove shield (40); then position heat exchanger with inlet end down, and carefully place on a prepared surface. Remove sling.

3-102. INSTALLING HEAT EXCHANGER AND HEAT EXCHANGER DUCTS AND HOSES. (See figure 3-30.) Where multiple fasteners are used at joints, the applicable torque and safetywiring methods outlined in section I must be used. An alternate procedure is provided in paragraph 3-102A for installing the heat exchanger.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

WARNING

The use of contaminated parts in a liquid oxygen or indirect liquid oxygen system can cause an explosion resulting in injury to personnel and damage to equipment.

CAUTION

If the heat exchanger or any of the heat exchanger ducts and hoses have been subjected to solvent cleaning, the part must be inspected for residual halogenated solvents as outlined in section I. Residual solvents within the heat exchanger ducts and hoses can cause corrosion.

b. Make sure all parts are free of contaminants and are clean for oxidizer and helium systems; however, carbon must not be removed from external surfaces of heat exchanger coils.

c. Install adapter of sling 9024925-11 from Component Handling Fixture Set G4068 on heat exchanger. (See figure 3-31.) Hoist cable into position and attach to adapter.

CAUTION

The heat exchanger weighs approximately 823 pounds.

d. Install shield (40, figure 3-30) over heat exchanger inlet and secure to sling. Hoist heat exchanger sufficiently clear of floor area to allow rotation and rotate to desired position for installation. Make sure heat exchanger remains balanced in selected position.

NOTE

If the heat exchanger does not remain in the desired position, it will be necessary to set the heat exchanger down and adjust the cable attach points to obtain the correct center of gravity.

e. Hoist heat exchanger into position, install seal (42), and secure flanges. Cross-torque nuts to 130-140 in-lb.

f. Install shield (40), position cutout on No. 2 side of engine, and secure shield with coupling. Incrementally torque coupling fasteners to 90 ±5 in-lb.

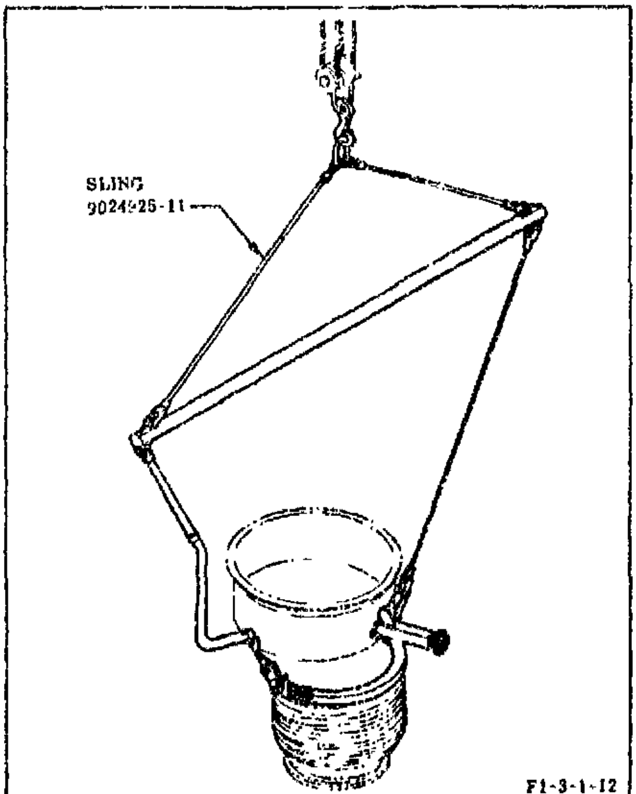


Figure 3-31. Handling Heat Exchanger

g. Install seal (41), and aline seal and heat exchanger flange with duct flange using 4 equally spaced (90-degree increments), extra-length bolts. Pull flanges together with extra-length bolts and secure flanges. Remove extra-length bolts, install remaining bolts, and torque nuts to 130-140 in-lb.

h. Remove heat exchanger sling.

i. Install hose (36), and support hose by installing cover (26) at strut. Do not torque cover bolts at this time.

j. Install seal (37), and connect hose to transducer. Cross-torque nuts to 255 ±5 in-lb.

k. Install ring flange and seal (38) at heat exchanger end of hose.

l. Verify that arc deflection for flexible section of hose is within tolerance indicated. (See figure 3-32.) Cross-torque bolts to 295 ±10 in-lb. Safetywire bolts.

m. Make sure liners (27, figure 3-30) are installed; then cross-torque bolts of cover (26) to 12-14 in-lb. Safetywire bolts.

n. Install duct (34) and seal (35) at heat exchanger. Install bolts loosely, and temporarily support duct at turbopump strut bracket.

o. Install duct (32) and seal (33) at heat exchanger. Install bolts loosely, and temporarily support duct at turbopump strut bracket.

p. Install duct (30) and seal (31) at heat exchanger. Install bolts loosely. Make sure liners (25, 29) are installed; then install covers (24, 28). Install bolts loosely.

NOTE

If wrap-around lines are not installed, perform step q. If wrap-around lines are installed, proceed to step r.

q. Install tool T-5039437 to interfaces to radially position duct flanges. Adjust extension of ducts to dimensions recorded during removal. Torque bolts for cover (24) to 25 ±5 in-lb, and bolts for cover (28) to 40 ±2 in-lb. Safetywire bolts, and remove alinement tool.

r. Adjust extension of ducts to values recorded during removal, and rotate ducts to match holes in wrap-around flanges. Cross-torque bolts for cover (24) to 25 ±5 in-lb, and bolts to cover (28) to 40 ±3 in-lb. Safetywire bolts. Install seals between wrap-around lines and duct flanges. Cross-torque nuts for GOX and helium return ducts to 265 ±10 in-lb, and nuts for helium supply duct to 265 ±5 in-lb.

s. Install hose (11), orifice plate (13), and 2 seals (10) at duct (34) bypass boss. Position tab of orifice plate (13) toward heat exchanger end of supply duct. Do not tighten bolts.

NOTE

The orifice plate must be the same as recorded in the Engine Log Book.

t. Install seal (12), and connect remaining end of hose (11) to duct (32). Do not tighten bolts.

u. Install hose (7), orifice plate (9), and 2 seals (10) at hose (36) bypass boss. Position tab of orifice plate (9) toward heat exchanger end of hose (36). Do not tighten bolts.

NOTE

The orifice plate must be the same as recorded in the Engine Log Book.

v. Install seal (8), and connect remaining end of hose (7) to duct (30). Do not tighten bolts.

CAUTION

When rotating ducts or lines at the heat exchanger or bypass line flanges, the duct or line must be pulled away from the flange base to prevent damage to seals.

w. Sight along duct (32) to make sure that section of duct between 2 bellows joints aft of turbopump strut is in line with section of duct attached by cover (28). Rotate duct as necessary at heat exchanger flange to obtain alinement. Using seal alinement tool T-5044717, aline seal, and cross-torque 2 opposite bolts at flange to 30 ±5 in-lb.

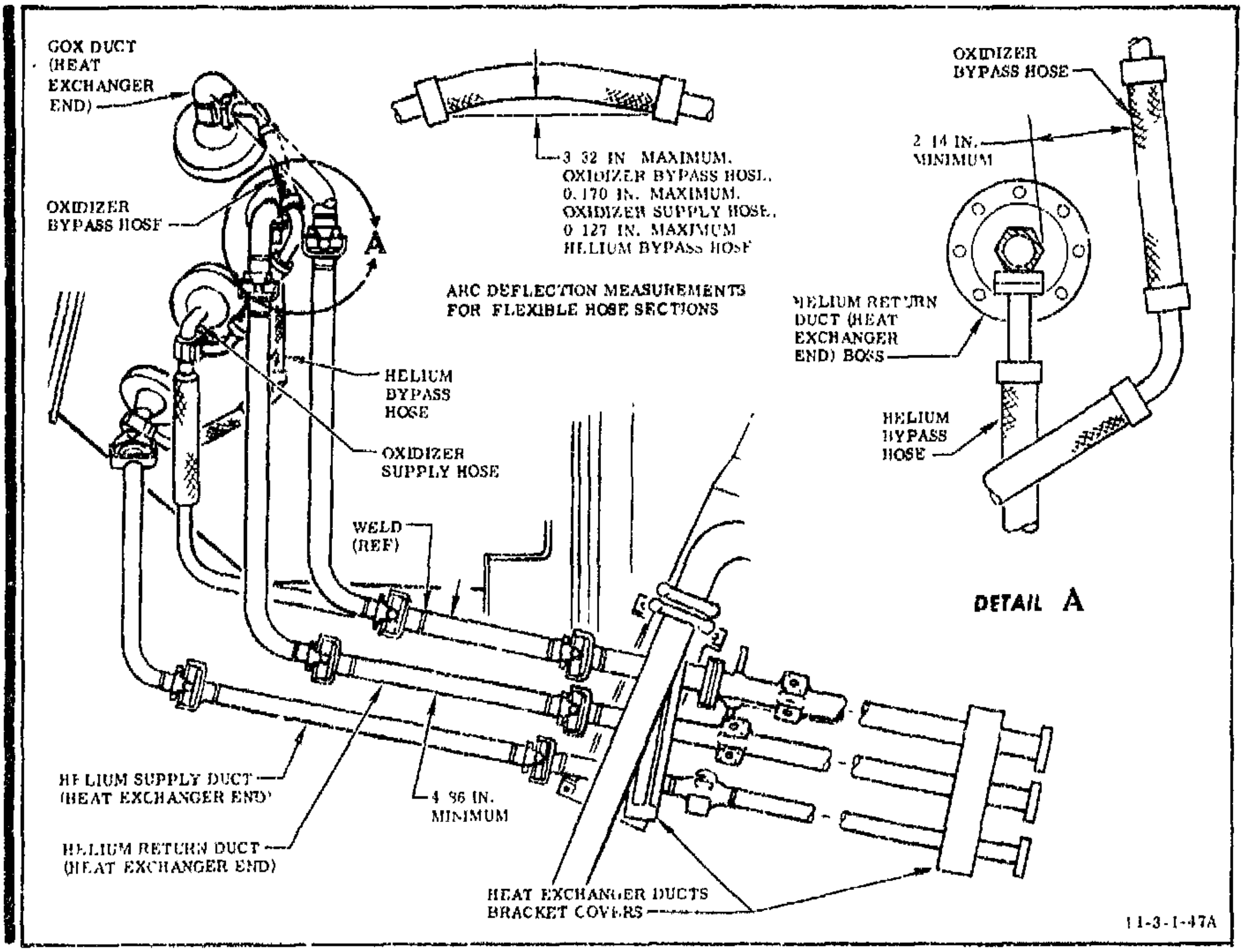


Figure 3-32. Alining Heat Exchanger Ducts and Hoses

x. Rotate duct (30) and hose (36) at heat exchanger flanges to meet the following dimensions: (Keep flexible section of hose (7) as straight as possible during rotation. Use seal alinement tool T-5044716 to aline seals, and incrementally torque 2 opposite bolts in each flange to 30 ±5 in-lb.) (See figure 3-32 for dimensional locations.)

(1) Clearance of flexible section of hose (7, figure 3-30) from nearest point of hexagonal section of duct (32): 2.14 inches minimum. (See figure 3-32, detail A.)

(2) Arc deflection in flexible section of hose (7, figure 3-30): 3/32 inch maximum.

(3) Arc deflection in flexible section of hose (36) nearest heat exchanger: 0.170 inch maximum.

y. Rotate duct (34) at heat exchanger flange until offset in flexible sections of hose (11) is within 0.127 inch maximum, as shown in figure 3-32. Keep flexible section of hose (11) as straight as possible during rotation. Use seal alinement tool T-5044717 to aline seal, and cross-torque 2 opposite bolts in duct flange to 30 ±5 in-lb.

z. Measure immediately forward of weld, between outer surfaces of duct (30, figure 3-30) and duct (32). (See figure 3-32.) Dimension must not be less than 4.60 inches. If measurement is unsatisfactory, readjust duct (32, figure 3-30) as outlined in step w and duct (34) as outlined in step y to obtain required spacing. Make sure flexible sections of hose (11) meet 0.127-inch requirement specified in step y.

aa. Cross-torque fastener group as follows:

(1) Hose (36) and duct (30) flanges: 295 ±10 in-lb.

(2) Duct (34) and duct (32) flanges: 110 ±10 in-lb.

(3) Hose (11) at helium supply duct (34): 100 ±10 in-lb.

(4) Helium bypass hose (11) at duct (32): 100 ±10 in-lb.

(5) Hose (7) at LOX supply hose (36) and duct (32): 100 ±10 in-lb.

ab. Safetywire fasteners using applicable method outlined in section I, and seal lockwire of fasteners used at orificed joints.

ac. On engines not incorporating MD96 change, install transducers (14, 18) using seals (15, 19). Install hoses (16, 20, 22) using seals (17, 21, 23). Torque fasteners to 45 ±5 in-lb. If harness plugs were disconnected, connect to transducers using method outlined in paragraph 3-15. Safetywire fasteners using applicable method outlined in section I.

NOTE

> Flexible instrumentation hoses must not have an installed bend radius of less than 3 inches. Hoses with bulges in the braids and/or a permanently set bend radius of less than 3 inches must not be used.

ad. If heat exchanger was replaced, refer to section I for lubricating method and lubricate (Method A) union (5) using thread compound C-5A (Felt Products). Install seal (6) and union, and torque union to 55-80 in-lb.

ae. Refer to section I for lubricating method, and using thread compound C-5A (Felt Products), lubricate (Method G) tube (3). Install seal (4) and tube. Torque tube coupling nut to 160 ±10 in-lb. Safetywire coupling nut.

af. Install seal plate (2) and tube (1). Cross-torque bolts to 45 ±5 in-lb. Safetywire bolts. Use torque and safetywiring methods outlined in section I.

ag. If wrap-around ducts are installed, reconnect them to heat exchanger lines as outlined in paragraph 3-92.

ah. Refer to section IV for post-maintenance test requirements.

3-102A. INSTALLING HEAT EXCHANGER (ALTERNATE PROCEDURE). (See figure 3-30.) This procedure may be used under certain field conditions as determined by the Rocketdyne representative. When multiple fasteners are used at joints, the applicable torque and safetywiring methods outlined in section I must be used.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

WARNING

The use of contaminated parts in a liquid oxygen or indirect liquid oxygen system can cause an explosion resulting in injury to personnel and damage to equipment.

CAUTION

If the heat exchanger or any of the heat exchanger ducts and hoses have been subjected to solvent cleaning, the part must be inspected for residual halogenated solvents as outlined in section I. Residual solvents within the heat exchanger ducts and hoses can cause corrosion.

b. Make sure all parts are free of contaminants and are clean for oxidizer and helium systems; however, carbon must not be removed from external surfaces of heat exchanger coils.

c. Install adapter of sling 9024925-11 from Component Handling Fixture Set G4068 on heat exchanger. (See figure 3-31.) Hoist cable into position and attach to adapter.

CAUTION

The heat exchanger weighs approximately 823 pounds.

d. Install shield (40, figure 3-30) over heat exchanger inlet and temporarily attach to heat exchanger forward flange. Hoist heat exchanger sufficiently clear of floor area to allow rotation and rotate to desired position for installation. Make sure heat exchanger remains balanced in selected position.

NOTE

If the heat exchanger does not remain in the desired position, it will be necessary to set the heat exchanger down and adjust the cable attach points to obtain the correct center of gravity.

e. Hoist heat exchanger into position, install seal (42), and attach forward flanges with 12 equally spaced bolts and nuts to support heat exchanger. Torque nuts until one thread (nominal) is visible through nut locking feature. Retain shield (40) attached to heat exchanger forward flange.

NOTE

Make sure that index marks located on turbine exhaust manifold flange and heat exchanger flange are alined.

f. Install seal (41), and aline seal and heat exchanger flange with turbine exhaust manifold flange. Install all bolts and nuts, and secure flanges by torquing nuts to 130-140 in-lb.

g. Remove heat exchanger sling.

h. Install remaining bolts and nuts, pull heat exchanger joint flanges together from partial installation of step e, and secure flanges by cross-torquing nuts to 130-140 in-lb.

i. Install shield (40), position cutout on No. 2 side of engine, and secure shield with coupling. Incrementally torque coupling fasteners to 90 ±5 in-lb.

j. Install heat exchanger ducts and hoses as outlined in paragraph 3-102, steps i through ah, as applicable.

3-103. ALINING CONTROL AND PURGE LINES.

NOTE

This procedure does not apply to the igniter fuel supply tube or the engine supply tube. Alinement for these tubes is outlined in paragraph 3-104A.

3-104. A flange-to-component boss alinement check of lines listed in figure 3-33 is required when specified in other procedures in this section or when any of the individual lines are disconnected for any purpose. Alinement is required to prevent excessive stressing of the lines during installation. Gages from alinement gage set T-5044743 are used to check offset and gap. The gap and offset dimensional limits listed in figure 3-33 are incorporated in the gages. Dimensional limits for angulation listed in figure 3-33 are applicable for use with gages. Seal plates with the molded rubber seals removed may be used to simulate gages if the gage set is not available. Offset, gap, and angulation dimensional limits listed in figure 3-33 are applicable when using seal plates as gages. The safety and contamination and damage prevention requirements outlined in section I apply to this procedure. The following requirements are applicable to obtain alinement.

(1) Install applicable clamping and brackets before making dimensional checks.

(2) Adjust brackets and clamping to obtain alinement. If alinement cannot be obtained in this manner, lines not exceeding one inch in diameter may be re-formed in place by hand. Lines exceeding one inch in diamter must be removed from engine for reforming. Reforming must not be performed in shot-peened or welded areas of lines.

(3) Repeat offset, gap, and angulation dimensional checks after reforming.

a. Perform steps b through f if alinement gage set T-5044743 is used. Proceed to step g if gage set is not available and seal plates without molded rubber seals are used.

b. With joint disconnected and seal plate removed, install appropriate gage from alinement gage set T-5044743.

c. Measure positive gap between connector and alinement gage with a feeler gage.

NOTE

A negative gap, up to the thickness of the alinement gage, can be measured using a feeler gage with the alinement gage removed. The measurement obtained must be subtracted from the alinement gage thickness to obtain negative gap.

d. Check line offset by visually observing that line connector falls within scribed circle on alinement gage. Make this check at 2 points 90 degrees apart.

e. Measure angulation with feeler gage at point of greatest gap. Opposite side of connector must be in contact with alinement gage when taking measurements. Angulation limits are listed in figure 3-33.

f. Remove alinement gage, install seal plate, and connect line. Cross-torque fasteners, and install safetywire. Use torque and safetywire methods as outlined in section I.

NOTE

Steps g through m aline lines using the alinement seal plates with the molded rubber seals removed.

g. With joint disconnected and seal plate removed, install appropriate alinement seal plate.

h. Measure positive gap between connector and alinement seal plate with a feeler gage.

NOTE

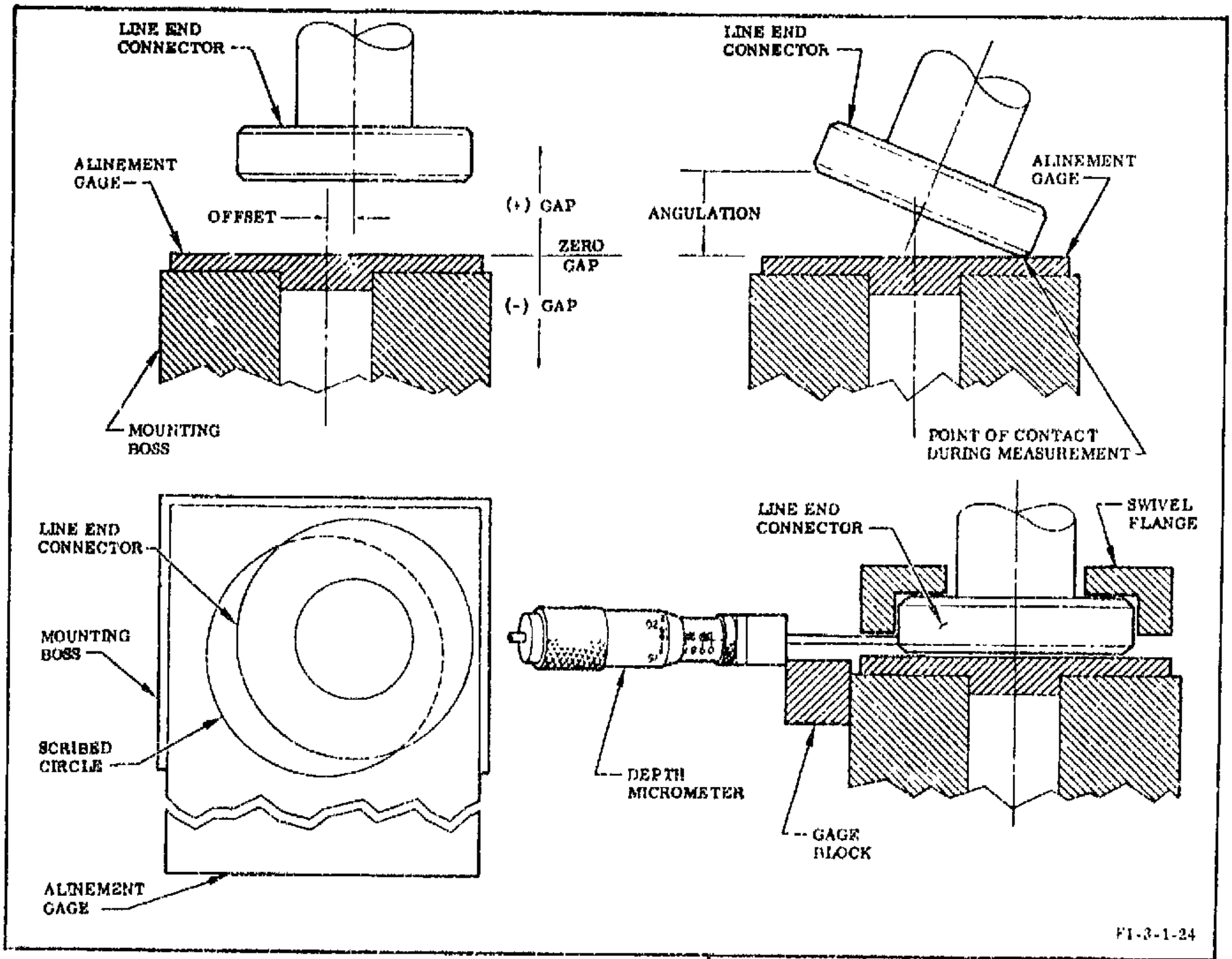
A negative gap, up to the thickness of the alinement seal plate, can be measured using a feeler gage with the plate removed. The measurement obtained must be subtracted from the plate thickness to obtain negative gap.

i. Measure offset of line at connector using a depth micrometer with a flat, rotatable blade. Insert blade between swivel flange and mounting boss to engage connector circumference. Record measurement.

NOTE

A gage block placed against the body of the mounting boss will provide a firm, flat surface for the foot of the depth micrometer.

j. Measure offset of lines at a point 90 degrees from that used in step i. Record measurement.



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 tube	No. 1 oxidizer dome purge check valve	0.10	±0.05	0.009

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

Figure 3-33. Control and Purge Line Joint Alinement Dimensions (Sheet 1 of 2)

Line	Joint Location	Maximum Allowable Limits		
		Offset (inch)	Gap (inch)	Angulation[(a)] (inch)
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
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	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 3-33. Control and Purge Line Joint Alinement Dimensions (Sheet 2 of 2)

k. Measure angulation with feeler gage at point of greatest gap. Opposite side of connector must be in contact with alinement seal plate when taking measurement.

l. Remove alinement seal plate, install seal plate, and connect line. Torque fasteners as required.

m. Measure offset of line in bolted position by repeating steps i and j. The difference between readings taken with connectors bolted in place and in the free position is offset misalinement in each of the two axes. Record offset misalinement.

3-104A. ALINING IGNITER FUEL SUPPLY AND ENGINE SUPPLY TUBES.

3-104B. This procedure is performed only when designated in other procedures in this section, or when either of the tubes is disconnected. Alinement dimensions are listed in figure 3-33 for each tube. The following definitions apply to this procedure:

(1) Offset: Lateral misalinement in two axes of tube in free position required to install bolts.

(2) Gap: Distance measured (with tube in free position) between eccentric spacer and boss with spacer in full contact with tube flange.

(3) Angulation: Difference between maximum and minimum gaps.

a. Make sure O-rings are removed from eccentric spacers and engine connections.

b. Install eccentric spacers in tube ends, aline any marks on flanges and spacers for initial alinement, and attach valve end of tube to valve. Tighten bolts to obtain metal-to-metal contact of flange and boss surfaces.

c. Measure gap at duct end of tube. If gap meets requirement of figure 3-33, proceed to step f.

d. Disconnect valve end of tube, rotate eccentric spacer 90 degrees, and retighten bolts.

e. Repeat steps c and d until the gap measurement at duct end of tube is obtained that most closely meets the gap requirement specified in figure 3-33 for the applicable tube.

f. Rotate eccentric spacer at duct end of tube to obtain minimum offset condition.

g. Verify offset, gap, and angulation dimensions at duct end of tube meet requirements of figure 3-33.

NOTE

If the requirements of figure 3-33 are not met, the direction and magnitude of movement required for correction must be determined, the tube removed, and mechanically reformed. For a negative gap condition, the gap measurement must be taken with the eccentric spacer removed at duct end. Steps a through g must be repeated until the offset, gap, and angulation requirements are met.

h. Using a marking method that can be removed, mark across joint flanges and eccentric spacer flanges. Remove any other markings.

i. Remove tube and eccentric spacers. Do not remove final markings from flanges.

j. Install tube as outlined in applicable procedure.

3-104C. <u>IGNITER FUEL SUPPLY TUBE</u>.

3-104D. REMOVING IGNITER FUEL SUPPLY TUBE. (See figure 3-33A.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

aA. Using a marking method that can be removed, mark across spacer and flanges.

b. Disconnect flange of tube (1) and remove tube.

c. Remove O-rings (2) and spacers (3). Retain spacers.

3-104E. INSTALLING IGNITER FUEL SUPPLY TUBE. (See figure 3-33A.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Aline tube (1) and spacers (3) as outlined in paragraph 3-104A.

c. Lubricate (Method K) 4 O-rings (2) with lubricant grease RB0140-012 (Rocketdyne), and install O-rings in spacer and flange grooves.

CAUTION

Spacers must not be rotated during assembly in tube or when tube is installed. Damage to O-rings may result.

d. Aline markings on spacers (3) and flanges and install spacers in tube (1).

e. Carefully install tube. Make sure O-rings in grooves are in place, and cross-torque bolts at manifold end to 60 ±5 in-lb; then cross-torque bolts at duct end to 60 ±5 in-lb.

f. Safetywire bolts and remove markings from flanges.

g. Refer to section IV for post-maintenance test requirements.

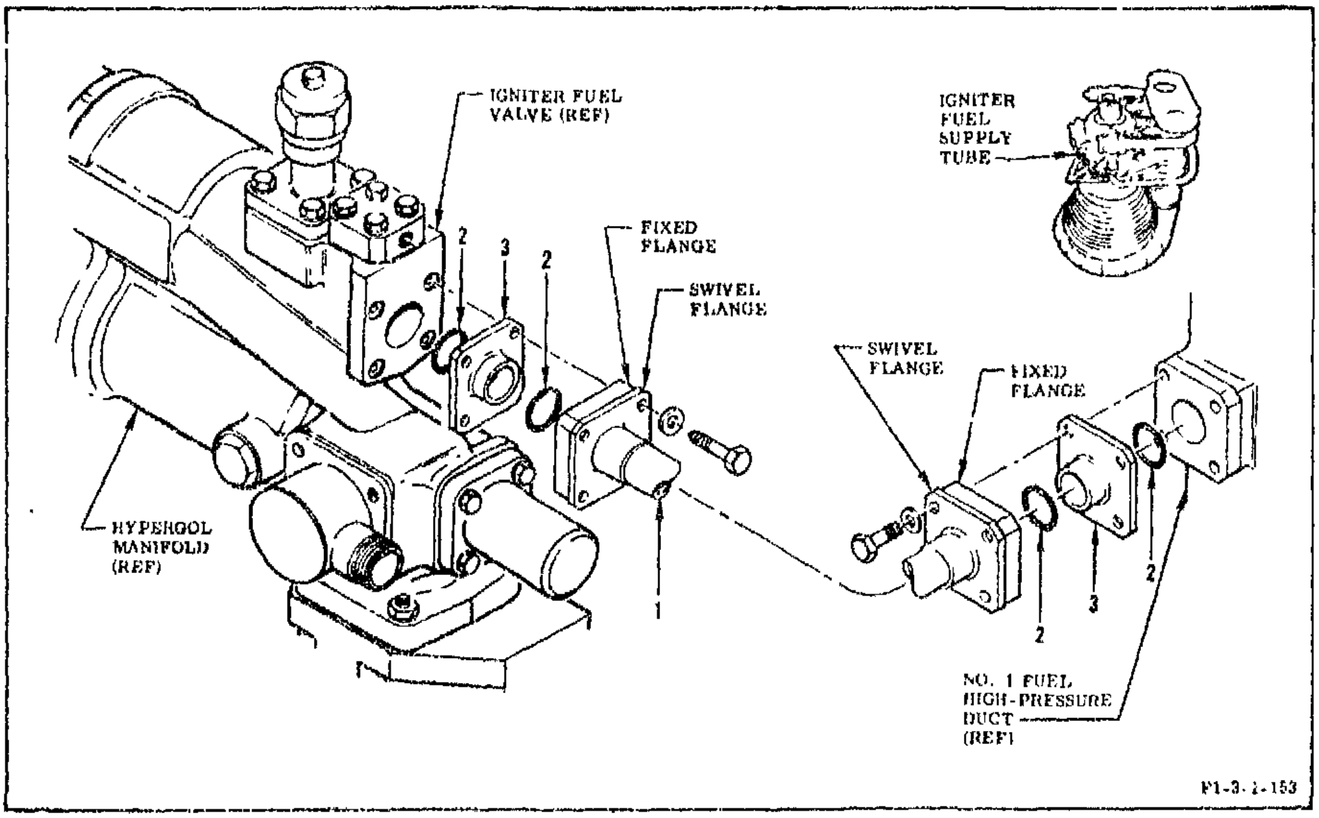
3-104F. <u>ENGINE SUPPLY TUBE</u>.

3-104G. REMOVING ENGINE SUPPLY TUBE. (See figure 3-33B.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

aA. Using a marking method that can be removed, mark across spacer and flanges.

b. Disconnect flanges of tube (1) and remove tube.



1	Tube	2	O-ring	3	Spacer

Figure 3-33A. Igniter Fuel Supply Tube

c. Remove O-rings (2) and spacer (3). Retain spacer.

d. Remove O-rings (4) and spacer (5). Retain spacer.

e. If tube will be replaced, remove quick-disconnect.

f. Lubricant (Method A) check valve flange closure fasteners with lubricant grease RB0140-012 (Rocketdyne).

3-104H. INSTALLING ENGINE SUPPLY TUBE. (See figure 3-33B.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Aline tube (1) and spacers (3, 5) as outlined in paragraph 3-104A.

c. Lubricate (Method K) O-rings (2) with lubricant grease RB0140-012 (Rocketdyne), and install O-rings in groove of spacer (3) and in flange groove.

d. Lubricate (Method K) O-rings (4) with lubricant grease RB0140-012 (Rocketdyne), and install in grooves of spacer (5).

CAUTION

Spacers must not be rotated during assembly in tube or when tube is installed. Damage to O-rings may result.

e. Aline markings on spacer (3) and on flange at duct end of tube (1) and install spacer in tube.

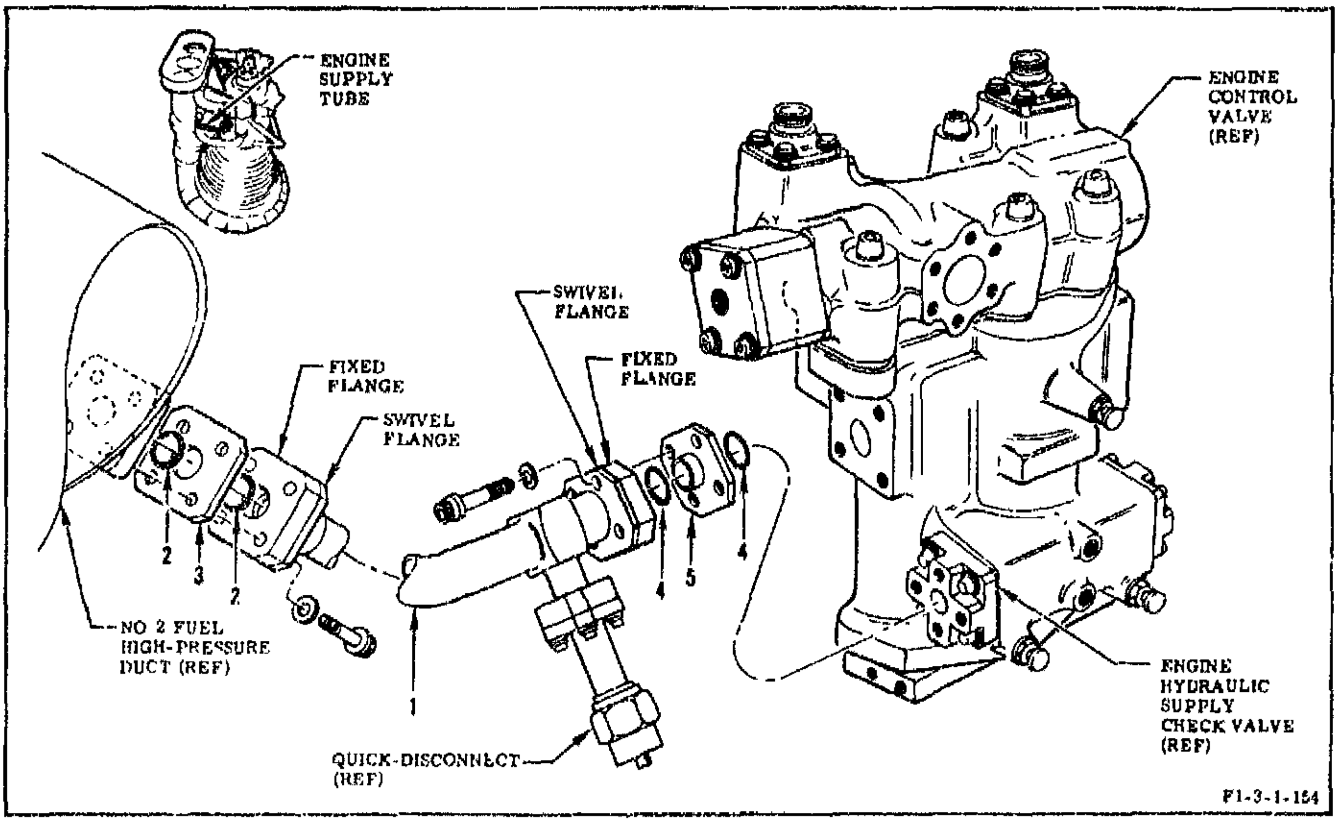
f. Aline markings on spacer (5) and on flange at valve end of tube and install spacer in tube.

g. Carefully install tube. Make sure O-rings are in grooves and cross-torque bolts at valve end to 85 ±5 in-lb; then cross-torque bolts at duct end to 85 ±5 in-lb.

h. Safetywire bolts and remove markings from flanges.

i. If quick-disconnect was removed, reinstall quick-disconnect as outlined in paragraph 3-62.

j. Refer to section IV for post-maintenance test requirements.



1	Tube	3	Spacer	5	Spacer
2	O-ring	4	O-ring		

Figure 3-33B. Engine Supply Tube

3-105. FUEL HIGH-PRESSURE DUCT FIT CHECK (ENGINES NOT INCORPORATING MD137 CHANGE).

3-106. This procedure is performed only when designated in other procedures in this section. The applicable main fuel valve must be installed prior to performing this procedure. Contamination and damage prevention requirements outlined in section I apply to this procedure.

NOTE

The spacing of flange bolts installed in this procedure must be approximately equal.

- Fit-check procedures are the same for No. 1 and No. 2 fuel ducts except as noted.

a. Using a 0.250 ±0.001 inch thick shim (T-5041258, detail 102) to simulate a seal plate, install spacer at turbopump outlet flange with shim positioned against flange. Make sure that flow arrow on spacer points away from turbopump and that spacer is rotated to locate drivescrew at D degrees counterclockwise from maximum forward position of turbopump fuel discharge flange, as specified in rigid-duct spacer dimension chart in Engine Log Book. Secure with 6 bolts. Torque bolts to 400 ±5 in-lb.

b. Using applicable handling equipment from Component Handling Fixture Set G4068, position duct to engine.

c. Install spacer and a 0.250 ±0.001 inch-thick shim (T-5041258, detail 102) at the fuel valve flange. Place shim between spacer and valve flange with narrow flange of spacer facing valve flange.

NOTE

The spacer drivescrew must be positioned in the maximum inboard position.

d. Position fuel duct centerline as closely as possible to centerlines of fuel valve and turbopump spacer. Secure each flange with 6 bolts, approximately equally spaced. Torque fasteners to 400 ±5 in-lb, and remove handling equipment.

e. Loosen, then torque bolts at fuel valve flange to 400 ±4 in-lb.

f. Loosen bolts at duct inlet flange.

g. Make sure shim is flush against turbopump flange and spacer; then measure and record maximum axial gap and minimum gap between duct flange and spacer. Record gap locations relative to drivescrew. Gap limitations are as follows:

(1) Maximum gap: 0.040 inch

(2) Maximum differential gap (maximum gap less minimum gap): 0.020 inch

h. Torque duct inlet flange bolts to 400 ±5 in-lb and loosen bolts at valve end of duct.

i. Make sure shim is flush against valve flange and spacer; then measure and record maximum axial gap and minimum gap between duct flange and spacer. Record gap locations relative to drivescrew. Gap limitations are as follows:

(1) No. 1 fuel duct maximum gap: 0.110 inch with engine in vertical position or 0.040 inch with engine in horizontal position

(2) No. 2 fuel duct maximum gap: 0.060 inch with engine in vertical position or 0.040 inch with engine in horizontal position

(3) Maximum differential gap for No. 1 or No. 2 fuel duct: 0.020 inch

NOTE

Steps j through r provide final installation and alinement for fuel ducts, spacers, and seal plates.

j. Make sure that bolts at valve flanges are torqued to 400 ±5 in-lb.

k. Mark (2 places, 90 degrees apart) across volute flange and spacer. Use a marking method that will allow mark to be removed. Do not scribe surfaces.

l. Remove spacer and shim at volute, and examine all sealing surfaces for damage that would impair sealing function. Remove all alining sleeves or centering pins.

m. Install spacer and seal plates with alining marks on spacer alined with marks on volute flange. Install volute flange bolts, and torque bolts to 1,150 to 1,250 in-lb.

n. Install seal plates, and connect duct flange to spacer. Torque bolts to 1,150-1,250 in-lb.

o. Mark across valve flange and spacer using method that will allow removal of mark. Do not scribe surfaces.

p. Remove spacer and shim at valve flange. Examine sealing surfaces for damage that would impair sealing function. Remove all alining sleeves or centering pins.

q. Install spacer and seal plates with mark on spacer alined with mark on valve flange. Secure joint, and torque bolts to 1,150-1,250 in-lb.

r. Safetywire bolts at volute and duct flanges.

s. Record final spacer information, as specified, in Engine Log Book.

t. Complete installation as outlined in applicable procedure.

3-107. OXIDIZER HIGH-PRESSURE DUCT FIT CHECK (ENGINES NOT INCORPORATING MD137 CHANGE).

3-108. This procedure is performed only when designated in other procedures in this section. The applicable main oxidizer valve must be installed prior to performing this procedure. The safety, and contamination and damage prevention requirements outlined in section I apply to this procedure. Handling equipment required consists of adapter 9025431 (No. 1 fuel duct), 9025432 (No. 2 fuel duct), and fixture 9024921-11 from Component Handling Fixture Set G4068.

NOTE

The spacing of flange bolts installed in this procedure must be approximately equal.

- Fit-check procedures are the same for No. 1 and No. 2 oxidizer ducts.

a. Using applicable handling equipment from Component Handling Fixture Set G4068, position applicable duct between turbopump discharge flange and oxidizer valve flange.

b. Install spacers and a 0.346 ±0.001 inch-thick shim (T-5041250, detail 101) between each duct flange and turbopump and valve flanges. Place shims at turbopump and valve flanges. Position spacers so that flanges of spacers face valve flange and turbopump flange, respectively, with spacer drivescrews positioned fully forward.

bA. Verify torque required to overcome locking feature of nuts when nuts are installed on volute flange bolts. Torque on a new nut must be 15-300 in-lb. Torque on a used nut must be 5-300 in-lb. A nut is considered used after the first turning of the nut on a bolt.

c. Position oxidizer duct centerline as closely as possible to centerlines of oxidizer valve and turbopump spacer. Secure each flange with 6 bolts, approximately equally spaced. Torque fasteners to 400 ±5 in-lb, and remove handling equipment.

d. Loosen; then torque bolts at oxidizer valve flange to 400 ±5 in-lb.

e. Loosen bolts at volute flange.

f. Make sure shim is flush with flange and spacer.

g. Measure and record maximum axial gap at widest point and minimum gap between applicable spacer and duct flange. Record gap locations relative to drivescrew. Maximum axial gap for vertical or horizontal assembly is 0.040 inch. Differential gap (maximum gap less minimum gap) must not exceed 0.020 inch.

h. Torque bolts at volute flange to 400 ±5 in-lb.

i. Loosen bolts at valve end flange of duct.

j. Make sure shim is flush against valve flange and spacer.

k. Repeat step g.

l. Record final spacer information, as specified, in Engine Log Book.

NOTE

Steps m through u provide final installation and alinement for oxidizer ducts.

m. With bolts at both flanges torqued to 400 ±5 in-lb, mark flanges for location of spacer drivescrews using a marking method that allows mark to be removed. Do not scribe surfaces.

n. Loosen bolts at both flanges, and remove shim and spacer at valve end of duct.

o. Make sure that all sealing surfaces are free of damage that could impair sealing function; then install spacer and pressure-actuated seals between duct and valve with drivescrew of spacer alined with mark on flange.

p. Install 6 bolts and washers at valve flange. Tighten but do not torque bolts.

q. Remove shim and spacer at volute.

r. Make sure that all sealing surfaces are free of damage that would impair their sealing function; then install spacer and pressure-actuated seals between duct flange and volute with drivescrew of spacer alined with mark on flange. Secure flange with 6 bolts.

s. Torque bolts at valve flange to 400 ±5 in-lb; then torque at volute to same value.

t. Loosen bolts at volute flange; then install remaining bolts at flange, and cross-torque nuts and bolts secured with threaded brackets to 92 ±5 ft-lb. Safetywire bolts.

u. Install remaining bolts at valve flange, and torque to 1,150-1,250 in-lb. Safetywire bolts. Complete installation as outlined in applicable procedure.

3-109. FUEL HIGH-PRESSURE DUCT FIT CHECK (ENGINES INCORPORATING MD137 CHANGE).

3-110. This procedure is used when designated in other procedures in this section. The procedure finalizes the alined position of the fuel ducts by determining the size, location, and position of the spacers used at the volute and valve ends of the ducts. The safety, and contamination and damage prevention requirements outlined in section I apply to this procedure. The following equipment is required:

(1) Component Handling Fixture Set G4068 components: adapter 9025431 (No. 1 fuel duct), adapter 9025432 (No. 2 fuel duct), and fixture 9024921-11.

(2) Suitable alinement pins to center flange boltholes or alinement sleeves to center bolts in flange holes.

(3) Dummy seal set T-5041258.

(4) Selective spacers, part numbers 410835 and 410836, consisting of the following sizes indicated by the dash number following the basic part number.

Dash Number (410835-)	Tapered Thickness (Inch)
-11	2.562 to 2.562
-21	2.562 to 2.552
-31	2.552 to 2.562
-41	2.500 to 2.490

Dash Number (410836-)	Tapered Thickness (Inch)
-3	0.880 to 0.870
-5	0.850 to 0.840
-7	0.910 to 0.900

NOTE

The applicable fuel valve must be installed to fit-check duct.

a. Refer to Engine Log Book for previously installed spacer sizes and spacer positioning information.

b. Note directional arrow on sides of spacers, and use spacers and shims for applicable fuel duct as follows:

(1) No. 1 fuel duct: shim T-5041258, detail 102 (0.250 ±0.001 inch), between spacer and fuel volute flange and shim T-5041258, detail 105 (0.180 ±0.001 inch), between fuel valve flange and spacer.

(2) No. 2 fuel duct: 2 shims T-5041258, detail 102 (0.250 ±0.001 inch), one shim between spacer and fuel volute and one shim between fuel valve flange and spacer.

c. Using suitable centering pins or bolts with alining sleeves, install shim and spacer at fuel volute. Refer to step b for shim and spacer location. Secure with 6 bolts approximately equally spaced and torque bolts to 400 ±5 in-lb.

d. Using applicable handling equipment, position fuel duct for installation. Using suitable centering pins or bolts with alining sleeves, fasten duct to spacer installed in step c, and secure duct flange with 6 approximately equally spaced bolts. Torque bolts to 400 ±5 in-lb.

e. Using suitable centering pins or bolts with alining sleeves, install applicable spacer and shim at valve end of duct, and aline with valve flange so that 6 approximately equally spaced bolts will turn freely when threads are engaged in valve body. (Refer to step b for shim and spacer location.) If alinement cannot be obtained, make necessary correction at volute end of duct using one or both of the following methods:

(1) Rotation of spacer.

(2) Replacing spacer with one of a different size.

f. Torque bolts at valve end of duct to 400 ±5 in-lb.

g. Loosen flange bolts at volute end of duct, remove centering pins or alinement sleeves, and retorque bolts to 400 ±5 in-lb.

h. Remove bolts at valve end of duct.

i. Measure and record maximum axial gap and minimum axial gap between valve flange and shim. Determine maximum differential gap (maximum axial gap less minimum axial gap). Rotate or change spacer size, as necessary, to meet the following requirements:

(1) No. 1 fuel duct (valve flange to shim); maximum axial gap 0.180 inch, maximum differential gap 0.020 inch.

(2) No. 2 fuel duct (valve flange to shim); maximum axial gap 0.060 inch, maximum differential gap 0.020 inch.

NOTE

If the gap requirements of steps i and l cannot be met, perform steps m through r, as required.

j. Using 6 approximately equally spaced bolts, secure duct, spacer, and shim at valve flange. Torque bolts to 400 ±5 in-lb.

k. Loosen bolts of volute end of duct.

l. Measure and record maximum axial gap and minimum axial gap between duct flange and spacer; then determine maximum differential gap (maximum axial gap less minimum axial gap). Change spacer, as necessary, to meet requirements. The maximum axial gap for either fuel duct (duct flange to spacer) is 0.040 inch. The maximum differential is 0.020 inch.

NOTE

Steps m through o, or p through r, or both, are performed only if necessary to meet gap requirements of steps i and l.

m. Torque bolts at both duct flanges to 400 ±5 in-lb.

n. Loosen fuel valve flange bolts at fuel manifold; then retorque bolts to 400 ±5 in-lb. Bolts must rotate freely (with threads engaged) when turned by hand.

o. Loosen bolts at duct to valve flange, and repeat steps i through l.

p. Torque bolts at both duct flanges to 400 ±5 in-lb.

q. Remove centering pins or alining sleeves at volute flange, and loosen bolts. Make sure bolts will rotate freely (with threads engaged) when turned by hand; then torque bolts to 400 ±5 in-lb.

r. Loosen bolts at duct to valve flange, and repeat steps i through l.

s. Record final spacer information, as specified, in Engine Log Book.

NOTE

Steps t through ab provide final installation and alinement for fuel ducts, spacers, and seal plates.

t. Make sure that bolts at valve flange are torqued to 400 ±5 in-lb.

u. Mark (2 places, 90 degrees apart) across volute flange and spacer. Using a marking method that will allow mark to be removed. Do not scribe surfaces.

v. Remove spacer and shim at volute, and examine all sealing surfaces for damage that would impair sealing function. Remove all alining sleeves or centering pins.

w. Install spacer and seal plate, with alining marks on spacer alined with marks on volute flange, and tab of seal plate positioned forward. Install volute flange bolts, and torque to 1,150-1,250 in-lb.

x. Install seal plate with tab positioned forward, and connect duct flange to spacer. Torque bolts to 1,150-1,250 in-lb.

y. Mark across valve flange and spacer using method that will allow removal of mark. Do not scribe surfaces.

z. Remove spacer and shim at valve flange. Examine sealing surfaces for damage that would impair sealing function. Remove all alining sleeves or centering pins.

aa. Install spacer and seal plates, with mark on spacer alined with mark on valve flange and tab of seal plates positioned outward. Secure joint, and torque bolts to 1,150-1,250 in-lb.

ab. Safetywire flange bolts at volute and valve.

abA. If fuel valve to fuel manifold bolts were loosened, torque bolts to 1,150-1,250 in-lb. Safetywire bolts.

ac. Complete installation as outlined in applicable procedure.

3-111. OXIDIZER HIGH-PRESSURE DUCT FIT CHECK (ENGINES INCORPORATING MD137 CHANGE).

3-112. This procedure is used when designated in other procedures in this section. The procedure finalizes the alined position of the oxidizer ducts by determining the size, location, and position of the spacers used at the volute and valve ends of the ducts. The safety, and contamination and damage prevention requirements outlined in section I apply to this procedure. The following equipment is required:

(1) Component Handling Fixture Set G4068 components: adapter 9025433 (No. 1 oxidizer duct), adapter 9025434 (No. 2 oxidizer duct), and fixture 9024921-11 (No. 1 or No. 2 oxidizer duct).

(2) Suitable alinement pins to center flange boltholes or alinement sleeves to center bolts in flange holes.

(3) Dummy seal set T-5041258.

(4) Selective spacers, part number 410837, consisting of the following sizes, indicated by the dash number following the basic part number.

Dash Number (410837-)	Tapered Thickness (Inch)
-3	0.800 to 0.790
-5	0.830 to 0.820
-7	0.860 to 0.850
-9	0.890 to 0.880
-13	0.920 to 0.910
-15	0.950 to 0.940
-17	0.980 to 0.970
-19	1.010 to 1.000
-23	1.040 to 1.030
-25	1.070 to 1.060
-27	1.100 to 1.090
-29	1.130 to 1.120
-33	1.160 to 1.150
-35	1.190 to 1.180

CAUTION

Component parts must be maintained in an oxidizer-clean condition and parts handled so as to preclude damage to sealing surfaces.

NOTE

The applicable oxidizer valve must be installed to fit-check duct.

a. Use applicable handling equipment to place oxidizer duct in position.

b. Refer to Engine Log Book for previously installed spacers and spacer positioning information.

c. Note directional arrow on side of spacers, and install appropriate spacer at each end of duct in exact position as recorded in Engine Log Book. Use one shim T-5042158, detail 101 (0.346 ±0.001 inch), between spacer and volute flange and one shim between spacer and valve flange. Aline flanges, spacers and shims at valve using 2 suitable centering pins or bolts with alining sleeves.

d. Secure joint at valve using 6 approximately equally spaced bolts. Bolts must turn freely by hand with threads engaged. Tighten, but do not torque bolts or remove centering devices.

e. Remove handling equipment, and check alinement of boltholes at volute flange joint by installing 6 approximately equally spaced bolts. If bolts cannot be installed and rotated freely by hand, correct alinement by replacing valve spacer with a spacer size that will provide correct alinement. Use handling equipment if required.

f. Torque bolts at valve flange to 400 ±5 in-lb.

NOTE

If the gap requirements of steps g through k cannot be met, steps l through n may be performed.

g. Measure and record maximum and minimum axial gaps at volute end of duct between duct flange and spacer. Make sure that no gap exists between volute flange, shim, and spacer when measurements are made. Maximum axial gap must not exceed 0.040 inch. If maximum axial gap exceeds 0.040 inch, rotate volute spacer to position spacer notch at location of maximum axial gap; then repeat measurements. If acceptable maximum gap cannot be obtained, rotate or replace spacer, as necessary, to meet requirements.

h. Determine maximum differential gap (maximum axial gap less minimum axial gap). Maximum differential gap must not exceed 0.020 inch.

hA. Verify torque required to overcome locking feature of nuts when nuts are installed on volute flange bolts. Torque on a new nut must be 15-300 in-lb. Torque on a used nut must be 5-300 in-lb. A nut is considered used after the first turning of the nut on a bolt.

i. Torque bolts at volute flange to 400 ±5 in-lb, and loosen bolts at valve flange. Remove valve flange alinement sleeves or centering pins, as applicable. Make sure that valve flange bolts (with threads engaged) rotate freely when turned by hand. If bolts do not rotate freely, repeat steps d through h until required condition is obtained.

j. Measure and record maximum and minimum axial gaps between valve flange and shim. Make sure that no gaps exist between duct flange, spacer, and shim when measurements are made. Maximum axial gap must not exceed 0.040 inch. If maximum axial gap exceeds 0.040 inch, rotate spacer to position notch of spacer at location of maximum axial gap and repeat measurements. If acceptable maximum gap cannot be obtained, rotate or replace spacer, as necessary, and repeat measurements.

k. Determine maximum differential gap (maximum axial gap less minimum axial gap). Maximum differential gap must not exceed 0.020 inch.

NOTE

Steps l through n are performed only if the gap requirements of steps g through k were not obtained.

l. Make sure that 6 bolts at each end of duct are torqued to 400 ±5 in-lb.

m. Loosen bolts at oxidizer valve to oxidizer dome flange; then retorque bolts to 1,150-1,250 in-lb. Safetywire bolts, and install aluminum seal on safetywire.

n. Repeat steps a through k, as necessary, until dimensional requirements can be obtained.

o. Record final spacer information, as specified, in Engine Log Book.

NOTE

Steps p through y provide final installation and alinement for oxidizer ducts.

p. With bolts at both flanges torqued to 400 ±5 in-lb, mark flanges for location of spacer notches using a marking method that allow mark to be removed. Do not scribe surfaces.

q. Loosen bolts at both flanges, and remove shim and spacer at valve end of duct.

r. Make sure that all sealing surfaces are free of damage that could impair sealing function; then install spacer and pressure-actuated seals between duct and valve with notch of spacer alined with mark on flange.

s. Install 6 bolts and washers at valve flange using 2 alining sleeves on bolts 180 degrees apart. Tighten but do not torque bolts.

t. Remove shim and spacer at volute.

u. Make sure that all sealing surfaces are free of damage that would impair their sealing function; then install spacer and pressure-actuated seals between duct flange and volute with mark on spacer alined with mark on flange. Secure with 6 bolts.

v. Torque bolts at valve flange to 400 +5 in-lb; then torque bolts at volute to same value.

w. Loosen bolts at valve flange, remove sleeves from bolts, then torque bolts to 400 +5 in-lb.

x. Loosen bolts at volute flange; then install remaining bolts at flange, and cross-torque nuts and bolts secured with threaded bracket to 92 +5 ft-lb. Safetywire bolts not secured with nuts.

y. Install remaining bolts at valve flange and torque to 1,150-1,250 in-lb. Safetywire bolts, and complete installation as outlined in applicable oxidizer duct procedure.

NOTE

If the minimum thickness of the spacer at the valve flange is 0.903 inch or less, additional washers 409203 must be used under the bolthead.

3-113. FUEL HIGH-PRESSURE DUCT SPACERS AND SEAL PLATES.

3-114. Fuel duct spacers and/or seal plates may be replaced. The spacers must be the same size and installed in the same position as recorded in the Engine Log Book.

3-115. REMOVING FUEL HIGH-PRESSURE DUCT SPACERS AND SEAL PLATES.

a. Mark across flanges of applicable joint 2 places, 90 degrees apart, using markings that can be removed. Do not scribe.

b. Refer to applicable fuel duct removal procedure and disassemble applicable joint.

3-116. INSTALLING FUEL HIGH-PRESSURE DUCT SPACERS AND SEAL PLATES.

a. Install new spacer and/or seal plates using 2 bolts with alining sleeves or alining pins to aline flanges, spacer, seal plates, and flange marks. Make sure that seal plate tabs are positioned forward at volute joints and outward at valve joints and that spacer is positioned as recorded in Engine Log Book.

b. Install 5 bolts at flange and tighten to maintain alinement; then remove alining pins or bolts with alining sleeves.

c. Install remaining fasteners at joint, and cross-torque fasteners to 1,150-1,250 in-lb. Safetywire fasteners.

d. Refer to applicable fuel duct installation procedure and install remaining parts at applicable joint.

e. Refer to section IV for post-maintenance test requirements.

3-117. FUEL VALVE TO FUEL MANIFOLD ORIFICE PLATE.

3-118. The orifice plate between either fuel valve and the thrust chamber fuel manifold may be replaced.

3-119. REMOVING FUEL VALVE TO FUEL MANIFOLD ORIFICE PLATE.

a. Support applicable fuel valve to maintain alinement of manifold and valve flanges when joint is disconnected.

b. Refer to applicable fuel valve removal procedure and disassemble joint, as required.

c. Remove orifice plate.

3-120. INSTALLING FUEL VALVE TO FUEL MANIFOLD ORIFICE PLATE.

a. Install orifice plate with tab forward, and install flange fasteners.

b. Cross-torque fasteners to 1,150-1,250 in-lb. Safetywire fasteners, and install an aluminum seal on lockwire.

c. Reinstall parts removed to disassemble joint as outlined in applicable fuel valve installation procedure.

d. Refer to section IV for post-maintenance test requirements.

3-121. OXIDIZER HIGH-PRESSURE DUCT SPACERS AND PRESSURE-ACTUATED SEALS.

3-122. Replacing oxidizer duct spacer and/or pressure-actuated seals at the oxidizer duct joints requires removal and installation of the applicable oxidizer duct as outlined in paragraph 3-135 or 3-139.

3-123. OXIDIZER VALVE TO OXIDIZER DOME PRESSURE-ACTUATED SEAL.

3-124. The pressure-actuated seal between either oxidizer valve and oxidizer dome may be replaced.

CAUTION

Personnel must not apply weight on the oxidizer valve and duct when the valve is disconnected from the oxidizer dome.

3-125. REMOVING OXIDIZER VALVE TO OXIDIZER DOME PRESSURE-ACTUATED SEAL.

a. Refer to applicable oxidizer valve removal procedure and disassemble joint, as required.

b. Remove pressure-actuated seal.

3-126. INSTALLING OXIDIZER VALVE TO OXIDIZER DOME PRESSURE-ACTUATED SEAL.

a. Install pressure-actuated seal and flange fasteners.

b. Cross-torque fasteners to 1,150-1,250 in-lb. Safetywire fasteners, and install an aluminum seal on lockwire.

c. Reinstall parts removed to disassemble joint, as outlined in applicable oxidizer valve installation procedure.

d. Refer to section IV for post-maintenance test requirements.

3-127. NO. 1 FUEL HIGH-PRESSURE DUCT.

3-128. Equipment required for removing and installing the duct consists of adapter 9025431 and fixture 9024921-11 from Component Handling Fixture Set G4068. An alternate procedure is provided in paragraphs 3-129A and 3-130A for replacing the No. 1 fuel high-pressure duct with the engine positioned horizontally (as in the vehicle) and with the No. 1 and No. 2 oxidizer high-pressure ducts and the No. 2 fuel high-pressure duct installed.

3-129. REMOVING NO. 1 FUEL HIGH-PRESSURE DUCT. (See figure 3-34.)

WARNING

Component Handling Fixture Set G4068 must be operated by authorized personnel trained in the use of the equipment.

a. Observe contamination and damage prevention requirements outlined in Section I.

b. Disconnect thermal insulation bracket (1). Secure strut clear of duct flange.

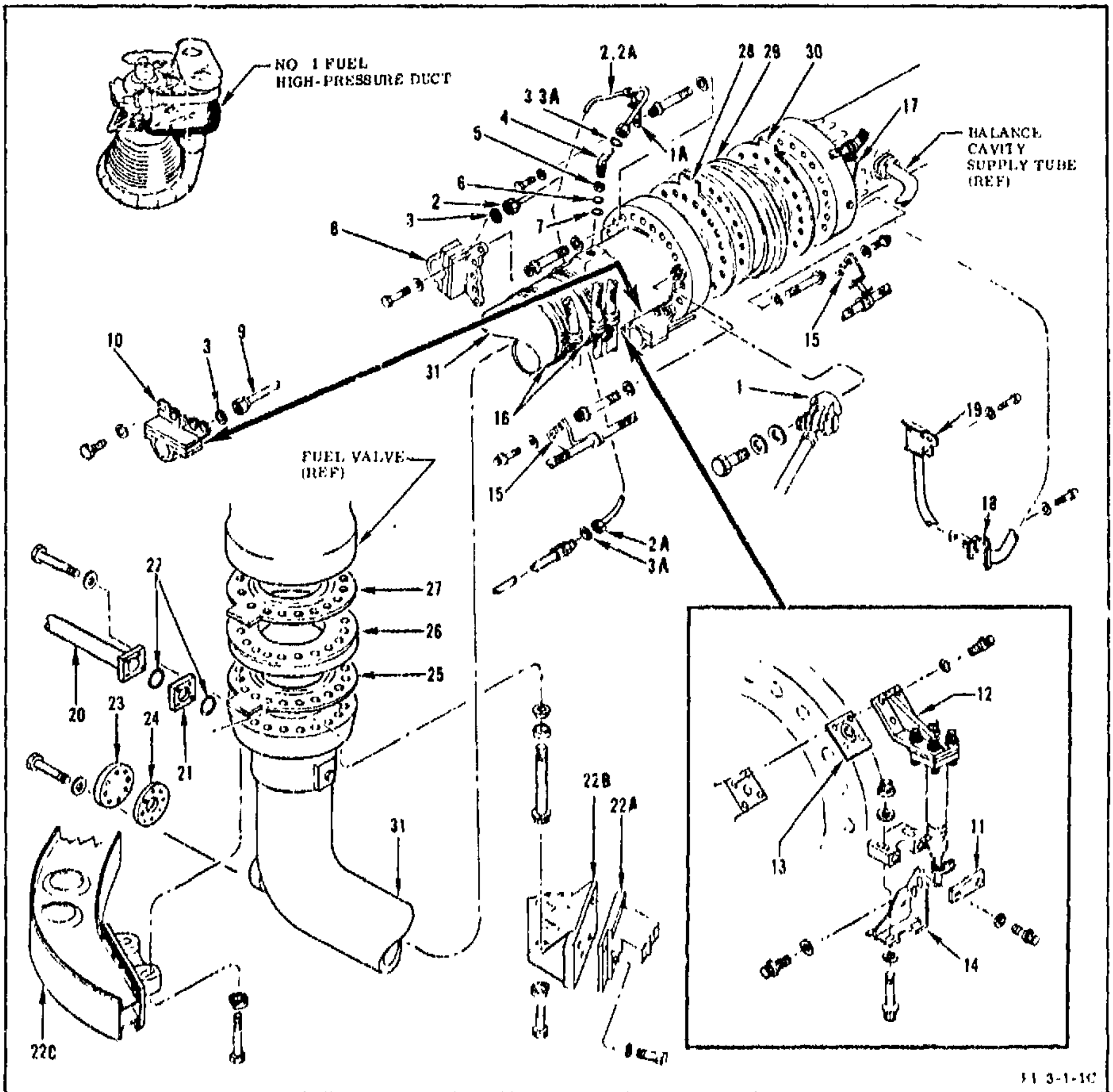
c. Disconnect bracket (1A) from bolthead.

d. On engines not incorporating MD150 change or MD151 change, remove tube (2) and seals (3). On engines incorporating MD150 change or MD151 change, remove tube (2A) and seals (3A).

e. If fuel duct is to be replaced, remove elbow (4), nut (5), ring (6), and gasket (7).

f. Remove support (8).

g. Remove tube (9), seals (3), and support (10).



1	Bracket	7	Gasket	16	Clamp	22C	Stiffener
1A	Bracket	8	Support (a)	17	Bracket	23	Plate
2	Tube (a)	9	Tube (a)	18	Bracket	24	Seal plate
2A	Tube (b)	10	Support (a)	19	Bracket	25	Seal plate
3	Seal (a)	11	Clamp (c)	20	Tube	26	Spacer
3A	Seal (b)	12	Adapter (c)	21	Spacer	27	Seal plate
4	Elbow	13	Seal (c)	22	O-ring	28	Seal plate
5	Nut	14	Bracket (c)	22A	Angle	29	Spacer
6	Ring	15	Bracket	22B	Bracket	30	Seal plate
						31	Duct

(a) Engines not incorporating MD150 or MD151 change
(b) Engines incorporating MD150 or MD151 change
(c) Engines not incorporating MD96 change

Figure 3-34. No. 1 Fuel High-Pressure Duct

h. On engines not incorporating MD96 change, disconnect clamp (11) and transducer connector as outlined in paragraph 3-16.

i. Remove adapter (12) (with transducer attached), seal (13), and bracket (14).

j. Disconnect 2 brackets (15), clamps (16), and brackets (17 through 19).

k. Remove tube (20), spacer (21), and O-rings (22). The same parts are used at hypergol manifold end of tube.

l. If fuel duct is to be replaced, remove plate (23) and seal plate (24).

lA. Disconnect thermal insulation angle (22A) from bracket (22B) and remove bracket. Retain attaching parts.

lB. Disconnect thermal insulation stiffener (22C). (The stiffener is a part of thermal insulation frame 145477 and may be removed with the outer portion of the frame.) (Refer to R-3896-6.)

m. Install adapter 9025431 on fuel duct, and connect fixture 9024921-11 to adapter. (See figure 3-35.) Make sure that hoist hook is used at proper lift points of lift fixture.

n. Note position of spacers by drivescrew or notch locations. Spacer sizes and positions are recorded in the Engine Log Book.

o. Remove fasteners from valve end of duct, and remove seal plates (25, 27, figure 3-34) and spacer (26).

p. Remove fasteners from volute end of duct, remove seal plate (28), and carefully remove duct (31).

q. Remove fasteners from volute flange and remove spacer (29) and seal plate (30).

r. If duct will be replaced, remove drain quick-disconnect from duct.

3-129A. REMOVING NO. 1 FUEL HIGH-PRESSURE DUCT (ALTERNATE PROCEDURE). (See figure 3-34.) This procedure is to be used only if the engine is positioned horizontally (as in the vehicle) and if the No. 1 and No. 2 oxidizer high-pressure ducts and the No. 2 fuel high-pressure duct are installed. The location and position of the No. 1 fuel valve must remain the same as in the initial installation, and the dash numbers and orientation of duct spacers 410835 and 410836 must remain unchanged.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect thermal insulation bracket (1). Secure clear of duct flange.

c. Disconnect bracket (1A) from bolthead.

d. On engines not incorporating MD150 or MD151 change, remove tube (2) and seals (3). On engines incorporating MD150 or MD151 change, remove tube (2A) and seals (3A).

e. Remove elbow (4), nut (5), ring (6), and gasket (7).

f. Remove support (8).

g. Remove tube (9), seals (3), and support (10).

h. On engines not incorporating MD96 change, disconnect clamp (11) and transducer connector as outlined in paragraph 3-16.

i. Remove adapter (12) (with transducer attached), seal (13), and bracket (14).

j. Disconnect 2 brackets (15), clamps (16), and brackets (17 through 19).

k. Remove tube (20), spacer (21), and O-rings (22). Same parts are used at hypergol manifold end of tube.

kA. Disassemble thermal insulation angle (22A) and bracket (22B) and remove bracket. Retain attaching parts.

kB. Disconnect thermal insulation stiffener (22C). (The stiffener is a part of thermal insulation frame 145477 and may be removed with the outer portion of the frame.) (Refer to R-3896-6.)

l. Remove plate (23) and seal plate (24).

m. Mark across valve flange and spacer using method that will allow removal of mark. Do not scribe surfaces.

n. Remove fasteners from valve end of duct, and remove seal plates (25, 27) and spacer (26).

o. Remove fasteners from volute end of duct, remove seal plate (28) and carefully remove duct. (Duct weight is approximately 85 pounds.) Do not remove spacer (29) and seal plate (30) from volute end of duct.

3-130. INSTALLING NO. 1 FUEL HIGH-PRESSURE DUCT. (See figure 3-34.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne), unless otherwise specified. Specified lubricating procedures (methods) are outlined in section I. Where multiple fasteners are used at joints, the applicable torque and safetywiring methods outlined in section I must be used.

a. On engines not incorporating MD137 change, perform fit check and installation of fuel duct (31), spacers (26, 29) and seal plates (25, 27, 28, 30) as outlined in paragraph 3-105. On engines incorporating MD137 change, perform fit check and installation of fuel duct, spacers, and seal plates as outlined in paragraph 3-109. Following completion of applicable procedure, complete installation of remaining parts index (1 through 24) as outlined in the following steps.

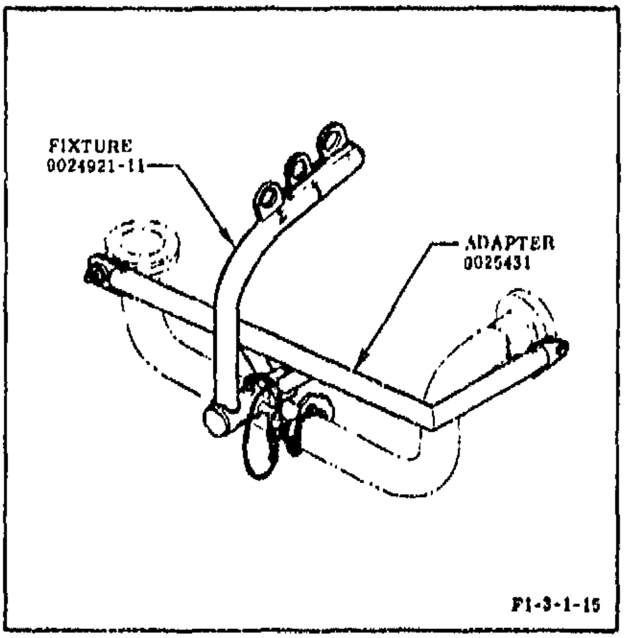


Figure 3-35. Handling No. 1 Fuel High-Pressure Duct

b. Observe safety, and contamination and damage prevention requirements outlined in section I.

c. If fuel duct was replaced, install seal plate (24) and plate (23). Cross-torque bolts to 60 ±5 in-lb. Safetywire bolts.

d. Aline igniter fuel supply tube (20) and spacers (21) to duct (31) as outlined in paragraph 3-104A.

dA. Lubricate (Method K) 4 O-rings (22) and install in flange and spacer grooves.

CAUTION

Spacers must not be rotated during assembly in tube or when tube is installed. Damage to O-rings may result.

dB. Aline markings on spacers and flanges and install spacers in tube.

dC. Carefully install tube. Make sure O-rings in grooves are in place, and cross-torque bolts at manifold end to 60 ±5 in-lb; then cross-torque bolts at duct end to 60 ±5 in-lb.

dD. Safetywire bolts and remove markings from flanges.

dE. If stiffener (22C) was removed as a part of thermal insulation frame 145477, reinstall frame portion using information in R-3896-6. If stiffener was disconnected only, attach stiffener to flange boltheads using bolts NAS1005-13H and washers RD153-9004-0002. Lubricate (Method A) bolts with thread compound C-5A (Felt Products). Torque bolts to 68 ±7 in-lb. Safetywire bolts.

dF. Assemble angle (22A) and bracket (22B) using bolts NAS1004-4H or bolts RD111-1009-0411 and washers LD153-0013-0002. If bolts NAS1004-4H are used, lubricate them as outlined in step dE. Torque bolts to 68 ±7 in-lb. Safetywire bolts.

dG. Attach bracket (22B) to flange boltheads using bolts NAS1005-4H and washers RD153-9004-0002. Lubricate bolts as outlined in step dE. Torque bolts to 68 ±7 in-lb. Safetywire bolts.

e. Connect brackets (18, 19) to volute flange boltheads. Torque bolts to 160-210 in-lb. Safetywire bolts.

NOTE

If the fuel impeller balance cavity supply tube was removed, it must be installed as outlined in paragraph 3-313.

f. Install brackets (15, 17). Torque bolts to 100 ±5 in-lb. Safetywire bolts.

g. Install harness clamps (16). Torque nuts to 24-30 in-lb.

h. On engines not incorporating MD96 change, install bracket (14). Torque bolts to 70 ±5 in-lb. Safetywire bolts.

i. On engines not incorporating MD96 change, install seal (13) and adapter (12) with transducer attached. Cross-torque bolts to 70 ±5 in-lb. Safetywire bolts.

j. Refer to paragraph 3-17 and connect transducer plug and install clamp (11).

k. On engines not incorporating MD150 or MD151 change, install supports (8, 10). Torque bolts to 22 ±5 in-lb. Safetywire bolts.

l. On engines not incorporating MD150 or MD151 change, lubricate (Method A) fittings in preparation for installing tube (9). Lubricate (Method G) tube (9). Install tube (9) and seals (3). Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

m. If elbow (4), nut (5), ring (6), and gasket (7) were removed, lubricate (Method J) gasket (7). Lubricate (Method A) elbow (4), and install and position elbow for connecting with tube (2). Torque nut (5) to 75-100 in-lb.

n. On engines not incorporating MD150 or MD151 change, lubricate (Method A) elbow (4) and union in transducer of support (8). Lubricate (Method G) tube (2). Install tube and seals (3). Torque coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

o. On engines incorporating MD150 or MD151 change, lubricate (Method A) elbow (4) and union at tube junction. Lubricate (Method G) tube (2A), and install tube and seals (3A). Torque coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

p. Connect bracket (1A) to duct flange bolthead. Torque bracket bolt to 17-27 in-lb. Safetywire bolt.

q. On engines incorporating MD150 or MD151 change, attach tube (2, 2A) clamping brackets to perimeter of fuel inlet elbow. Torque bolts as follows, and safetywire bolts.

(1) Two brackets at lower end of fuel inlet elbow; 260-350 in-lb. Bolts used are fuel inlet elbow handling bolts RD111-9001-0018.

(2) One bracket at fuel inlet elbow flange bolthead; 30-40 in-lb.

r. Install thermal insulation bracket (1). Lubricate (Method A) bolt with thread compound C-5A (Felt Products). Torque bolt to 68 ±7 in-lb. Safetywire bolt.

rA. If duct was replaced, install drain quick-disconnect as outlined in paragraph 3-60.

s. Refer to section IV for post-maintenance test requirements.

3-130A. INSTALLING NO. 1 FUEL HIGH-PRESSURE DUCT (ALTERNATE PROCEDURE). (See figure 3-34.) This procedure is to be used only if the engine is positioned horizontally (as in the vehicle) and if the No. 1 and No. 2 oxidizer high-pressure ducts and the No. 2 fuel high-pressure duct are installed. The location and position of the No. 1 fuel valve must remain the same as in the initial duct installation, and the dash numbers and orientation of duct spacers 410835 and 410836 must remain unchanged. The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne), unless otherwise specified. Specified lubricating (methods) are outlined in section I. Where multiple fasteners are used at joints, the applicable torque and safetywiring methods outlined in section I must be used.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Manually position fuel duct for installation. (Duct weight is approximately 85 pounds.)

c. Install spacer (26) and seal plates (25, 27) with mark on spacer and fuel valve flange alined and tab of seal plates positioned outward at fuel valve end of duct. Install 6 approximately equally spaced bolts. Do not torque bolts. If replacement of spacer (26) is necessary, refer to Engine Log Book for spacer orientation.

d. Install seal plate (28). Check alinement of boltholes at volute end of duct. Reposition duct, as required, to obtain alinement of boltholes at both ends of duct. Bolts must turn freely by hand when threads are engaged. Install and cross-torque all bolts to 1,150-1,250 in-lb. Safetywire bolts at volute end and fuel valve end of duct.

e. Install seal plate (24) and plate (23). Cross-torque bolts to 60 ±5 in-lb. Safetywire bolts.

f. Aline igniter fuel supply tube (20) and spacers (21) to duct (31) as outlined in paragraph 3-104A.

fA. Lubricate (Method K) 4 O-rings (22) and install in flange and spacer grooves.

CAUTION

Spacers must not be rotated during assembly in tube or when tube is installed. Damage to O-rings may result.

fB. Aline markings on spacers and flanges and install spacers in tube.

fC. Carefully install tube. Make sure O-rings in grooves are in place, and cross-torque bolts at manifold end to 60 ±5 in-lb; then cross-torque bolts at duct end to 60 ±5 in-lb.

fD. Safetywire bolts and remove markings from flanges.

fE. If stiffener (22C) was removed as a part of thermal insulation frame 145477, reinstall frame portion using information in R-3896-6. If stiffener was disconnected only, attach stiffener to flange boltheads using bolts NAS1005-13H and washers RD153-9004-0002. Lubricate (Method A) bolts with thread compound C-5A (Felt Products). Torque bolts to 68 ±7 in-lb. Safetywire bolts.

fF. Assemble angle (22A) and bracket (22B) using bolts NAS1004-4H or bolts RD111-1009-0411 and washers LD153-0013-0002. If bolts NAS1004-4H are used, lubricate them as outlined in step fE. Torque bolts to 68 ±7 in-lb. Safetywire bolts.

fG. Attach bracket (22B) to flange boltheads using bolts NAS1005-4H and washers RD153-9004-0002. Lubricate bolts as outlined in step fE. Torque bolts to 68 ±7 in-lb. Safetywire bolts.

g. Connect brackets (18, 19) to volute flange boltheads. Torque bolts to 160-210 in-lb. Safetywire bolts.

NOTE

If the fuel impeller balance cavity supply tube was removed, it must be installed as outlined in paragraph 3-313.

h. Install brackets (15, 17). Torque bolts to 100 ±5 in-lb. Safetywire bolts.

i. Install harness clamps (16). Torque nuts to 24-30 in-lb.

j. On engines not incorporating MD96 change, install bracket (14). Torque bolts to 70 ±5 in-lb. Safetywire bolts.

k. On engines not incorporating MD96 change, install seal (13) and adapter (12) with transducer attached. Cross-torque bolts to 70 ±5 in-lb. Safetywire bolts.

l. Refer to paragraph 3-17 and connect transducer plug; install clamp (11).

m. On engines not incorporating MD150 or MD151 change, install supports (8, 10). Torque bolts to 22 ±5 in-lb. Safetywire bolts.

n. On engines not incorporating MD150 or MD151 change, lubricate (Method A) fittings in preparation for installing tube (9). Lubricate (Method G) tube (9). Install tube (9) and seals (3). Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

o. Lubricate (Method J) gasket (7). Lubricate (Method A) elbow (4). Install gasket (7), ring (6), and nut (5) on elbow (4). Install and position elbow for connecting with tube (2). Torque nut (5) to 75-100 in-lb.

p. On engines not incorporating MD150 or MD151 change, lubricate (Method A) elbow (4) and union in transducer of support (8). Lubricate (Method G) tube (2). Install tube and seals (3). Torque coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

q. On engines incorporating MD150 or MD151 change, lubricate (Method A) elbow (4) and union at tube junction. Lubricate (Method G) tube (2A), and install tube and seals (3A). Torque coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

r. Connect bracket (1A) to duct flange bolthead. Torque bracket bolt to 17-27 in-lb. Safetywire bolt.

s. On engines incorporating MD150 or MD151 change, attach tube (2, 2A) clamping brackets to perimeter of fuel inlet elbow. Torque bolts as follows, and safetywire bolts.

(1) Two brackets at lower end of fuel inlet elbow; 260-350 in-lb. Bolts used are fuel inlet elbow handling bolts RD111-9001-0018.

(2) One bracket at fuel inlet elbow flange bolthead; 30-40 in-lb.

t. Install thermal insulation bracket (1). Lubricate (Method A) bolt with thread compound C-5A (Fel Products). Torque bolt to 68 ±7 in-lb. Safetywire bolt.

u. Refer to section IV for post-maintenance test requirements.

3-131. NO. 2 FUEL HIGH-PRESSURE DUCT.

3-132. Equipment required for removing and installing the duct consists of adapter 9025432 and fixture 9024921-11 from Component Handling Fixture Set G4068.

3-133. REMOVING NO. 2 FUEL HIGH-PRESSURE DUCT. (See figure 3-36.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove thermal insulation frame 145497, and retain hardware. (Refer to R-3896-6.)

c. Refer to paragraph 3-219 and completely remove duct (1). Retain orifice plate (2).

d. On engines not incorporating MD150 or MD151 change, remove tube (3) and seals (4). On engines incorporating MD150 or MD151 change, remove tube (3A) and seals (4A).

e. If fuel duct is to be replaced, remove elbow (5), nut (6), ring (7), and gasket (8).

eA. Disconnect bracket (8A).

f. On engines not incorporating MD150 or MD151 change, remove support (9).

g. On engines not incorporating MD150 or MD151 change, disconnect bracket (10), and remove tube (11), seal (4), and support (12).

h. Disconnect clamp (13) and connector of transducer as outlined in paragraph 3-16.

i. Remove adapter (14) (with transducer attached), seal plate (15), and bracket (16).

j. Disconnect hose (17), and remove orifice plate (18).

k. Remove tube (19), O-rings (21, 23), and spacers (20, 22).

l. Install adapter 9025431 on fuel duct, and connect fixture 9024921-11 to adapter. (See figure 3-37.) Make sure hoist hook is used at proper lift point of fixture.

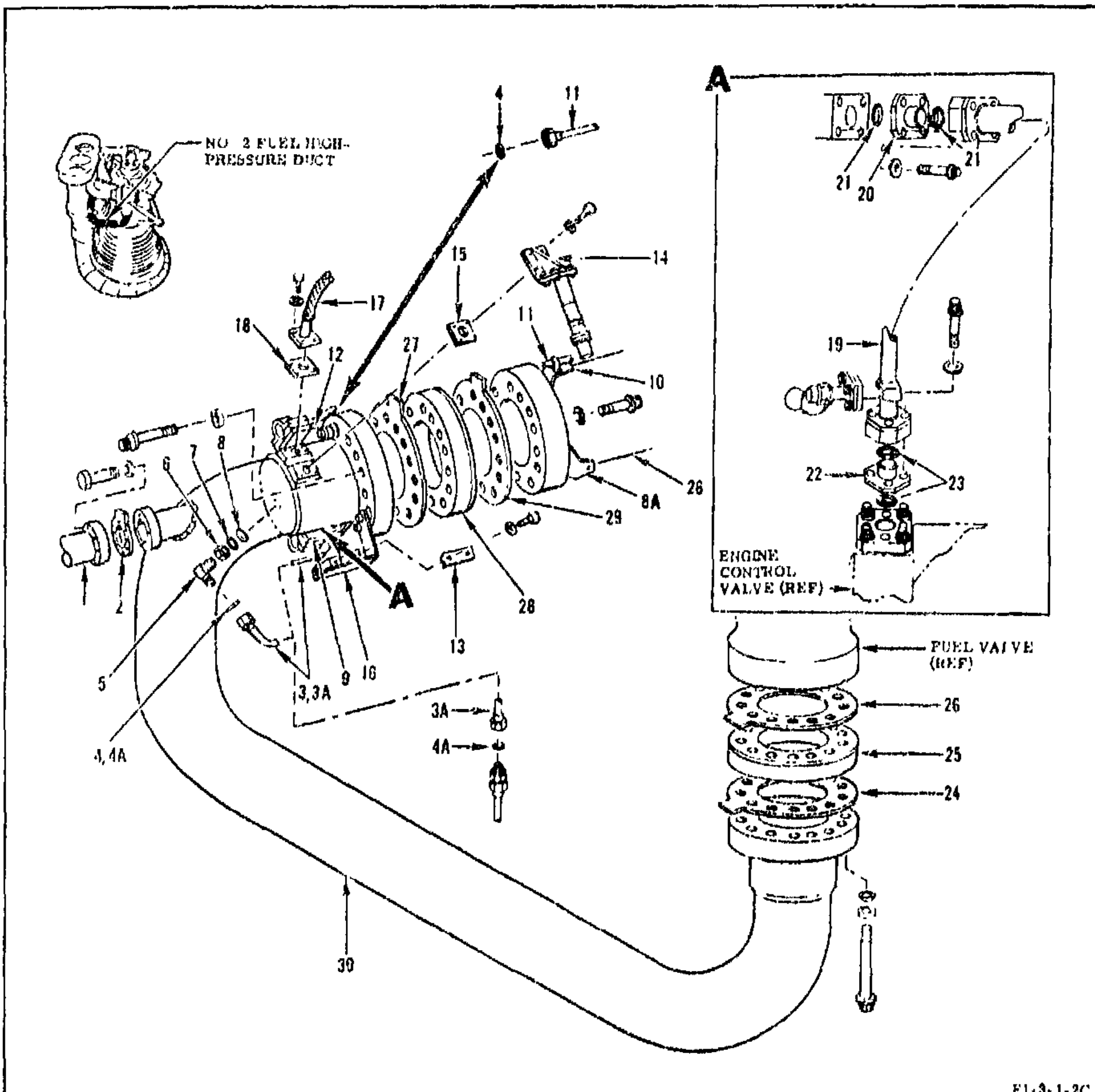
m. Note position of spacers by drivescrew or notch location. Spacer sizes and positions are recorded in Engine Log Book.

n. Remove fasteners from valve end of duct, and remove seal plate (24, 26, figure 3-36) and spacer (25).

o. Remove fasteners from volute end of duct, remove seal plate (27), and carefully remove duct.

p. Remove fasteners from volute flange, and remove spacer (28) and seal plate (29).

q. If duct will be replaced, remove drain quick-disconnect from duct.



1	Duct	8	Gasket	15	Seal plate	23	O-ring
2	Orifice plate	8A	Bracket	16	Bracket	24	Seal plate
3	Tube[a]	9	Support[a]	17	Hose	25	Spacer
3A	Tube[b]	10	Bracket[a]	18	Orifice plate	26	Seal plate
4	Seal[a]	11	Tube[a]	19	Tube	27	Seal plate
4A	Seal[b]	12	Support[a]	20	Spacer	28	Spacer
5	Elbow	13	Clamp	21	O-ring	29	Seal plate
6	Nut	14	Adapter	22	Spacer	30	Duct
7	Ring						

(a) Engines not incorporating MD150 or MD151 change
(b) Engines incorporating MD150 or MD151 change

Figure 3-36. No. 2 Fuel High-Pressure Duct

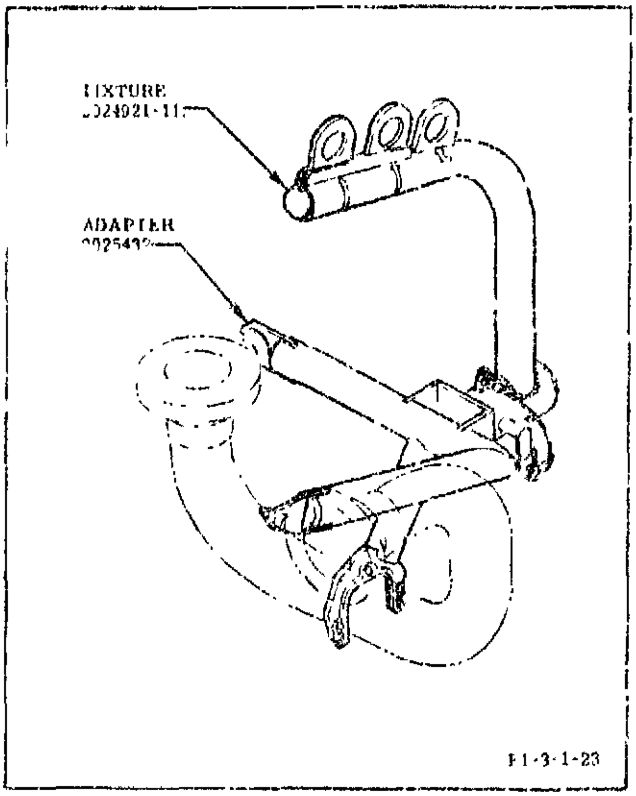


Figure 3-37. Handling No. 2 Fuel High-Pressure Duct

3-134. INSTALLING NO. 2 FUEL HIGH-PRESSURE DUCT. (See figure 3-36.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne). Specified lubricating procedures (methods) are outlined in section I. Where multiple fasteners are used at joints, the applicable torque and safetywiring method outlined in section I must be used.

a. On engines not incorporating MD137 change, perform fit check and installation of fuel duct (30), spacers (25, 28), and seal plates (24, 26, 27, 29) as outlined in paragraph 3-105. On engines incorporating MD137 change, perform fit check and installation of fuel duct, spacers, and seal plates as outlined in paragraph 3-109. Following completion of applicable procedure, complete installation of parts indexed (1 through 23) as outlined in the following steps.

b. Observe safety, and contamination and damage prevention requirements outlined in section I.

c. Aline engine supply tube (19) and spacers (20, 22) to duct (30) as outlined in paragraph 3-104A.

cA. Lubricate (Method K) 2 O-rings (23) and install in grooves of spacer (22).

cB. Lubricate (Method K) 2 O-rings (21) and install in groove of spacer (20) and flange groove.

CAUTION

Spacers must not be rotated during assembly in tube or when tube is installed. Damage to O-rings may result.

cC. Aline markings on flanges and install spacers (20, 22) in tube.

cD. Carefully install tube. Make sure O-rings in grooves are in place, and cross-torque bolts at valve end to 85 ±5 in-lb; then cross-torque bolts at duct end to 85 ±5 in-lb.

cE. Safetywire bolts and remove markings from flanges.

d. Install orifice plate (18) and hose (17). Cross-torque bolts to 25 ±2 in-lb. Safetywire bolts and install an aluminum seal on lockwire.

NOTE

If hose (17) was removed, it must be routed between the turbopump strut and the wire group that parallels the strut when reinstalled. Hose bend radii for installation is 1.50 inches minimum. Braid bulge must not extend beyond the hex flat dimension of the braid retaining collar.

e. Install bracket (16). Cross-torque bolts to 100 ±5 in-lb. Safetywire bolts.

f. Install seal plate (15) and adapter (14) with transducer attached. Torque bolts to 70 ±5 in-lb. Safetywire bolts.

g. Refer to paragraph 3-17 and connect transducer plug and install clamp (13).

gA. Attach bracket (8A) at volute flange bolthead. Torque bolts to 90-100 in-lb. Safetywire bolts.

h. On engines not incorporating MD150 or MD151 change, install support (12). Torque bolts to 22 ±5 in-lb. Safetywire bolts.

i. Lubricate (Method A) threads of fittings in preparation to install tube (11).

j. Lubricate (Method G) tube (11). Install seals (4) and tube (11). Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

k. Attach bracket (10) at volute flange bolthead. Torque bolts to 90-100 in-lb. Safetywire bolt.

l. If elbow (5), nut (6), ring (7), and gasket (8) were removed, lubricate (Method J) gasket (8). Lubricate (Method A) elbow (5). Install and position elbow for connecting tube (3, 3A). Torque nut (6) to 75-100 in-lb. Safetywire nut.

m. On engines not incorporating MD150 or MD151 change, lubricate (Method A) union in transducer in support (9) and elbow (5). Lubricate (Method G) tube (3). Install seals (4) and tube (3). Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

n. On engines incorporating MD150 or MD151 change, lubricate (Method A) union at tube junction and elbow (5). Lubricate (Method G) tube (3A). Install seals (4A) and tube. Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

o. Fasten bracket supporting tube (3, 3A) to flange bolthead. Torque bolt to 90-100 in-lb. Safetywire bolt.

p. Completely install duct (1) and retained orifice plate (2) as outlined in paragraph 3-220.

q. If duct was replaced, install drain quick-disconnect as outlined in paragraph 3-60.

r. Reinstall thermal insulation frame 145497. (Refer to R-3896-6.)

s. Refer to section IV for post-maintenance test requirements.

3-135. NO. 1 OXIDIZER HIGH-PRESSURE DUCT.

3-136. Equipment required for removing and installing the duct consists of adapter 9025433, fixture 9024921-11, and strut 9025193 from Component Handling Fixture Set G4068.

3-137. REMOVING NO. 1 OXIDIZER HIGH-PRESSURE DUCT. (See figure 3-38.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

aA. Remove thermal insulation frame 145325. (Refer to R-3896-6.)

b. Disconnect thermal insulation bracket (1). Secure strut clear of duct flange.

c. On engines not incorporating MD141, MD150, or MD151 change, remove tube (1A) and seals (2) from support (3) and union (4). Remove union (4) and seal (13) if duct is to be replaced.

d. On engines incorporating MD141 change and not incorporating MD150 or MD151 change, remove tube (5), seals (6), bolt (7), fitting (8), and seals (9).

e. On engines incorporating MD150 or MD151 change, remove tube (10) and seals (11, 12). If duct is to be replaced, remove union (4) and seal (13).

f. On engines not incorporating MD150 or MD151 change, remove support (3).

g. On engines not incorporating MD150 or MD151 change, remove tube (14), seals (2), and support (15).

h. Disconnect bracket (16) from flange boltheads.

NOTE

Steps i through l apply to engines not incorporating MD96 change. Steps m through o apply to engines incorporating MD96 change.

i. Disconnect connector from transducers (17, 18) as outlined in paragraph 3-16.

j. Disconnect bracket (19) from flange bolthead, and remove tube (20) and seal (21).

k. Disconnect bracket (22) from bracket (23), if required, to clear harnesses.

l. Remove bracket (23, 24).

m. Remove transducer (25) as outlined in paragraph 3-65.

n. Disconnect bracket (26) from bracket (27), if required, to clear harnesses.

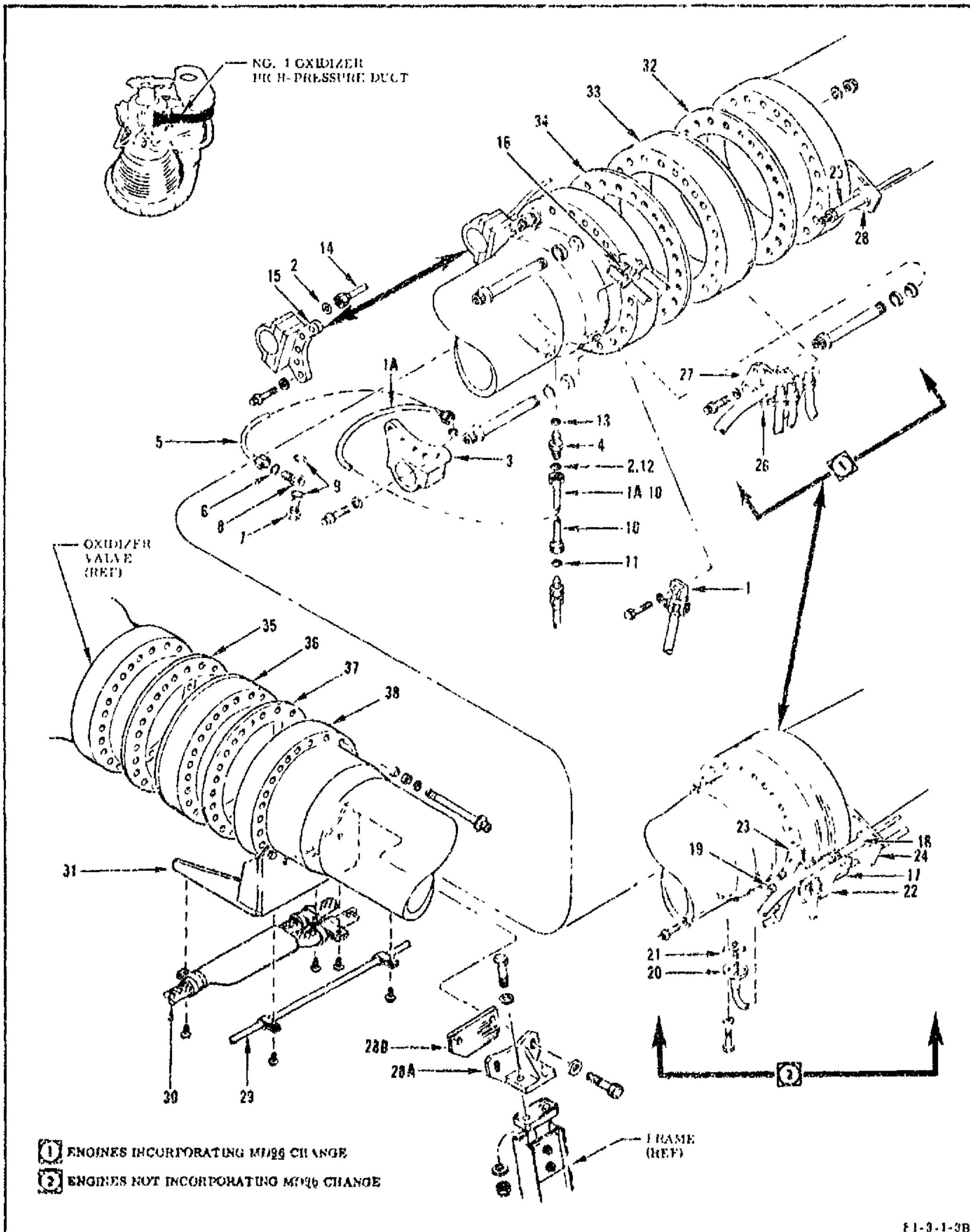


Figure 3-38. No. 1 Oxidizer High-Pressure Duct (Sheet 1 of 2)

1	Bracket	11	Seal[e]	22	Bracket[f]	31	Bracket
1A	Tube[a]	12	Seal[e]	23	Bracket[f]	32	Pressure-actuated seal
2	Seal[a]	13	Seal[c]	24	Bracket[f]	33	Spacer
3	Support[b]	14	Tube[b]	25	Transducer[g]	34	Pressure-actuated seal
4	Union[c]	15	Support[b]	26	Bracket[g]	35	Pressure-actuated seal
5	Tube[d]	16	Bracket	27	Bracket[g]	36	Spacer
6	Seal[d]	17	Transducer[f]	28	Bracket[g]	37	Pressure-actuated seal
7	Bolt[d]	18	Transducer[f]	28A	Bracket	38	Duct
8	Fitting[d]	19	Bracket[f]	28B	Plate		
9	Seal[d]	20	Tube[f]	29	Line		
10	Tube[e]	21	Seal[f]	30	Harness		

(a) Engines not incorporating MD141, MD150, or MD151 change
(b) Engines not incorporating MD150 or MD151 change
(c) Engines not incorporating MD141 change
(d) Engines incorporating MD141 change
(e) Engines incorporating MD150 or MD151 change
(f) Engines not incorporating MD96 change
(g) Engines incorporating MD96 change

Figure 3-38. No. 1 Oxidizer High-Pressure Duct (Sheet 2 of 2)

o. Remove brackets (27, 28).

oA. Disconnect thermal insulation bracket (28A) from frame. Remove bracket and plate (28B). Retain attaching parts.

p. Disconnect line (29) and harness (30) from bracket (31), and remove bracket (31). Leave clamps installed on line and harness.

q. Install adapter 9025433 on duct, and install fixture 9024921-11 on adapter. (See figure 3-39.) Make sure that hoist hook is used at proper lift points of lift fixture. Strut 9025193 must be installed to support turbopump if joints of No. 2 oxidizer high-pressure duct and valve are not intact.

r. Note location of spacers by drivescrew or notch position. Spacer sizes and positions are noted in the Engine Log Book.

s. Remove fastener at volute flange, and remove pressure-actuated seal (32, figure 3-38), spacer (33), and pressure-actuated seal (34).

t. Remove fasteners at valve flange, and remove pressure-actuated seal (35), spacer (36), and pressure-actuated seal (37).

u. Carefully remove oxidizer duct (38).

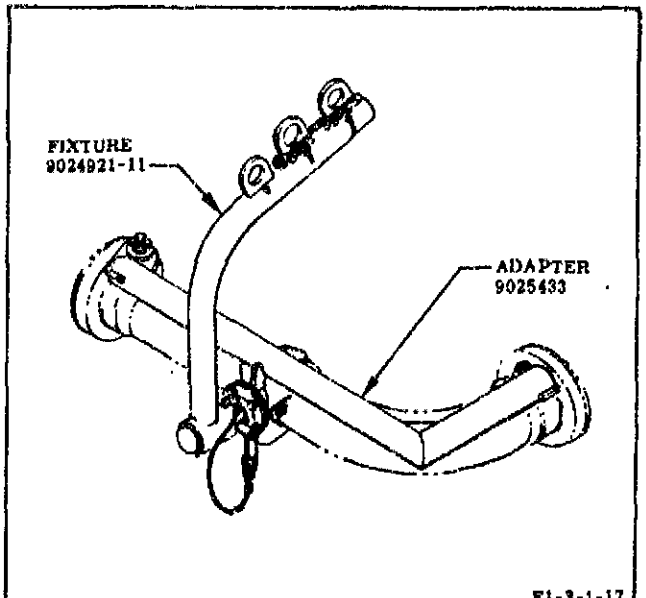


Figure 3-39. Handling No. 1 Oxidizer High-Pressure Duct

3-138. INSTALLING NO. 1 OXIDIZER HIGH-PRESSURE DUCT. (See figure 3-38.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne), unless otherwise specified. Specified lubricating procedures (methods) are outlined in section I. Where multiple fasteners are used at joints, the applicable torque and safetywiring methods outlined in section I must be used.

a. On engines not incorporating MD137 change, perform fit check and installation of duct (38), pressure-actuated seals (32, 34, 35, 37), and spacers (33, 36), as outlined in paragraph 3-107. On engines incorporating MD137 change, perform fit check and installation of duct, pressure-actuated seals, and spacers, as outlined in paragraph 3-111. Following completion of applicable procedure, complete installation of remaining parts indexed (1 through 31) as outlined in the following steps.

b. Observe safety, and contamination and damage prevention requirements outlined in section I.

c. Install bracket (31). Torque bolts to 75 ±5 in-lb. Safetywire bolts.

d. Secure harness (30) and line (29) to bracket (31). Torque nuts to 8-10 in-lb.

e. On engines incorporating MD96 change, install bracket (27). Torque bolts to 70 ±5 in-lb. Safetywire bolts. If bracket (26) was disconnected from bracket (27), install bracket (26) and torque nuts to 95-105 in-lb.

eA. Install thermal insulation bracket (28A) on frame. Torque nuts to 68 ±7 in-lb.

eB. Using thread compound C-5A (Felt Products), lubricate (Method A) bolts used to attach bracket (28A) and plate (28B) to flange boltheads.

eC. Install plate (28B) and torque bolts to 68 ±7 in-lb. Safetywire bolts.

f. If bracket (28) was not installed during duct fit check and installation, install bracket with flange bolts and torque bolts to 92 ±5 ft-lb. Safetywire bolts.

g. Install transducer (25) as outlined in paragraph 3-66.

NOTE

Steps h through l apply to engines not incorporating MD96 change.

h. Install bracket (23). Torque bolts to 100 ±5 in-lb. Safetywire bolts.

NOTE

Bracket (24) was installed as part of duct alinement and installation.

i. If bracket (22) was removed from bracket (23), install bracket (22) and torque nuts to 70 ±5 in-lb.

j. Install seal (21) and tube (20). Torque bolts to 70 ±5 in-lb. Safetywire bolts.

k. Connect bracket (19) to flange bolthead. Torque bolt to 100 ±5 in-lb. Safetywire bolt.

l. Install transducers (17, 18) as outlined in paragraph 3-66.

m. Install bracket (16). Torque bolts to 100 ±5 in-lb. Safetywire bolts.

n. On engines not incorporating MD150 or MD151 change, install support (15). Torque bolts to 22 ±5 in-lb. Safetywire bolts.

o. Lubricate (Method G) tube (14). Lubricate (Method A) unions for tube (14). Install seals (2) and tube (14). Torque coupling nuts to 160 ±10 in-lb, and safetywire coupling nuts.

p. On engines not incorporating MD141 change, lubricate (Method J) seal (13) and lubricate (Method A) union (4). Install union and seal, and torque union to 55-80 in-lb. Safetywire union.

q. On engines incorporating MD150 or MD151 change, lubricate (Method A) union and lubricate (Method G) tube (10). Install seals (11, 12) and tube (10). Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

r. On engines incorporating MD141 change but not incorporating MD150 or MD151 change, lubricate (Method J) seals (9). Lubricate (Method G) tube (5). Install seals (9), fitting (8), seals (6), and tube. Position fitting to aline with tube (5). Torque bolt (7) to 55-80 in-lb and tube coupling nuts to 160 ±10 in-lb. Safetywire bolt and coupling nuts.

s. On engines not incorporating MD141, MD150, or MD151 change, lubricate (Method J) seal (13). Lubricate (Method A) union (4) and lubricate (Method G) tube (1A). Install seal (13) and union (4). Torque union to 55-80 in-lb. Install seals (2) and tube (1A). Torque tube coupling nuts to 160 ±10 in-lb. Safetywire union and coupling nuts.

t. Lubricate bolt as outlined in step eB; then install thermal insulation bracket (1). Torque bolt to 68 ±7 in-lb. Safetywire bolt.

tA. Install thermal insulation frame 145325. (Refer to R-3896-6.)

u. Refer to section IV for post-maintenance test requirements.

3-139. NO. 2 OXIDIZER HIGH-PRESSURE DUCT.

3-140. Equipment required for removing and installing the duct consists of adapter 9025434, fixture 9024921-11, and strut 9025193 from Component Handling Fixture Set G4068.

3-141. REMOVING NO. 2 OXIDIZER HIGH-PRESSURE DUCT. (See figure 3-40.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove thermal insulation support 145324-11. (Refer to R-3896-6.)

bA. Mark position of thermal insulation bracket (18A) to frame. Remove bracket and serrated washers. Washers are installed between bracket (18A) and bracket (19).

c. Remove tube (1) and seals (2). Disconnect bracket (3) from flange boltheads.

d. On engines not incorporating MD150 or MD151 change, remove support (4).

e. If duct is to be replaced, remove bolt (5), seal (6), and fitting (7).

f. Disconnect duct (8) and remove seal (9), orifice plate (10), and scoop (11).

g. Disconnect tube (12) and remove seal (13).

h. Remove brackets (14, 15, 16).

i. Disconnect line (17) and harness (18) from bracket (19); then remove bracket (19).

j. Install adapter 9025434 on duct, and install fixture 9024921-11 on adapter. (See figure 3-41.) Make sure that hoist hook is used at proper lift points of lift fixture. Strut 9025193 must be installed to support turbopump if joints of No. 1 oxidizer high-pressure duct and valve are not intact.

k. Note location of spacers by drivescrew or notch position.

l. Disconnect duct at volute, and remove pressure-actuated seal (20, figure 3-40), spacer (21), and pressure-actuated seal (22).

m. Disconnect duct at valve, and remove pressure-actuated seal (23), spacer (24), and pressure-actuated seal (25).

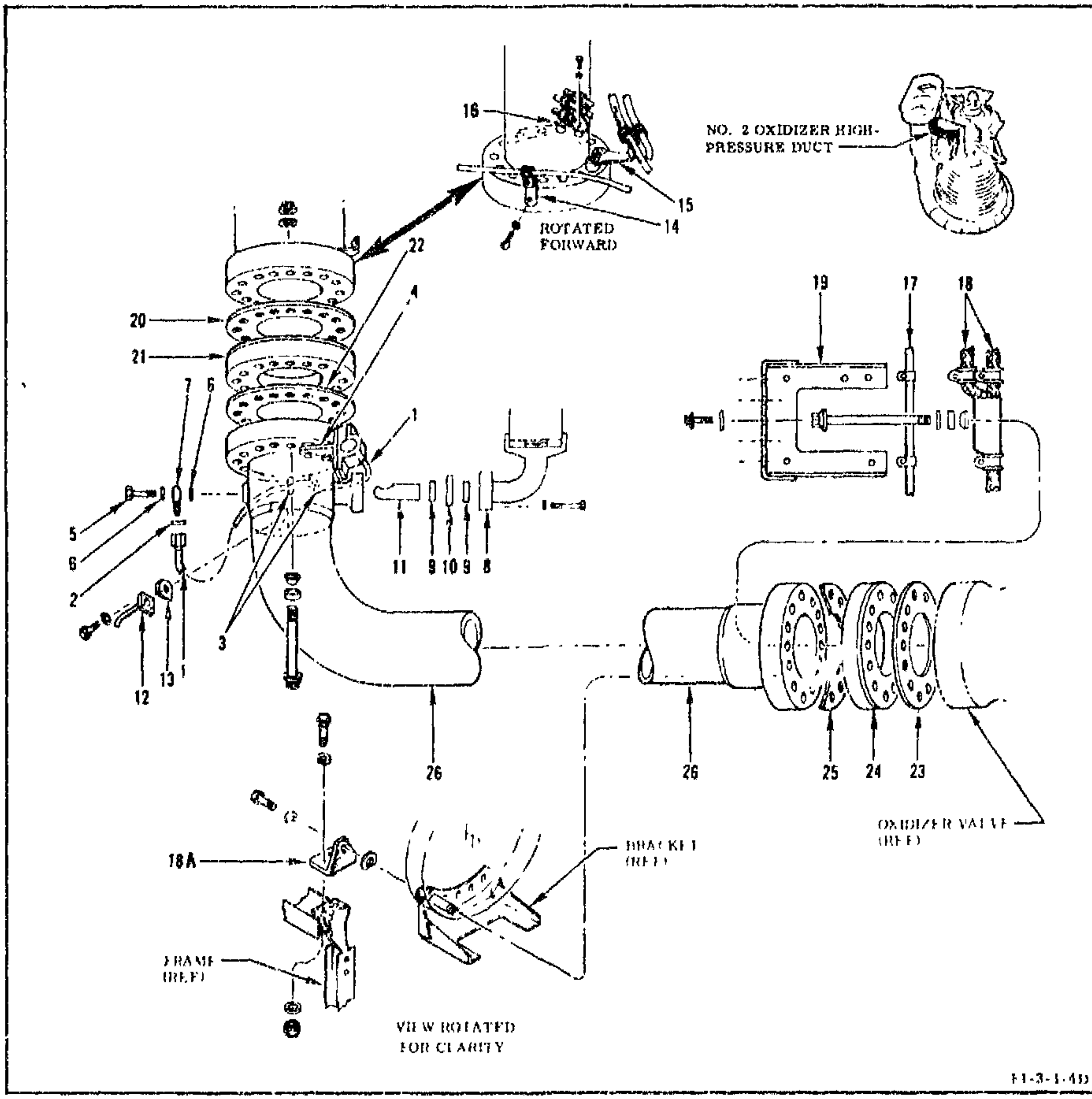
n. Carefully remove duct (26).

3-142. *INSTALLING NO 2 OXIDIZER HIGH-PRESSURE DUCT.* (See figure 3-40.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne), unless otherwise specified. Specified lubricating procedures (methods) are outlined in section I. Where multiple fasteners are used at joints, the applicable torque and safetywiring methods outlined in section I must be used.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. On engines not incorporating MD137 change, perform fit check and installation of duct (26), pressure-actuated seals (20, 22, 23, 25), and spacers (21, 24) as outlined in paragraph 3-107. On engines incorporating MD137 change, perform fit check and installation of duct, pressure-actuated seals, and spacers as outlined in paragraph 3-111. Following completion of the applicable procedure, complete installation of remaining parts indexed (1 through 19) as outlined in the following steps.

c. Install bracket (19). Torque bolts to 75 ±5 in-lb. Safetywire bolts.



1	Tube	9	Seal	17	Line	23	Pressure-actuated seal
2	Seal	10	Orifice plate	18	Harness	24	Spacer
3	Bracket	11	Scoop	18A	Bracket	25	Pressure-actuated seal
4	Support[a]	12	Tube	19	Bracket	26	Duct
5	Bolt	13	Seal	20	Pressure-actuated seal		
6	Seal	14	Bracket	21	Spacer		
7	Fitting	15	Bracket	22	Pressure-actuated seal		
8	Duct	16	Bracket				

(a) Engines not incorporating MD150 or MD151 change

Figure 3-40. No. 2 Oxidizer High-Pressure Duct

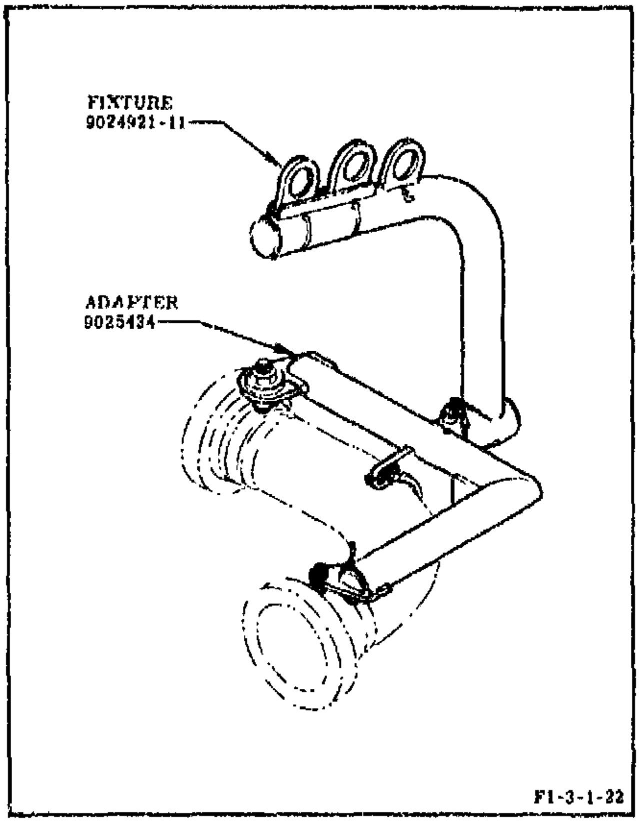


Figure 3-41. Handling No. 2 Oxidizer High-Pressure Duct

cA. Install thermal insulation bracket (18A) to frame. Aline bracket to position marked during removal, and torque nuts to 68 ±7 in-lb.

cB. Install serrated washer between bracket (18A) and bracket (19).

cC. Lubricate (Method A) bolt with thread compound C-5A (Felt Products) and secure bracket (18A) to flange bolthead. Torque bolt to 68 ±7 in-lb. Safetywire bolt.

d. Attach harness (18) and line (17) to bracket (19). Torque nuts to 8-10 in-lb.

e. Install bracket (16). Torque bolts to 1[illegible] ±5 in-lb. Safetywire bolts.

f. If not installed during duct fit check and installation, install bracket (15) with flange bolts. Torque bolts to 92 ±5 ft-lb. Safetywire bolts.

g. Install bracket (14). Torque bolts to 80 ±5 in-lb. Safetywire bolts.

h. Install seal (13) and tube (12). Cross-torque bolts to 70 ±5 in-lb. Safetywire bolts.

i. Install scoop (11), orifice plate (10), and seals (9). Connect duct (8) and cross-torque bolts to 350 ±10 in-lb. Safetywire bolts, and install an aluminum seal on lockwire.

j. If parts indexed (5 through 7) were removed, lubricate (Method A) bolt (5) and fitting (7). Install seals (6), fitting, and bolt. Position fitting to aline for tube (1). Torque bolt to 55-80 in-lb. Safetywire bolt.

k. On engines not incorporating MD150 or MD151 change, install support (4). Torque bolts to 22 ±5 in-lb. Safetywire bolts.

l. Lubricate (Method A) union in transducer for attaching tube (1). Lubricate (Method G) tube (1). Install seals (2) and tube. Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

m. Install thermal insulation support 145324-11. (Refer to R-3896-6.)

n. Refer to section IV for post-maintenance test requirements.

3-143. FUEL VALVE FIT CHECK.

3-144. This procedure applies to the No. 1 or No. 2 fuel valve and is performed only when designated in other procedures in this section. The following equipment is required.

(1) Dummy seal set T-5041258.

(2) Dummy seal set T-5043413.

(3) Adapter 9025463 and fixture 9024923-11 from Component Handling Fixture Set G4068.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. If not already installed, attach adapter 9025463 to valve and fixture 9024923-11 to adapter. Position valve for installation.

CAUTION

The fuel valve weighs approximately 90 pounds.

c. Aline valve to fuel manifold using suitable centering pins or alining sleeves on bolts. Install shim, detail 102, from dummy seal set T-5043413 between manifold and valve. Secure valve to manifold using 6 approximately equally spaced bolts. Torque bolts to 400 ±5 in-lb.

d. Refer to Engine Log Book, and obtain spacer recorded for use at applicable joint. Spacers used on engines not incorporating MD137 change contain a drivescrew in outer surface of spacer. Spacers used on engines incorporating MD137 change contain a notch in spacer flange.

e. Select the following applicable shim from dummy seal set T-5041258:

(1) Engines not incorporating MD137 change: shim, detail 102

(2) Engines incorporating MD137 change: No. 1 fuel valve shim, detail 105; No. 2 fuel valve shim, detail 102

f. Install spacer against duct flange in same position as recorded in Engine Log Book, and install shim between spacer and valve. Secure joint with 6 approximately equally spaced bolts. Do not tighten bolts.

g. Make sure that shim and spacer are compressed against duct flange; then measure and record location and dimensions of maximum and minimum axial gap between shim and valve. Determine maximum differential gap by subtracting minimum axial gap from maximum axial gap. Maximum axial and differential gap limitations are as follows:

(1) No. 1 fuel valve (engines not incorporating MD137 change) maximum axial gap, 0.110 inch; maximum differential gap, 0.020 inch

(2) No. 1 fuel valve (engines incorporating MD137 change) maximum axial gap, 0.180 inch; maximum differential gap, 0.020 inch

(3) No. 2 fu.. valve maximum axial gap, 0.060 inch; maxi..m differential gap, 0.020 inch

NOTE

Fasteners at valve to fuel manifold may be loosened and centering pins and/or alining sleeves removed, if required, to meet gap requirements. Fasteners must be retorqued to 400 ±5 in-lb before making gap measurements.

h. Record final spacer information, as specified, in Engine Log Book.

i. Mark across valve flanges, duct flange, and spacer in 2 places, 90 degrees apart. Use markings that can be removed.

j. Using applicable handling equipment, remove valve, spacer, and shims. Complete valve installation as outlined in applicable fuel valve procedure.

3-145. OXIDIZER VALVE FIT CHECK.

3-146. This procedure applies to the No. 1 or No. 2 oxidizer valve and is performed only when designated in other procedures in this section. The following equipment is required:

(1) Dummy seal set T-5041258

(2) Dummy seal set T-5043413

(3) Adapter 9020250 and fixture 9024921-11 from Component Handling Fixture Set G4008

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. If not already installed, attach adapter 9020250 to valve and fixture 9024921-11 to adapter. Position valve for installation.

CAUTION

The oxidizer valve weighs approximately 168 pounds.

c. Aline valve to oxidizer dome using centering pins or alining sleeves with bolts. Install shim, detail 101, from dummy seal set T-5043413 between valve and oxidizer dome flange. Secure with 6 approximately equally spaced bolts. Torque bolts to 400 ±5 in-lb.

d. Refer to Engine Log Book and select spacer for use at applicable joint. Spacers used on engines not incorporating MD137 change incorporate a drivescrew in the outer surface of the spacer. Spacers used on engines incorporating MD137 change incorporate a notch in the spacer flange.

e. Install spacer against duct flange in same position as recorded in Engine Log Book. Install shim, detail 101, from dummy seal set T-5041258 between spacer and valve. Secure joint with 6 approximately equally spaced bolts. Do not tighten bolts.

f. Make sure that shim and spacer are compressed against duct flange; then measure and record location and dimension of maximum and minimum axial gap between shim and valve. Determine maximum differential gap by subtracting minimum axial gap from maximum axial gap. Maximum axial gap must not exceed 0.040 inch. Maximum differential gap must not exceed 0.020 inch. Fasteners at valve to oxidizer dome joint may be loosened and centering pins and/or alining sleeves removed, if required, to meet gap requirements. Torque fasteners to 400 ±5 in-lb before making gap measurements.

g. Record final spacer information, as specified, in Engine Log Book.

h. Mark across valve flanges, duct flange, and spacer in 2 places, 90 degrees apart. Use marking that can be removed.

i. Using applicable handling equipment, remove valve, spacer, and shims. Complete valve installation as outlined in applicable oxidizer valve procedure.

3-147. <u>NO. 1 FUEL VALVE.</u>

3-148. Equipment required consists of adapter 9025463 and fixture 9024923-11 from Component Handling Fixture Set G4068.

3-149. REMOVING NO. 1 FUEL VALVE. (See figure 3-42.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. (Deleted)

c. If fuel valve will be reinstalled, mark across valve-to-manifold flanges and valve-to-duct flanges and spacer in 2 places each, 90 degrees apart. Use markings that can be removed. Do not scribe parts.

d. Disconnect plug (1) as outlined in paragraph 3-14.

e. Disconnect bracket (2) from valve. Reinstall bolt. Torque bolt to 80-100 in-lb.

f. Disconnect tube (3) and bracket (4), and remove tube.

g. Disconnect tubes (5, 7), and remove orifice plate (6) and seal (8). Retain orifice plate.

h. Disconnect bracket (9).

i. On engines not incorporating MD150 or MD151 change, disconnect tube (10), remove seal (11), and remove support (12).

j. Disassemble and remove parts indexed (13 through 18), as necessary, for access to remove flange bolts under bracket (13).

k. If valve will be replaced, remove parts indexed (19 through 25).

kA. Disconnect thermal insulation angle (25A) from bracket (25B) and remove bracket. Retain attaching parts.

kB. Disconnect thermal insulation stiffener (25C). (The stiffener is part of thermal insulation frame 14?477 and may be removed with the NO. 1 side portion of the frame.) (Refer to R-3896-6.)

l. Install adapter 9025463 on valve, and attach fixture 9024923-11 to adapter. (See figure 3-43.) Use proper lift points of fixture. If handling bolts for adapter attachment are required, use bolts RD111-9001-0018 and torque them to 80-100 in-lb.

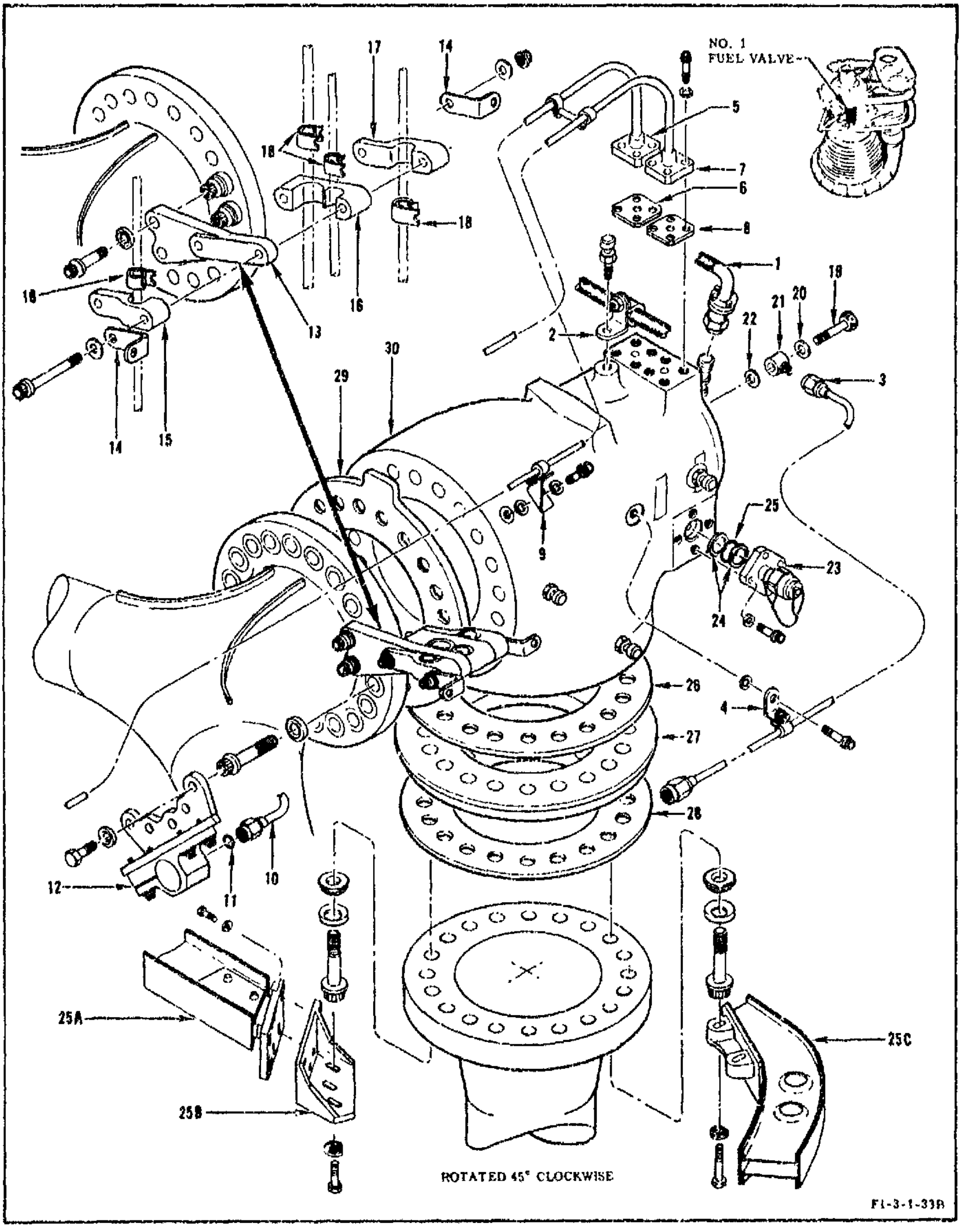


Figure 3-42. No. 1 Fuel Valve (Sheet 1 of 2)

1	Plug	10	Tube[a]	19	Bolt	25B	Bracket
2	Bracket	11	Seal[a]	20	Seal	25C	Stiffener
3	Tube	12	Support[a]	21	Elbow	26	Seal plate
4	Bracket	13	Bracket	22	Seal	27	Spacer
5	Tube	14	Bracket	23	Quick-disconnect	28	Seal plate
6	Orifice plate	15	Block			29	Orifice plate
7	Tube	16	Block	24	Retainer		
8	Seal	17	Block	25	Packing	30	Valve
9	Bracket	18	Clamp	25A	Angle		

(a) Engines not incorporating MD150 or MD151 change

Figure 3-42. No. 1 Fuel Valve (Sheet 2 of 2)

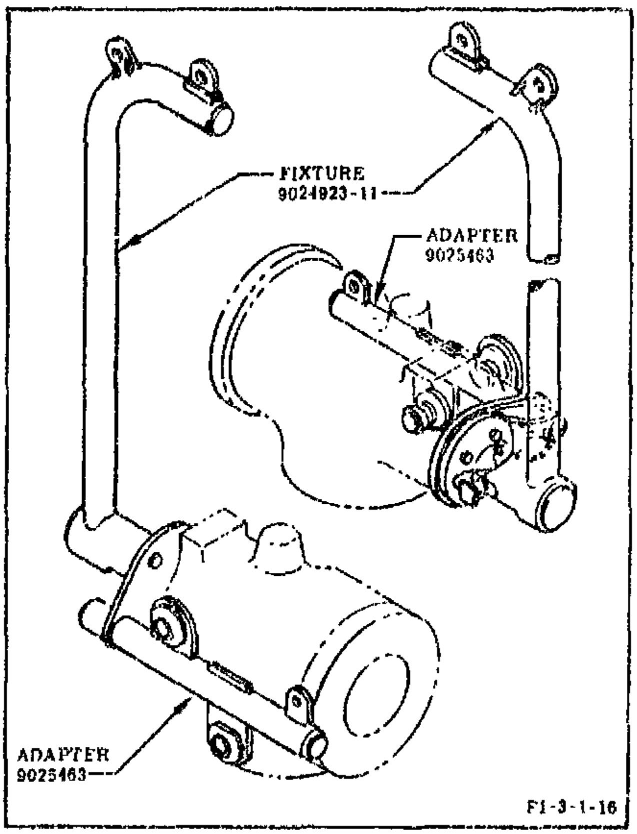


Figure 3-43. Handling Fuel Valves

m. Disconnect valve from duct flange, and remove seal plate (26, figure 3-42), spacer (27), and seal plate (28).

n. Disconnect valve from manifold, and remove orifice plate (29).

o. Carefully remove valve (30).

CAUTION

The fuel valve weighs approximately 90 pounds.

3-150. INSTALLING NO. 1 FUEL VALVE. (See figure 3-42.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne), unless otherwise specified. Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install adapter 9025463 on valve, and attach fixture 9024923-11 to adapter. Use proper lift points of fixture, and position valve for installation.

CAUTION

The fuel valve weighs approximately 90 pounds.

c. If valve is a replacement, fit-check valve as outlined in paragraph 3-143. If same valve is being installed, proceed to step d.

d. Install orifice plate (29) with tab positioned forward.

e. Aline markings on valve flange with markings on fuel manifold flange, and secure joint. Cross-torque bolts to 1,150-1,250 in-lb. Safety-wire bolts, and install an aluminum seal on lockwire. Remove handling equipment.

f. Install seal plate (28), spacer (27), and seal plate (26) between valve and duct. Position seal plates with tabs outward.

g. Aline markings on valve, spacer, and duct flange. Secure joint, and cross-torque bolts to 1,150-1,250 in-lb. Safetywire bolts.

gA. If stiffener (25C) was removed as a part of thermal insulation frame 145477, reinstall frame portion using information in R-3896-6. If stiffener was disconnected only, attach stiffener to flange boltheads using bolts NAS1005-13H and washers RD153-9004-0002. Lubricate (Method A) bolts with thread compound C-5A (Felt Products). Torque bolts to 68 ±7 in-lb. Safetywire bolts.

gB. Assemble angle (25A) and bracket (25B) using bolts NAS1004-4H or bolts RD111-1009-0411 and washers RD153-0013-0002. If bolts NAS1004-4H are used, lubricate them as outlined in step gA. Torque bolts to 68 ±7 in-lb. Safetywire bolts.

gC. Attach bracket (25B) to flange boltheads using bolts NAS1005-4H and washers RD153-9004-0002. Lubricate bolts as outlined in step gA. Torque bolts to 68 ±7 in-lb. Safetywire bolts.

h. If valve was replaced, lubricate (Method J) packing (25) and install packing, retainers (24), and quick-disconnect (23). Cross-torque bolts to 35 ±2 in-lb. Safetywire bolts.

i. If valve was replaced, lubricate (Method A) bolt (19) and elbow (21). Install seals (20, 22), elbow (21), and bolt (19). Position elbow to aline with tube (3). Torque bolt to 220 ±20 in-lb. Safetywire bolt.

j. Install bracket (13). Torque bolts to 125 ±5 in-lb. Safetywire bolts.

k. Install parts indexed (14 through 18). Torque nuts to 75 ±5 in-lb.

l. On engines not incorporating MD150 or MD151 change, install support (12). Torque bolts to 22 ±2 in-lb. Safetywire bolts.

m. On engines not incorporating MD150 or MD151 change, lubricate (Method A) union for attaching tube (10). Lubricate (Method G) tube (10). Install seal (11) and tube. Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

n. Aline propellant valves close tube (7) to valve (30) as outlined in paragraph 3-103; then install seal (8) and connect tube to valve. Cross-torque bolts to 36 ±3 in-lb. Safetywire bolts.

o. Aline No. 1 fuel valve open control tube (5) to valve (30) as outlined in paragraph 3-103; install orifice plate (6), and connect tube to valve. Cross-torque bolts to 36 ±3 in-lb. Safetywire bolts, and install an aluminum seal on lockwire.

p. Lubricate (Method A) threads of fittings for installing tube (3). Lubricate (Method G) tube (3). Install tube, and torque coupling nuts to 135-185 in-lb.

q. Attach the following brackets, torque fasteners as indicated, and safetywire fasteners for brackets (4, 9). Make sure that bracket (9) (602069) is welded on both sides of joint. Some brackets are welded on one side only and are not usable.

(1) Bracket (2): 80-100 in-lb.

(2) Bracket (4): 45 ±3 in-lb.

(3) Bracket (9): 40 ±5 in-lb.

r. Install plug (1) as outlined in paragraph 3-15.

s. (Deleted)

t. Refer to section IV for post-maintenance test requirements.

3-151. NO. 2 FUEL VALVE.

3-152. Equipment required consists of adapter 9025463 and fixture 9024923-11 from Component Handling Fixture Set G4068.

3-153. REMOVING NO. 2 FUEL VALVE. (See figure 3-44.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. (Deleted)

c. If fuel valve will be reinstalled, mark across valve-to-manifold flanges and valve-to-duct flanges and spacer at 2 places each, 90 degrees apart. Use markings that can be removed. Do not scribe parts.

d. Disconnect plug (1) as outlined in paragraph 3-14.

e. Disconnect bracket (2), and reinstall bolt. Torque bolt to 80-100 in-lb.

f. Disconnect bracket (3), and remove tube (4).

g. On engines incorporating MD162 or MD163 change, remove parts indexed (5 through 13). Parts to retainers (5, 12) are matched. If a detail part requires replacement, the complete retainer must be replaced.

h. On engines not incorporating MD150 or MD151 change, disconnect tube (14), and remove seal (15) and support (16).

i. Disconnect tubes (17, 19), and remove seal (18) and orifice plate (20). Retain orifice plate.

j. If valve will be replaced, remove parts indexed (21 through 26).

jA. Disconnect thermal insulation angle (26A) from bracket (26B) and remove bracket. Retain attaching parts.

k. Install adapter 9025463 on valve, and attach fixture 9024923-11 to adapter. (See figure 3-43.) Use proper lift points of fixture. If handling bolts for adapter attachment are required, use bolts RD111-9001-0018 and torque bolts to 80-100 in-lb.

l. Disconnect valve from duct flange, and remove seal plate (27, figure 3-44), spacer (28), and seal plate (29).

m. Disconnect valve at manifold, remove orifice plate (30), and carefully remove valve (31).

CAUTION

The fuel valve weighs approximately 90 pounds.

3-154. INSTALLING NO. 2 FUEL VALVE. (See figure 3-44.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne), unless otherwise specified. Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install adapter 9025463 on valve, and attach fixture 9024923-11 to adapter. Use proper lift points of fixture, and position valve for installation.

CAUTION

The fuel valve weighs approximately 90 pounds.

c. If valve is a replacement, fit-check valve as outlined in paragraph 3-143. If same valve is installed, proceed with step d.

d. Install orifice plate (30, figure 3-44) with tab positioned forward.

e. Aline markings on valve flange and manifold flange, and secure joint. Cross-torque bolts to 1,150-1,250 in-lb. Safetywire bolts, and install an aluminum seal on lockwire. Remove handling equipment.

f. Install seal plate (29), spacer (28), and seal plate (27) between valve and duct. Position seal plate with tabs outward.

g. Aline markings on valve, spacer, and duct flange. Secure joint, and cross-torque bolts to 1,150-1,250 in-lb. Safetywire bolts.

gA. Assemble angle (26A) and bracket (26B) using 4 bolts NAS1004-4H or bolts RD111-1009-0411 and washers LD153-0012-0002. If bolts NAS1004-4H are used, lubricate them (Method A) with thread compound C-5A (Felt Products). Torque bolts to 68 ±7 in-lb. Safetywire bolts.

gB. Attach bracket (26B) to flange boltheads using bolts NAS1005-4H and washers RD153-9004-0002. Lubricate bolts as outlined in step gA. Torque bolts to 68 ±7 in-lb. Safetywire bolts.

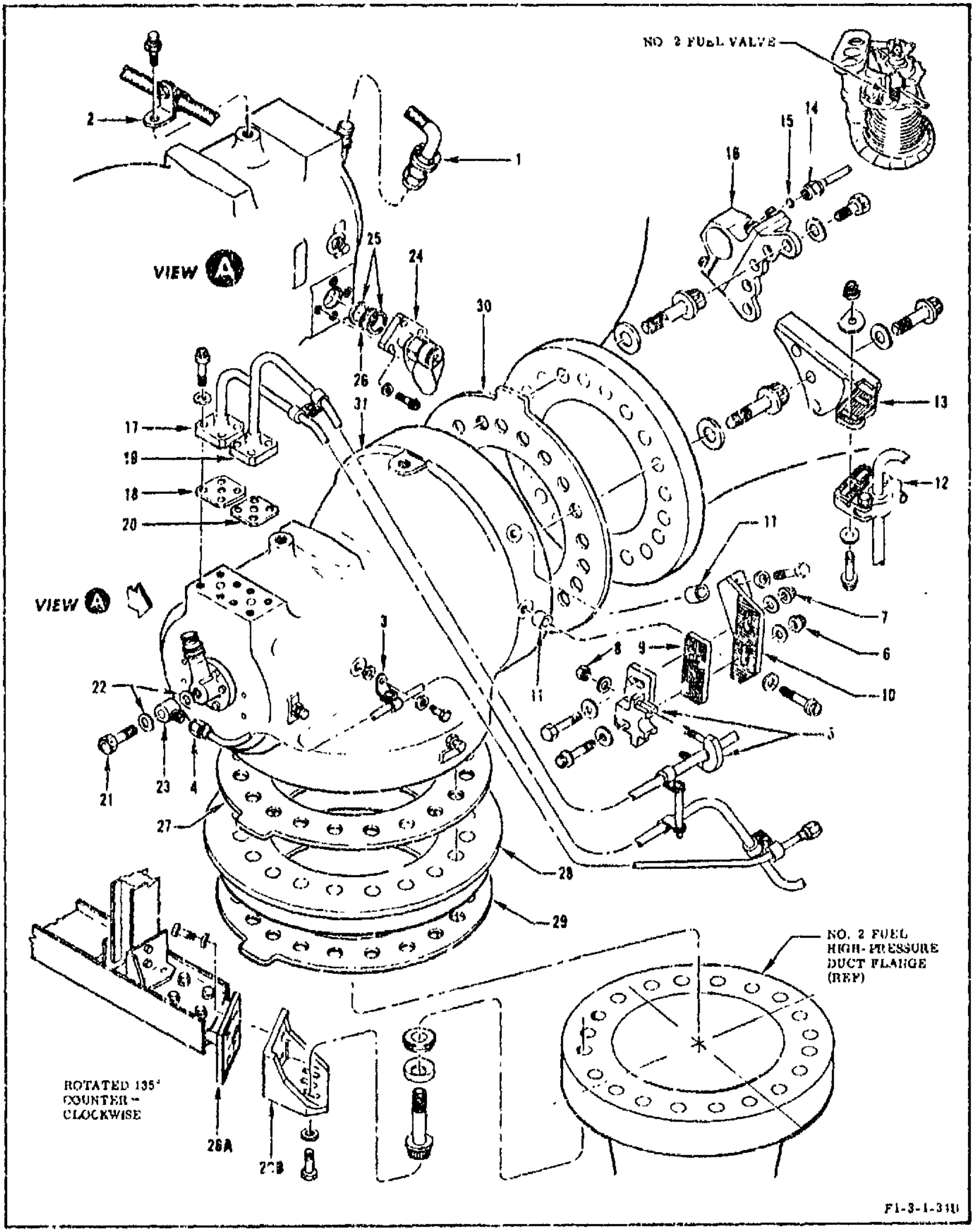


Figure 3-44. No. 2 Fuel Valve (Sheet 1 of 2)

1	Plug	10	Bracket[a]	19	Tube	26	Packing
2	Bracket	11	Spacer[a]	20	Orifice plate	26A	Angle
3	Bracket	12	Retainer[a][b]			26B	Bracket
4	Tube	13	Bracket[a]	21	Bolt	27	Seal plate
5	Retainer[a][b]	14	Tube[c]	22	Seal	28	Spacer
6	Nut[a]	15	Seal[c]	23	Elbow	29	Seal plate
7	Nut[a]	16	Support[c]	24	Quick-disconnect	30	Orifice plate
8	Nut[a]	17	Tube			31	Valve
9	Plate[a]	18	Seal	25	Retainer		

(a) Engines incorporating MD162 or MD163 change.
(b) Matched set.
(c) Engines not incorporating MD150 or MD151 change.

Figure 3-44. No. 2 Fuel Valve (Sheet 2 of 2)

h. If valve was replaced, lubricate (Method J) packing (26). Install packing, retainers (25), and quick-disconnect (24). Cross-torque bolts to 35 ±2 in-lb. Safetywire bolts.

i. If valve was replaced, lubricate (Method A) bolt (21). Install elbow (23), seals (22), and bolt (21). Position elbow to aline with tube (4). Torque bolt to 220 ±20 in-lb. Safetywire bolt.

j. Aline No. 2 fuel valve open control tube (19) to valve (31) as outlined in paragraph 3-103; then install orifice plate (20) and connect tube to valve. Cross-torque bolts to 36 ±3 in-lb. Safetywire bolts, and install an aluminum seal on lockwire.

k. Aline propellant valves close tube (17) to valve (31) as outlined in paragraph 3-103; then install seal (18), and connect tube to valve. Cross-torque bolts to 36 ±3 in-lb. Safetywire bolts.

l. On engines not incorporating MD150 or MD151 change, install support (16) and torque bolts to 22 ±2 in-lb. Safetywire bolts.

m. On engines not incorporating MD150 or MD151 change, lubricate (Method A) union in transducer of support (16). Lubricate (Method G) tube (14). Install seal (15) and tube. Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

NOTE

Steps n through r apply to engines incorporating MD162 or MD163 change. Parts must be installed so that no stress is exerted on tubes during or after installation.

n. Install bracket (13). Torque bolts to 170 ±10 in-lb.

o. Install retainer (12) around tube, and attach retainer to bracket (13). Torque nut on retainer to 30 ±5 in-lb. Torque bolt in retainer to 140 ±10 in-lb. Torque bolts that attach retainer to bracket (13) to 140 ±10 in-lb.

NOTE

Retainer (12) consists of matched parts. If one part is damaged, the complete retainer must be replaced.

p. Install spacers (11) and bracket (10). Alternately tighten and loosen attaching bolts, and check for gap in excess of 0.019 inch between either spacer and bracket. If gap at either point exceeds 0.019 inch, install washer RD153-1004-0014 between one spacer and bracket to reduce gap to less than 0.019 inch. A maximum of 2 washers may be used. If required, washer laminations may be removed.

q. Torque forward bolt for bracket (10) to 80 ±5 in-lb. Torque lower bolt to 250 ±15 in-lb. Safetywire bolts.

r. Assemble plate (9) and retainer (5) to bracket (10). Retainer (5) consists of matched parts. If one part is damaged, the complete retainer must be replaced. Make sure that no stress is exerted on tube (19) during or after torquing. Torque fasteners as follows:

(1) Nut (6): 100 ±10 in-lb.

(2) Nut (7): 50 ±10 in-lb.

(3) Nuts (8): 25 ±5 in-lb above running torque, except maximum torque must not exceed 60 in-lb.

s. Lubricate (Method A) bolt (21) and elbow (23). Lubricate (Method G) tube (4). Install tube, and torque coupling nuts to 135-185 in-lb.

t. Attach bracket (3) to valve. Torque bolts to 45 ±3 in-lb. Safetywire bolt.

u. Attach bracket (2) to valve. Torque bolt to 80-100 in-lb.

v. Connect plug (1) as outlined in paragraph 3-15.

w. (Deleted)

x. Refer to section IV for post-maintenance test requirements.

3-155. NO. 1 OXIDIZER VALVE.

3-156. Equipment required consists of adapter 9020250, fixture 9024921-11, and strut 9025193 from Component Handling Fixture Set G4063, and dummy seal set T-5043413.

3-157. REMOVING NO. 1 OXIDIZER VALVE. (See figure 3-45.) Specified lubricating procedures (methods) are outlined in section I.

WARNING

Component Handling Fixture Set G4068 must be operated by authorized personnel trained in the use of the equipment.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. (Deleted)

c. If oxidizer valve will be reinstalled, mark across valve and oxidizer dome flanges and valve-to-duct flanges and spacer at 2 places each, 90 degrees apart. Use markings that can be removed. Do not scribe parts.

d. Disconnect plug (1) as outlined in paragraph 3-14.

e. Remove tubes (2, 5, 6).

eA. If valve will be replaced, remove 3 unions (3) and 3 seals (4). Lubricate (Method A) closure threads and (Method J) packing with lubricant grease RB0140-012 (Rocketdyne). Torque closures to 20-30 in-lb.

f. Disconnect line (7), and remove seal (8).

g. Disconnect tube (9), and remove seal (10). Blocks 601883 and 601884 may be removed to gain additional clearance for hydraulic control lines.

h. Disconnect tube (11), and remove orifice plate (12). Retain orifice plate.

i. Disconnect tube (13), and remove seal (14).

j. Disconnect bracket (15).

k. Disconnect tube (16), and remove orifice plate (17). Retain orifice plate.

kA. Disconnect thermal insulation bracket (17A) from frame. Retain attaching parts.

kB. Remove bracket (17A) and plate (17B). Retain attaching parts.

l. Disconnect tube (16) and harness (18) from bracket (19); then remove bracket (19).

m. Measure and record extension of lines at support (22) from line flanges to support.

n. Remove cover (20), clamps (21), and support (22).

nA. Disconnect bracket (22A) from oxidizer dome-to-valve boltheads. Clear hinged bracket from flange area. Retain attaching parts.

o. Install adapter 9020250 on valve, and attach fixture 9024921-11 to adapter. (See figure 3-46.) Use proper lift points of fixture. If No. 2 oxidizer valve or duct joint is not intact, install strut 9025193 between turbopump and oxidizer dome.

NOTE

External surfaces and the area around the bolts should be vacuumed before disconnecting valve flanges.

p. Loosen valve at oxidizer dome flange, disconnect valve at duct flange, and remove pressure-actuated seal (23, figure 3-45), spacer (24), and pressure-actuated seal (25).

q. Disconnect valve at oxidizer dome flange, and remove pressure-actuated seal (26). Carefully remove valve (28).

CAUTION

The oxidizer valve weighs approximately 168 pounds.

r. Lubricate (Method A) oxidizer dome flange closure bolt threads with lubricant grease RB0140-012 (Rocketdyne).

3-158. INSTALLING NO. 1 OXIDIZER VALVE. (See figure 3-45.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne), unless otherwise specified. Specified lubricating procedures (methods) are outlined in section I.

WARNING

Component Handling Fixture Set G4068 must be operated by authorized personnel trained in the use of the equipment.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install adapter 9020250 on valve. (See figure 3-46.) Attach fixture 9024921-11 to adapter. Use proper lift points of fixture, and position valve for installation.

CAUTION

The oxidizer valve weighs approximately 168 pounds.

c. If valve is a replacement, fit-check valve as outlined in paragraph 3-145.

NOTE

Steps d through i apply to installing the valve that was removed. Steps j through o apply to installing a replacement valve. Steps p through ab install parts indexed (1 through 22A, figure 3-45).

d. Install pressure-actuated seal (26), and connect joint. Do not tighten fasteners.

e. Install pressure-actuated seals (23, 25) and spacer (24), and connect joint. Do not tighten fasteners.

f. Aline markings on valve and spacer with markings on duct, and secure joint to maintain alinement. Remove handling equipment.

g. Aline markings on valve with markings on oxidizer dome. Secure joint to maintain alinement.

h. Cross-torque fasteners at dome to 1,150-1,250 in-lb. Safetywire fasteners, and install aluminum seal on lockwire.

NOTE

If spacer (24) has a minimum thickness at any point of 0.903 inch or less, an additional countersink washer is required under the bolthead of each duct flange bolt.

i. Cross-torque fasteners at duct to 1,150-1,250 in-lb, and safetywire fasteners. Remove strut 9025193.

NOTE

Steps j through o apply to installing a replacement valve.

j. Install shim detail 101 from dummy seal set T-5043413 between valve and oxidizer dome. Install 6 approximately equally-spaced bolts and tighten bolts.

k. Install pressure-actuated seals (23, 25) and spacer (24) between valve and duct. Make sure spacer is installed as indicated in Engine Log Book, and cross-torque 6 approximately equally-spaced bolts to 400 ±5 in-lb.

l. Loosen fasteners at dome flange. With shim against dome flange, measure and record maximum and minimum axial gap between shim and valve, and determine maximum differential gap by subtracting minimum axial gap from maximum axial gap. Gap limitations are as follows:

(1) Engines not incorporating MD137 change: maximum axial gap, 0.090 inch; maximum differential gap, 0.020 inch

(2) Engines incorporating MD137 change: maximum axial gap, 0.065 inch; maximum differential gap, 0.015 inch

m. Record final dimensions, as specified, in Engine Log Book.

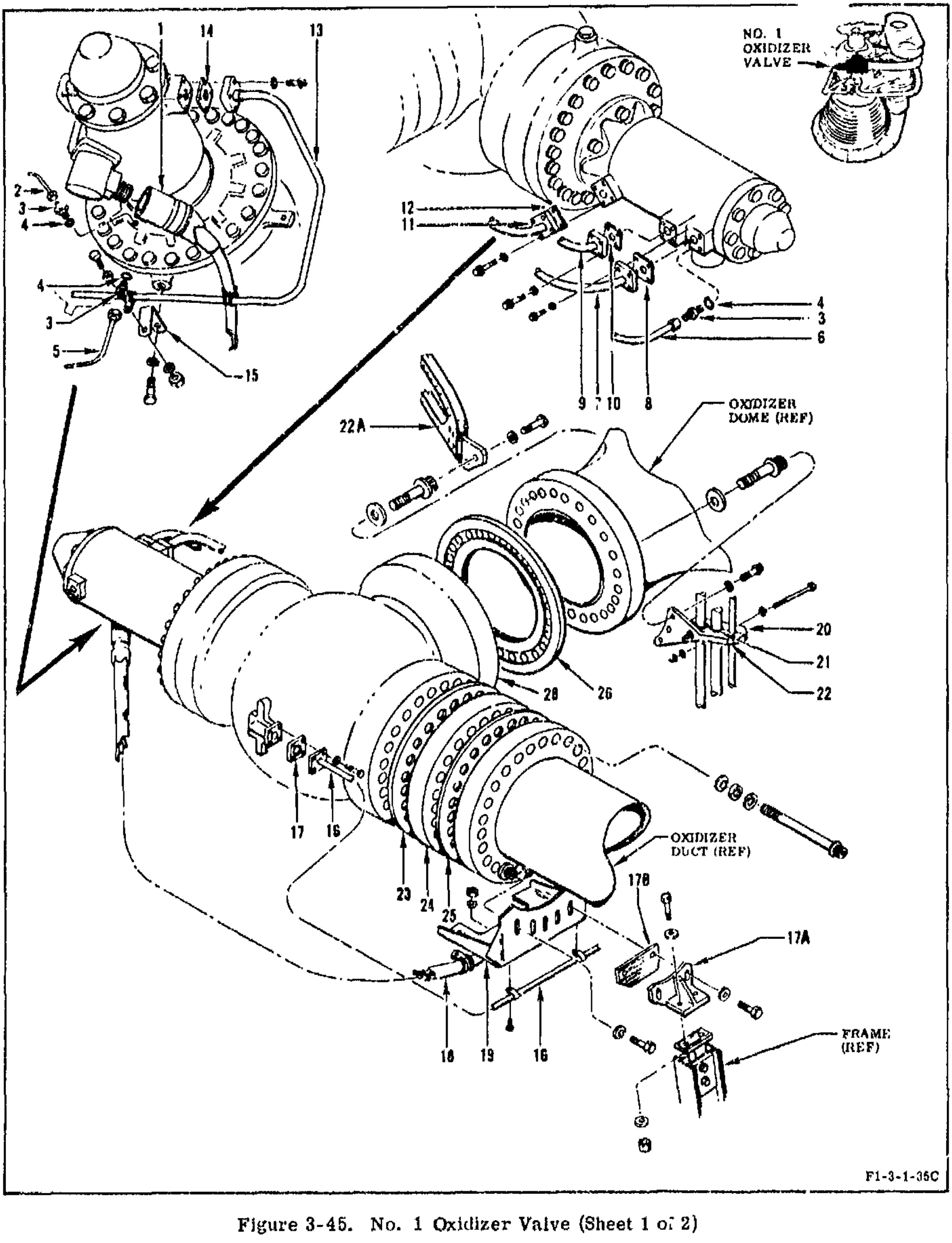


Figure 3-45. No. 1 Oxidizer Valve (Sheet 1 of 2)

1	Plug	10	Seal	17B	Plate	24	Spacer
2	Tube	11	Tube	18	Harness	25	Pressure-actuated seal
3	Union	12	Orifice plate	19	Bracket		
4	Seal	13	Tube	20	Cover	26	Pressure-actuated seal
5	Tube	14	Seal	21	Clamp		
6	Tube	15	Bracket	22	Support	27	(Deleted)
7	Line	16	Tube	22A	Bracket		
8	Seal	17	Orifice plate	23	Pressure-actuated seal	28	Valve
9	Tube	17A	Bracket				

Figure 3-45. No. 1 Oxidizer Valve (Sheet 2 of 2)

n. Remove shim, and install pressure-actuated seal (26). Cross-torque fasteners at each flange to 1,150-1,250 in-lb. Safetywire fasteners, and install an aluminum seal on lockwire at dome flange.

NOTE

If spacer (24) has a minimum thickness of 0.903 inch or less at any point, an additional countersink washer is required under the bolthead of each duct flange bolt.

o. Remove strut 9025193.

NOTE

Steps p through ab install parts indexed (1 through 22A).

p. Install support (22). Torque bolts to 100 ±5 in-lb. Safetywire bolts.

pA. Attach bracket (22A) to flange boltheads. Lubricate (Method A) bolts with thread compound C-5A (Felt Products). Torque bolts to 68 ±7 in-lb. Safetywire bolts.

q. Install clamps (21) and cover (20). Adjust lines to dimensions recorded during removal, and torque nuts to 75 ±5 in-lb.

r. Install bracket (19). Torque bolts to 75 ±5 in-lb. Safetywire bolts.

rA. Install thermal insulation bracket (17A) on frame. Torque nuts to 68 ±7 in-lb.

rB. Using thread compound C-5A (Felt Products), lubricate (Method A) bolts used to attach bracket (17A) and plate (17B) to flange boltheads.

rC. Install plate (17B) and torque bolts to 68 ±7 in-lb. Safetywire bolts.

s. Attach tube (16) and harness (18) to bracket (19). Torque nuts to 8-10 in-lb.

t. Aline No. 1 oxidizer valve dome purge tube (16) to valve (28) as outlined in paragraph 3-103. Then install orifice plate (17) with tab forward, and connect tube to valve. Cross-torque bolts to 36 ±3 in-lb. Safetywire bolts, and install an aluminum seal on lockwire.

u. Attach bracket (15) to valve. Torque bolt to 80 ±10 in-lb. Safetywire bolt.

v. Install seal (14) and connect tube (13) to valve (28). Cross-torque bolts to 36 ±3 in-lb. Safetywire bolts.

w. Aline propellant valves open tube (11) to valve (28) as outlined in paragraph 3-103; then install orifice plate (12) and connect tube to valve. Cross-torque bolts to 46 ±3 in-lb. Safetywire bolts, and install an aluminum seal on lockwire.

x. Aline sequence valve to sequence valve line (7) to valve (28) as outlined in paragraph 3-103; then install seal (8) and connect line to valve. Cross-torque bolts to 30 ±3 in-lb. Safetywire bolts.

y. Install seal (10), and connect tube (9). Cross-torque bolts to 85 ±5 in-lb. Safetywire bolts.

z. If seals (4) and unions (3) were removed, lubricate (Method I) unions. Install unions in preparation for installing tubes (2, 5, 6). Torque unions to 240 ±10 in-lb.

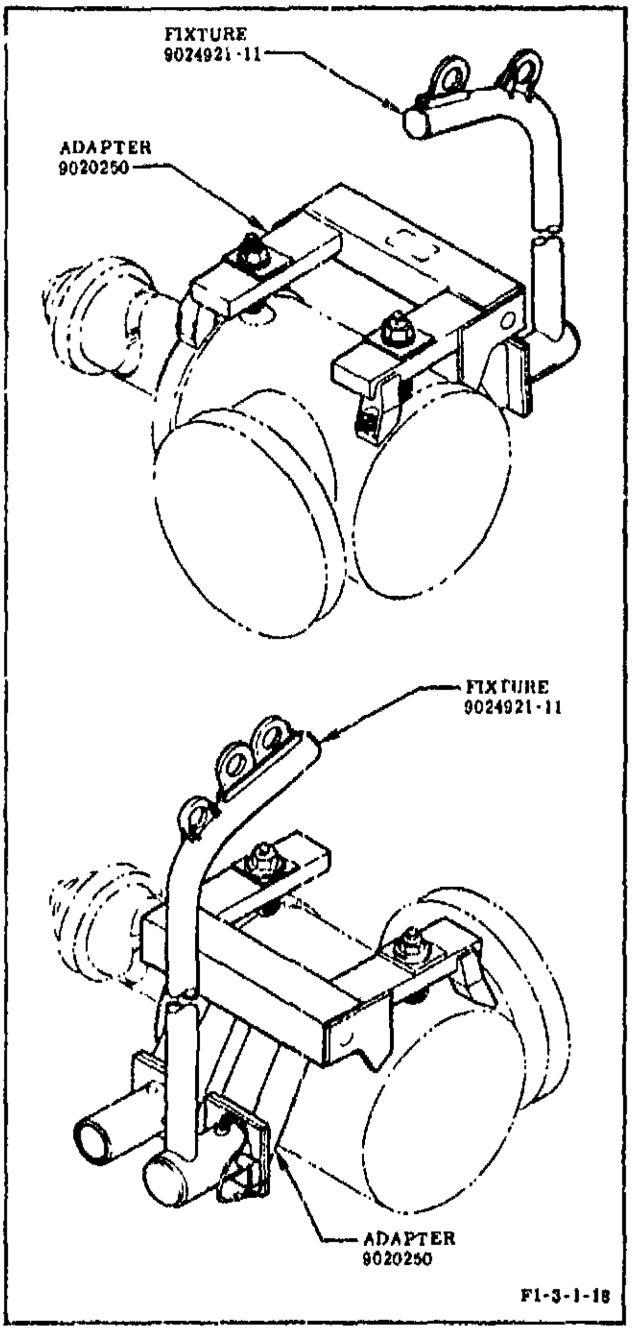


Figure 3-46. Handling Oxidizer Valves

aa. Lubricate (Method G) tubes (2, 5, 6). Install tubes, and torque coupling nuts to 135-185 in-lb.

ab. Install plug (1) as outlined in paragraph 3-15.

ac. (Deleted)

ad. Refer to section IV for post-maintenance test requirements.

3-159. NO. 2 OXIDIZER VALVE.

3-160. Equipment required consists of adapter 9020250, fixture 9024921-11, strut 9025193 from Component Handling Fixture Set G4068, and dummy seal set T-5043413.

3-161. REMOVING NO. 2 OXIDIZER VALVE. (See figure 3-47.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. (Deleted)

c. If oxidizer valve will be reinstalled, mark across valve and oxidizer dome flanges and valve-to-duct flanges and spacer at 2 places each, 90 degrees apart. Use markings that can be removed. Do not scribe parts.

d. On engines incorporating MD162 or MD163 change, remove parts indexed (1 through 12). Retainers (1, 5, 9) are matched sets. If one part of any retainer requires replacement, the complete retainer must be replaced.

e. Disconnect plug (13) as outlined in paragraph 3-14.

f. Remove tubes (14, 15, 16).

fA. If valve will be replaced, remove 3 unions (17) and 3 seals (18). Lubricate (Method A) closure threads and (Method J) packing with lubricant grease RB0140-012 (Rocketdyne). Torque closures to 20-30 in-lb.

g. Disconnect tube (19), and remove seal (20) and orifice plate (24). Retain orifice plate.

h. Disconnect tube (21), and remove seal (22).

i. (Deleted)

j. Disconnect line (25), and remove seal (26).

k. Disconnect tube (27) and harness from bracket (29).

l. Disconnect tube (27) from valve, and remove orifice plate (28). Retain orifice plate.

lA. Disconnect thermal insulation bracket (28A) from frame and remove bracket. Retain attaching parts.

lB. Remove bracket (29).

lC. Disconnect thermal insulation bracket (29A) from oxidizer valve. Secure tie rod and bracket clear of valve.

m. Install adapter 9020250 on valve, and attach fixture 9024921-11 to adapter. (See figure 3-46.) Use proper lift points of fixture. If No. 1 oxidizer valve or duct joint is not intact, install strut 9025193 between turbopump and oxidizer dome.

NOTE

External surfaces and the area around the bolts should be vacuumed before disconnecting valve flanges.

n. Loosen valve at oxidizer dome flange, disconnect valve at duct flange, and remove pressure-actuated seal (30, figure 3-47), spacer (31), and pressure-actuated seal (32).

o. Disconnect valve at oxidizer dome flange and remove pressure-actuated seal (33).

CAUTION

The oxidizer valve weighs approximately 168 pounds.

p. Lubricate (Method A) oxidizer dome flange closure bolt threads with lubricant grease RB0140-012 (Rocketdyne).

3-162. INSTALLING NO. 2 OXIDIZER VALVE. (See figure 3-47). The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne), unless otherwise specified. Specified lubricating procedures (methods) are outlined in section I.

WARNING

Component Handling Fixture Set G4068 must be operated by authorized personnel trained in the use of the equipment.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install adapter 9020250 on valve, and attach fixture 9024921-11 to adapter. (See figure 3-46.) Use proper lift points of fixture, and position valve for installation.

CAUTION

The oxidizer valve weighs approximately 168 pounds.

c. If valve is a replacement, fit-check valve as outlined in paragraph 3-145.

NOTE

Steps d through i apply to installing the valve that was removed. Steps j through o apply to installing a replacement valve.

d. Install pressure-actuated seal (33, figure 3-47), and connect joint. Do not tighten fasteners.

e. Install pressure-actuated seals (30, 32) and spacer (31), and connect joint. Do not tighten fasteners.

f. Aline markings on valve and spacer with markings on duct, and secure joint to maintain alinement. Remove handling equipment.

NOTE

If spacer (31) has a minimum thickness of 0.903 inch or less at any point, an additional countersink washer is required under the bolthead of each duct flange bolt.

g. Aline markings on valve with markings on oxidizer dome. Secure joint to maintain alinement.

h. Cross-torque fasteners to 1,150-1,250 in-lb. Safetywire fasteners.

i. Remove strut 9025193.

NOTE

Steps j through n apply to installing a replacement valve.

j. Install shim detail 101 from dummy seal set T-5043413 between valve and oxidizer dome. Secure joint with 6 approximately equally-spaced bolts.

k. Install pressure-actuated seals (30, 32) and spacer (31) between valve and duct. Make sure spacer is installed as indicated in Engine Log Book. Cross-torque 6 approximately equally-spaced bolts to 400 ±5 in-lb.

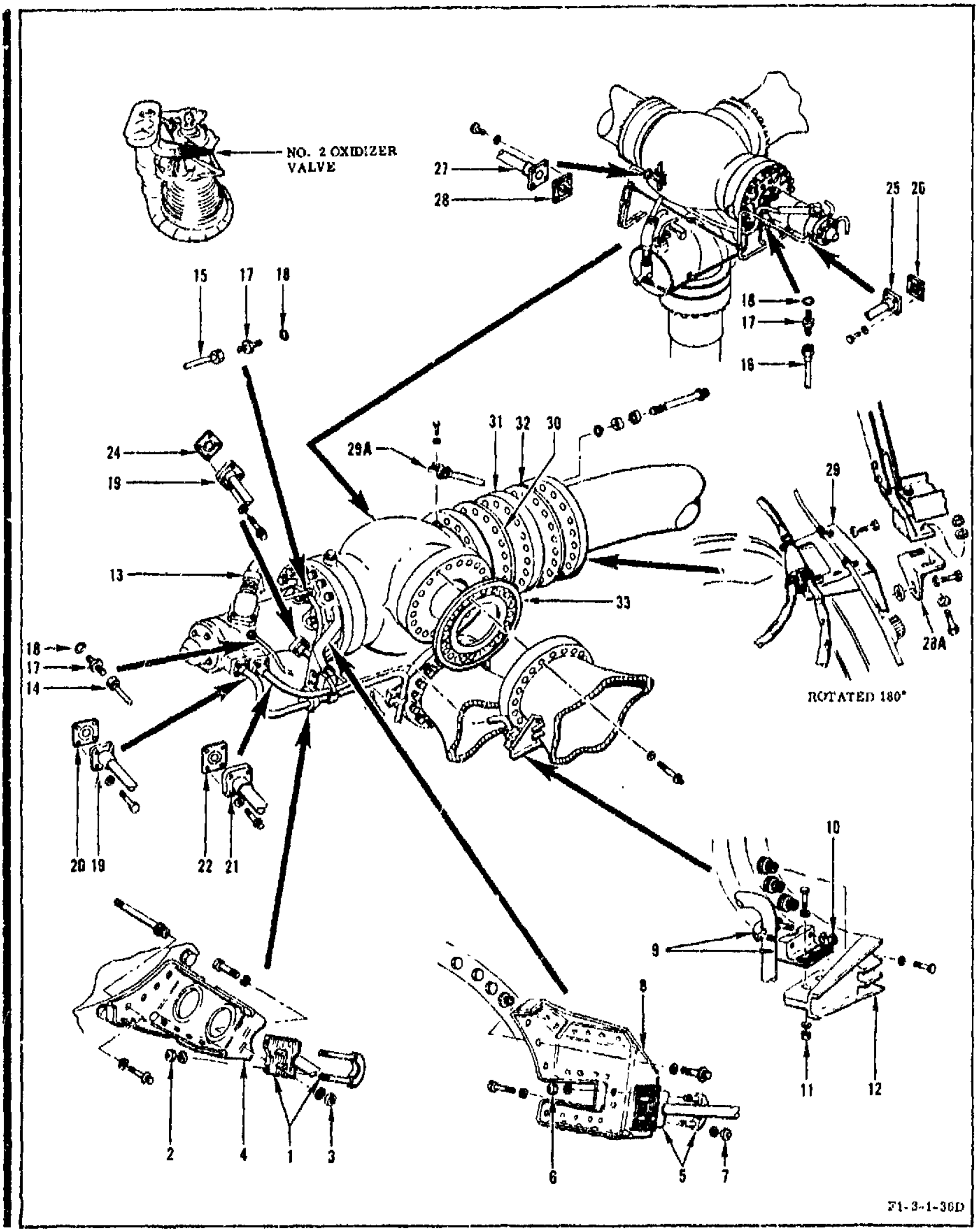


Figure 3-47. No. 2 Oxidizer Valve (Sheet 1 of 2)

1	Retainer[a][b]	12	Bracket[a]	23	Deleted	30	Pressure-actuated seal
2	Nut[a]	13	Plug	24	Orifice plate	31	Spacer
3	Nut[a]	14	Tube	25	Line	32	Pressure-actuated seal
4	Bracket[a]	15	Tube	26	Seal	33	Pressure-actuated seal
5	Retainer[a][b]	16	Tube	27	Line	34	(Deleted)
6	Nut[a]	17	Union	28	Orifice plate	35	Valve
7	Nut[a]	18	Seal	28A	Bracket		
8	Bracket[a]	19	Tube	29	Bracket		
9	Retainer[a][b]	20	Seal	29A	Bracket		
10	Nut[a]	21	Tube				
11	Nut[a]	22	Seal				

(a) Engines incorporating MD162 or MD163 change
(b) Matched set

Figure 3-47. No. 2 Oxidizer Valve (Sheet 2 of 2)

l. Loosen fasteners at dome flange, and with shim against dome flange, measure and record maximum and minimum axial gap between shim and valve. Determine maximum differential gap by subtracting minimum axial gap from maximum axial gap. Gap limitations are as follows:

(1) Engines not incorporating MD137 change: maximum axial gap, 0.070 inch; maximum differential gap, 0.020 inch.

(2) Engines incorporating MD137 change: maximum axial gap, 0.065 inch; maximum differential gap, 0.015 inch.

m. Record final dimensions in Engine Log Book.

n. Remove shim, and install pressure-actuated seal (33). Cross-torque fasteners at each flange to 1,150-1,250 in-lb. Safetywire fasteners, and install an aluminum seal on lockwire at dome flange.

NOTE

If spacer (31) has a minimum thickness of 0.903 inch or less at any point, an additional countersink washer is required under the bolthead of each duct flange bolt.

o. Remove strut 9025193.

NOTE

Steps oA through y install parts indexed (13 through 29A).

oA. Attach thermal insulation bracket (29A) to oxidizer valve. Torque bolt to 68 ±7 in-lb.

p. Install bracket (29). Torque bolts to 75 ±5 in-lb. Safetywire bolts.

pA. Attach thermal insulation bracket (28A) to frame. Torque nuts to 68 ±7 in-lb.

pB. Attach thermal insulation bracket (28A) to flange bolthead with serrated washer installed between bracket (28A) and bracket (29). Lubricate (Method A) bolt with thread compound C-5A (Felt Products). Torque bolt to 68 ±7 in-lb. Safetywire bolt.

q. Attach tube (27) and harness to bracket (29). Torque nuts to 8-10 in-lb.

r. Aline No. 2 oxidizer valve dome purge line (27) to valve (35) as outlined in paragraph 3-103; then install orifice plate (28) with tab forward, and connect tube to valve. Cross-torque bolts to 36 ±3 in-lb. Safetywire bolts, and install an aluminum seal on lockwire.

s. Install seal (26) and line (25). Cross-torque bolts to 36 ±3 in-lb. Safetywire bolts.

t. Aline propellant valves open tube (19) to valve (35) as outlined in paragraph 3-103; then install orifice plate (24) and seal (20) and connect tube to valve. Cross-torque bolts at orifice plate flange to 46 ±3 in-lb. Safetywire bolts, and install an aluminum seal on lockwire. Cross-torque bolts at seal flange to 30 ±3 in-lb. Safetywire bolts.

u. (Deleted)

v. Aline propellant valves close tube (21) to valve (35) as outlined in paragraph 3-103; then install seal (22) and connect tube to valve. Cross-torque bolts to 85 ±5 in-lb.

w. If unions (17) and seals (18) were removed, lubricate (Method A) unions. Install unions and seals, and torque unions to 240 ±10 in-lb.

x. Lubricate (Method G) tubes (14, 15, 16). Install tubes and torque coupling nuts to 135-185 in-lb.

y. Install plug (13) as outlined in paragraph 3-15.

NOTE

Steps z through ab apply to engines incorporating MD162 or MD163 change and install parts indexed (1 through 12). Parts must be installed so that no stress is exerted on tubes during or following installation.

z. Install brackets (4, 8, 12). Torque bolts for brackets (4, 8) to 125 ±10 in-lb. Torque bolts for bracket (12) to 175 ±15 in-lb. Safety-wire bolts.

NOTE

Retainers (1, 5, 9) are matched sets. If a part of any retainer requires replacement, the complete retainer must be replaced.

aa. Install retainers (5, 9). Torque bolts to the following values:

(1) Nut (6, 10): 25 ±5 in-lb above running torque, except maximum torque must not exceed 60 in-lb.

(2) Nut (7, 11): 75 ±10 in-lb.

ab. Install retainer (1), and loosen retainer from bracket at fuel manifold flange. Adjust retainers to tube (21), and torque nuts to the following values:

(1) Nuts for bolts through bracket and retainer at fuel manifold flange; 140 ±10 in-lb.

(2) Nuts (2); 25 ±5 in-lb above running torque, except maximum torque must not exceed 60 in-lb.

(3) Nut (3); 75 ±10 in-lb.

ac. (Deleted)

ad. Refer to section IV for post-maintenance test requirements.

3-163. FUEL VALVE POSITION TRANSDUCERS.

3-164. This procedure applies to the position transducers for the No. 1 fuel valve and the No. 2 fuel valve.

3-165. REMOVING FUEL VALVE POSITION TRANSDUCERS. (See figure 3-48.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove tube (1).

c. Disconnect plug (2) as outlined in paragraph 3-14.

CAUTION

Rotating the transducer more than 1/4 turn during removal can damage electrical leads.

d. Provide a one-gallon container to catch residual fluids, and carefully remove transducer (3) from valve body. Do not activate transducer shaft until all residual fuel is removed from shaft.

e. Prior to servicing, inspect shaft of transducer for presence of O-ring particles (black particles). If O-ring particles are present, remove bolt (7), seals (8), and elbow (9), and assign transducer for overhaul. If transducer will be reinstalled, remove O-ring (4), retainers (5), and packing (6).

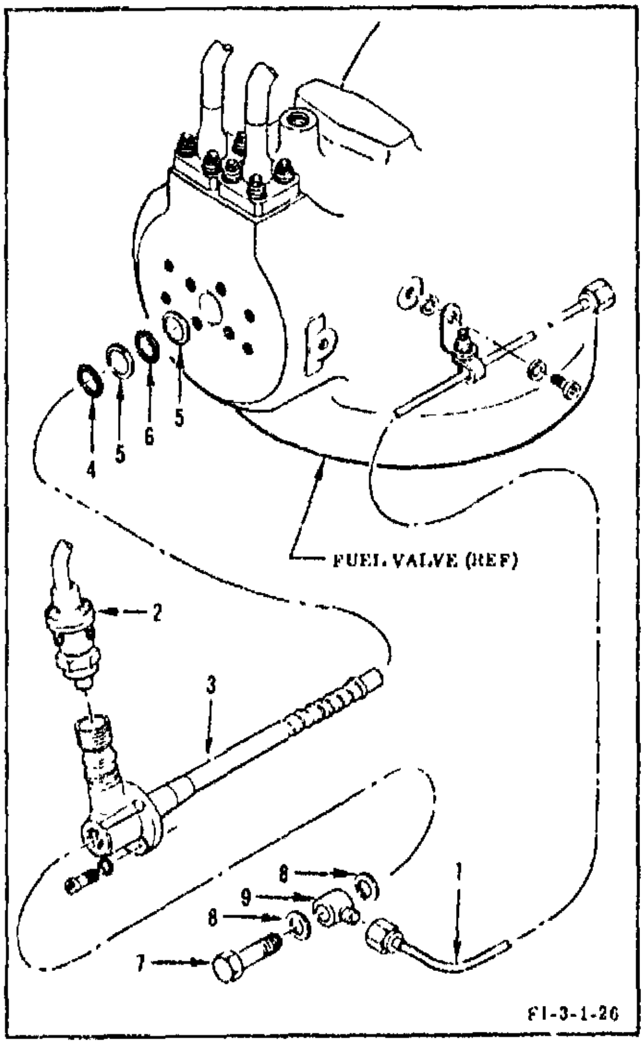
WARNING

- Trichloroethylene (MIL-T-27602) is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.
- 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.

CAUTION

The variable resistor must not be immersed in cleaning liquid, and the liquid must not be allowed to wet the resistor shaft O-ring, since the liquid will remove the lubricant from the shaft O-ring.

f. Clean removed parts except variable resistor by immersion or handwiping with trichloroethylene (MIL-T-27602) or cleaning compound (MIL-C-81302). Clean variable resistor, with parts attached, by handwiping only. Do not actuate variable resistor shaft with cleaning fluid on shaft. Dry parts with gaseous nitrogen (MIL-P-27401).



1	Tube	5	Retainer
2	Plug	6	Packing
3	Transducer	7	Bolt
4	O-ring	8	Seal
		9	Elbow

Figure 3-48. Fuel Valve Position Transducers

g. Allow all fuel to drain from fuel valve actuator housing, and siphon all remaining fuel from piston rod bore to prevent fuel from contacting shaft when a transducer is installed.

NOTE

Fuel may be siphoned using a one-pint plastic bottle with spout, No. 4653-15 (Matheson Scientific Co), or equivalent, with an 11-inch length of sleeving. Resinite No. EP-69C, 0.106-inch ID, 0.016-inch wall thickness (Installation Supply Co), or equivalent, must be secured to the spout.

3-166. INSTALLING FUEL VALVE POSITION TRANSDUCERS. (See figure 3-48.) Specified lubricating procedures (methods) are outlined in section I.

a. If installing a replacement position transducer, verify that position transducer preinstallation test outlined in section I has been performed.

aA. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Lubricate (Method J) O-ring (4) and packing (6) with lubricant grease RB0140-012 (Rocketdyne), and install O-ring, packing, and retainers (5).

c. Before installing transducer, inspect the following:

(1) Check shaft for evidence of O-ring particles (black particles). If present, assign transducer for overhaul.

CAUTION

In the following substep, the spring must be held firmly. If the transducer is allowed to snap open under spring force, damage to the slider block fastener will result.

(2) Check shaft for adequate lubrication. If lubricant on shaft is not visible, lubricate shaft with FS1281 grease (Dow Corning Corp), using swab 906919, or equivalent. If necessary, compress spring to gain access to shaft. Excess lubricant on shaft is acceptable.

(3) Check that all fluid has been removed from bore.

NOTE

Sufficient fluid must be removed from the closing side of the actuator cavity, and the piston rod bore must be dry, to prevent fluid from contacting the shaft when the transducer is installed.

d. Clean entire surface of bore with swab 906919, or equivalent nylon swab. (Depth of bore is approximately 11.25 inches.)

e. Prior to installing transducer, visually inspect fuel valve spring cavity and bore for chips, O-ring particles, and contamination.

CAUTION

Rotating the transducer more than 1/4 turn during installation can damage the electrical leads.

f. Make sure spring is centered in washer on end of shaft; then carefully insert transducer into fuel valve housing. Make sure shaft is not binding by measuring distance that transducer springs out from valve. Distance must not exceed 0.30 inch. Remove transducer and repeat steps e and f if distance exceeds 0.30 inch.

g. Secure transducer to housing with screws and washers. Torque screws to 60-70 in-lb.

h. Check that transducer is fully extended into valve piston and indicates that valve is in the closed position, as follows:

(1) Measure resistance between pins A and C. Resistance must be 2,000 ±100 ohms.

(2) Measure resistance between pins B and C. Resistance must be 2,095 ±325 ohms.

(3) Measure resistance between pins D and E. Resistance must not exceed 0.5 ohms.

i. If parts indexed (7 through 9) were removed, lubricate (Method A) elbow and bolt with lubricant grease RB0140-012 (Rocketdyne). Install elbow (9), seals (8), and bolt (7). Position elbow to aline with tube (1), and torque bolt to 220 ±20 in-lb. Safetywire bolt.

j. Lubricate tube (1) with lubricant grease RB0140-012 (Rocketdyne). Apply lubricant using Method G outlined in section I. Connect tube (1) to elbow. Torque coupling nut to 135-185 in-lb.

k. Connect plug (2) as outlined in paragraph 3-15.

l. Refer to section IV for post-maintenance test requirements.

3-167. OXIDIZER VALVE POSITION TRANSDUCERS.

3-168. This procedure applies to the No. 1 and No. 2 oxidizer valves.

3-169. REMOVING OXIDIZER VALVE POSITION TRANSDUCERS. (See figure 3-49.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect plug (1) as outlined in paragraph 3-14.

c. Disconnect housing of transducer (2) from valve, and carefully pull housing away until inner plug clips and screws are accessible.

d. Remove clips (3), transducer (2), and packing (4).

3-170. INSTALLING OXIDIZER VALVE POSITION TRANSDUCERS. (See figure 3-49.)

a. If installing a replacement position transducer, verify that position transducer preinstallation test outlined in section I has been performed.

aA. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install packing (4) over transducer cable; then aline slot in arm of transducer with drive pin in shaft, secure with clips (3), and tighten screws fingertight.

c. With valve in fully closed position, measure resistance across the following pins. Loosen clips (3), if required, and rotate transducer to obtain correct reading.

(1) Pin A to pin B: 482 ±25 ohms

(2) Pin A to pin C: 2,000 ±100 ohms

(3) Pin B to pin C: 2,120 ±130 ohms

d. Torque screws for clips (3) to 2.0 to 2.5 in-lb above locking feature. Do not exceed 9.0 in-lb.

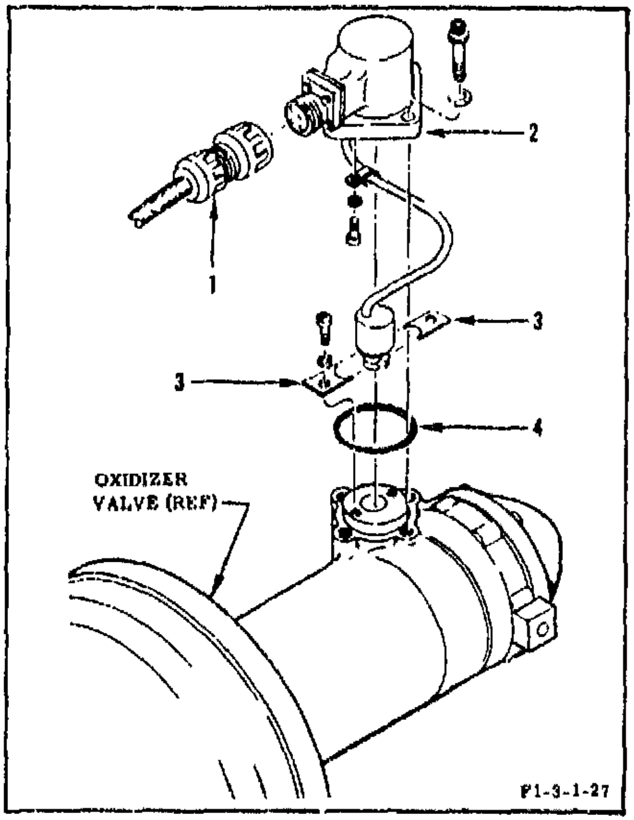
e. Lubricate packing (4) with FS1281 grease (Dow Corning Corp) using (Method J) outlined in section I. Install packing and transducer housing. Cross-torque screws to 20-25 in-lb.

f. Connect plug (1) as outlined in paragraph 3-15.

g. Refer to section IV for post-maintenance test requirements, and safetywire housing screws and plug following completion of requirements.

3-171. OXIDIZER DOME PURGE CHECK VALVE.

3-172. This procedure applies to the No. 1 and No. 2 oxidizer valves.



1	Plug	3	Clip
2	Transducer	4	Packing

Figure 3-49. Oxidizer Valve Position Transducers

3-173. REMOVING OXIDIZER DOME PURGE CHECK VALVE. (See figure 3-50.)

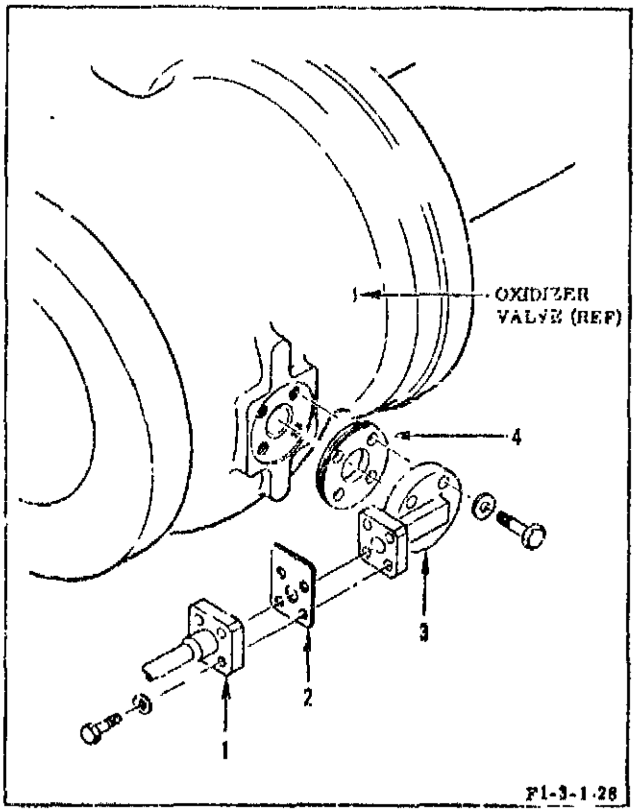
a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect tube/line (1) from check valve, and remove and retain orifice plate (2).

c. Remove valve (3) and seal (4).

3-174. INSTALLING OXIDIZER DOME PURGE CHECK VALVE. (See figure 3-50.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.



1	Tube/Line	3	Valve
2	Orifice plate	4	Seal

Figure 3-50. Oxidizer Dome Purge Check Valve

aA. Inspect that pin securing gate in valve (3) is installed.

b. Install seal (4) and valve (3). Cross-torque bolts to 110-130 in-lb. Safetywire bolts.

c. Aline No. 1 oxidizer dome purge tube or No. 2 oxidizer dome purge line (1) to valve (3), as outlined in paragraph 3-103; then install orifice plate with tab forward, and connect tube to valve.

d. Cross-torque bolts to 36 ±3 in-lb. Safetywire bolts, and install an aluminum seal on lockwire.

e. Refer to section IV for post-maintenance test requirements.

3-174A. SEQUENCE VALVE.

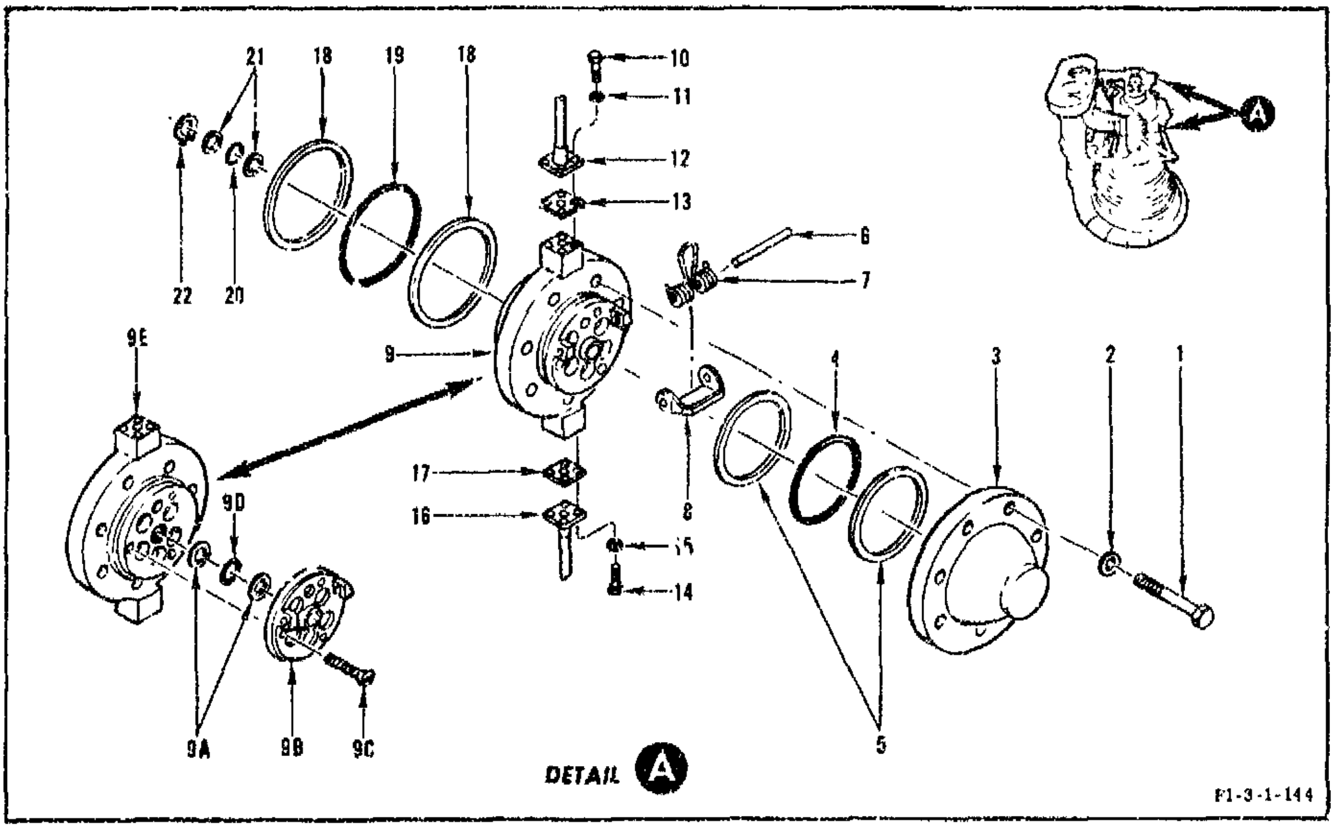
3-174B. This procedure applies to the No. 1 and No. 2 oxidizer valves. Disassemble the sequence valve, as required, to accomplish the necessary packings or parts replacement.

3-174C. REMOVING SEQUENCE VALVE. (See figure 3-50A.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect tube (12) from PRESS OUT port on sequence valve, and remove seal (13). Install protective closure on tube flange.

c. Disconnect tube (16) from PRESS IN port on sequence valve, and remove seal (17). Install protective closure on tube flange.



1	Bolt	9A	Retainer[a]	14	Bolt
2	Washer	9B	Plate[a]	15	Washer
3	Cap	9C	Screw[a]	16	Tube
4	Packing	9D	Packing[a]	17	Seal
5	Retainer	9E	Cylinder head[a]	18	Retainer
6	Pin	10	Bolt	19	Packing
7	Spring	11	Washer	20	Packing
8	Gate	12	Tube	21	Retainer
9	Cylinder head	13	Seal	22	Ring

(a) On oxidizer valve 409463-31

Figure 3-50A. Sequence Valve

d. Remove bolts (1) and washers (2) that secure sequence valve to oxidizer valve cylinder, and remove sequence valve. Two 1/4-28 bolts may be inserted into tapped holes in cap (3) to facilitate valve removal. Protect cylinder from contamination with clean plastic sheet and strip, (Federal Specification L-P-378, Type II). Seal plastic with pressure-sensitive tape RB0195-002 (Rocketdyne) or (Federal Specification PPP-T-60).

e. Remove cap (3) from cylinder head (9, 9E).

f. On oxidizer valves except 409465-31, remove packing (4) and retainers (5) from cylinder head (9). Do not remove pin (6), spring (7), and gate (8) from cylinder head (9) unless parts are to be replaced.

g. On oxidizer valve 409465-31, perform the following:

(1) Remove screws (9C) that attach plate (9B) to cylinder head (9E). Do not remove pin (6), spring (7), and gate (8) from cylinder head (9E) unless parts are to be replaced.

(2) Remove packing (4), retainers (5), packing (9D), and retainer (9A) from cylinder head (9E).

h. Remove packing (19), retainers (18), packing (20), and retainers (21) from cylinder head (9, 9E). Do not remove ring (22) from oxidizer valve piston rod.

3-174D. INSTALLING SEQUENCE VALVE. (See figure 3-50A.) The lubricant used in this procedure is FS1281 grease (Dow Corning Corp). Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Lubricate (Method L) packing (20); then insert packing and retainers (21) into center groove of cylinder head (9, 9E).

c. Lubricate (Method J) packing (19); then install packing and retainers (18) in large groove of cylinder head (9, 9E).

d. Lubricate (Method J) packing (4); then install packing and retainers (5) in groove of cylinder head (9).

e. If required, install gate (8) and spring (7) on cylinder head (9) and secure with pin (6). Spring must be rotated 180 degrees in direction of spring twist during installation, to hold gate in a closed position against cylinder head.

f. On oxidizer valve 409465-31, perform the following:

(1) Lubricate (Method J) packing (9D), then install packing and retainers (9A) into center groove of cylinder head (9E).

(2) Lubricate (Method J) packing (4); then install packing and retainers (5) in large groove of cylinder head (9E).

(3) If required, install gate (8) and spring (7) on plate (9B) and secure with pin (6). Spring must be rotated 180 degrees in direction of spring twist during installation, to hold gate in a closed position against plate.

(4) Secure plate (9B) to cylinder head (9E) with screws (9C). Torque screws to 20-30 in-lb.

g. Remove protective plastic from oxidizer valve cylinder. Inspect protective plastic to make certain that complete protective item is removed and that portions do not remain that could contaminate oxidizer valve.

h. Carefully position cylinder head (9, 9E) on valve cylinder with PRESS IN port facing inboard side of oxidizer valve. Position cap (3) on cylinder head, and secure cap and cylinder head to valve cylinder with bolts (1) and washers (2). Torque bolts to 175-271 in-lb.

i. Remove protective closure, and aline tube (16) to PRESS IN port as outlined in paragraph 3-103. Install seal (17), and connect tube with bolts (14) and washers (15). Cross-torque bolts to 30 ±3 in-lb. Safetywire bolts.

j. Remove protective closure, and aline tube (12) to PRESS OUT port as outlined in paragraph 3-103. (On No. 2 oxidizer valve, alinement of tube (12) is not required.) Install seal (13), and connect tube with bolts (10) and washers (11). Cross-torque bolts to 36 ±3 in-lb. Safetywire bolts.

k. Leak-test sequence valve cylinder head-to-cap joints. (Refer to section IV for post-maintenance test requirements.)

3-175. BEARING COOLANT CONTROL VALVE.

3-176. REMOVING BEARING COOLANT CONTROL VALVE. (See figure 3-51.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove tube (1) and seal (2).

c. On engines incorporating MD150 or MD151 change, remove tube (3) and seals (4).

d. Disconnect plug from transducer as outlined in paragraph 3-16.

e. Remove bracket (5), transducer (6), and seal (7).

f. Disconnect tube (8), and remove seal (9).

g. On engines not incorporating MD150 or MD151 change, remove elbow (10), nut (11), ring (12), and gasket (13). On engines incorporating MD150 or MD151 change, remove tee (14), nut (11), ring (12), and gasket (13).

h. Disconnect hose (15) and tube (16), and remove seals (17).

i. If valve will be replaced, remove coupling (18), retainer (19) and O-ring (20).

j. Remove valve (21) from bracket (22) by removing 4 bolts and 4 washers from back side of bracket (22).

3-177. INSTALLING BEARING COOLANT CONTROL VALVE. (See figure 3-51.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne). Specified lubricating procedures (methods) are outlined in section I. If the bearing coolant control valve is replaced, the original integral orifice must be installed in the replacement valve, or if the orifice is replaced, the replacement orifice must be within the machining tolerance of the size recorded in the Engine Log Book. Removal and installation procedures for the orifice are outlined in R-3896-3, Volume II. Orifice replacement and repair procedures are outlined in section I.

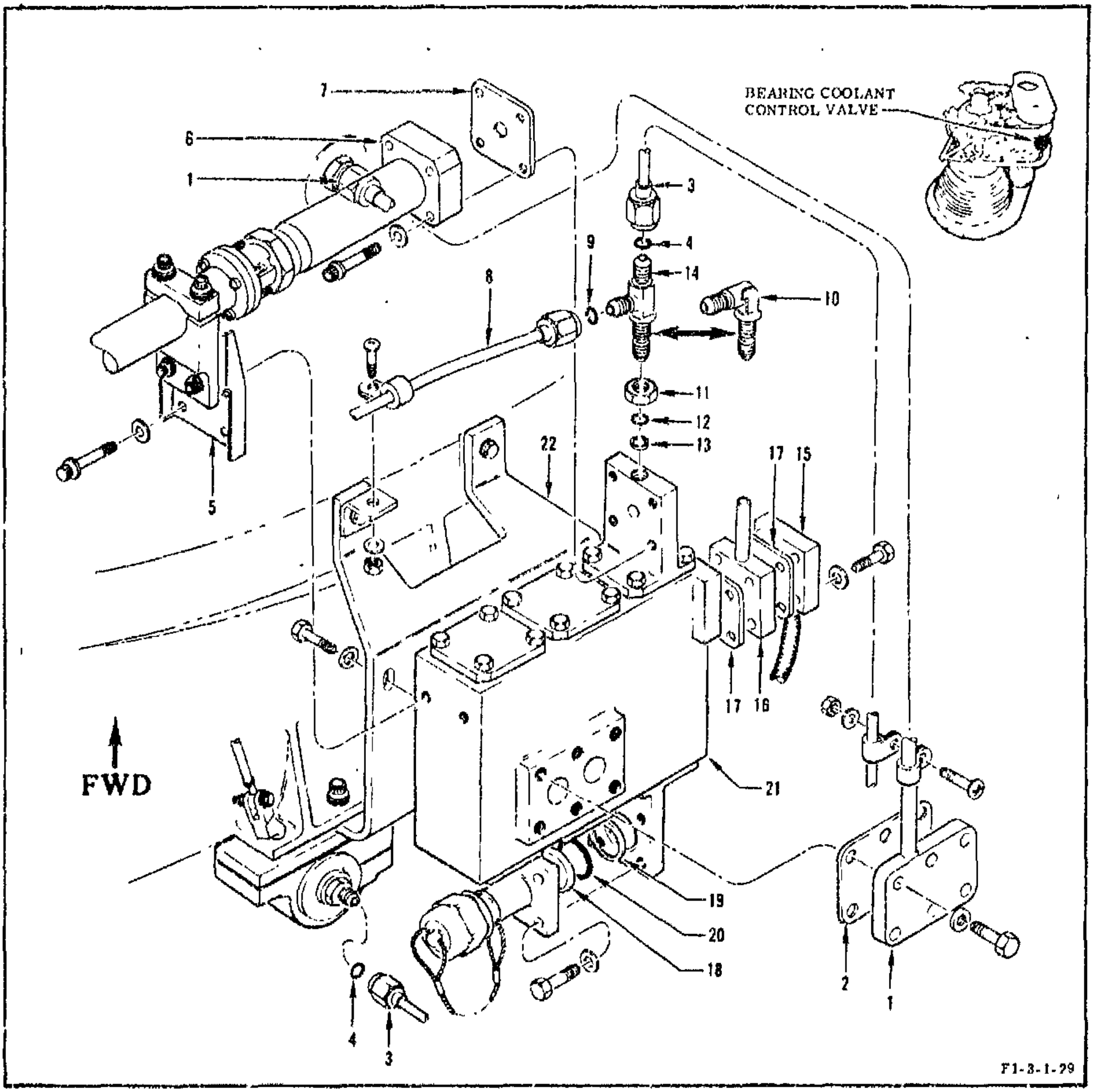
a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install valve (21) on bracket (22). Cross-torque bolts to 40-50 in-lb. Safetywire bolts.

c. If valve was replaced, lubricate (Method J) O-ring (20). Install O-ring, retainers (19), and coupling (18). Cross-torque bolts to 40-50 in-lb. Safetywire bolts. Torque cap, if required, to 30-40 ft-lb.

d. Install seals (17), tube (16), and hose (15). Cross-torque bolts to 40-50 in-lb. Safetywire bolts.

e. On engines not incorporating MD150 or MD151 change, lubricate (Method J) gasket (13). Install nut (11), ring (12) and gasket (13) on elbow. Lubricate (Method A) elbow (10), and install elbow. Torque nut (11) to 75-100 in-lb. Safetywire nut.



1	Tube	8	Tube	15	Hose
2	Seal	9	Seal	16	Tube
3	Tube[a]	10	Elbow[b]	17	Seals
4	Seal[a]	11	Nut	18	Coupling
5	Bracket	12	Ring	19	Retainer
6	Transducer	13	Gasket	20	O-ring
7	Seal	14	Tee[a]	21	Valve
				22	Bracket

(a) Engines incorporating MD150 or MD151 change
(b) Engines not incorporating $\overline{\text{MD}}$150 or $\overline{\text{MD}}$151 change

Figure 3-51. Bearing Coolant Control Valve

f. On engines incorporating MD150 or MD151 change, lubricate (Method J) gasket (13). Install nut (11), ring (12), and gasket (13) on tee. Lubricate (Method A) tee (14), and install tee. Torque nut (11) to 75-100 in-lb. Safetywire nut.

g. Lubricate (Method G) tube (8). Install seal (9), and connect tube (8) to tee or elbow, as applicable. Torque tube coupling nut to 160 ±10 in-lb. Safetywire coupling nut.

h. Install seal (7) and transducer (6). Cross-torque bolts to 45 ±5 in-lb. Safetywire bolts.

i. Install bracket (5). Torque bolts to 45 ±5 in-lb. Safetywire bolts.

j. Connect plug to transducer as outlined in paragraph 3-17.

k. On engines incorporating MD150 or MD151 change, lubricate (Method G) tube (3). Install seals (4) and tube (3). Torque coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

l. Install seal (2) and tube (1). Torque bolts to 15-20 in-lb. Safetywire bolts. Torque coupling nut to 330 ±15 in-lb above prevailing torque of coupling nut. Prevailing torque is obtained prior to seating of coupling nut and must be 24-200 in-lb.

m. If static firing instrumentation is intalled, torque nuts for tube supporting clamps to 8-10 in-lb.

n. Refer to section IV for post-maintenance test requirements.

3-178. BEARING COOLANT CONTROL VALVE FILTERS.

3-179. REMOVING BEARING COOLANT CONTROL VALVE FILTERS. (See figure 3-51.)

a. Remove coupling (18), retainers (19), and O-ring (20). Retain coupling for installation.

b. Refer to R-3896-3, Volume II, and replace filters as outlined in applicable procedure.

3-180. INSTALLING BEARING COOLANT CONTROL VALVE FILTERS. (See figure 3-51.)

a. Lubricate O-ring (20) with lubricant grease RB0140-012 (Rocketdyne). Apply lubricant using Method J outlined in section I.

b. Install O-ring (20), retainers (19), and coupling (18). Cross-torque bolts to 40-50 in-lb. Safetywire bolts.

c. If required, torque cap for coupling to 30-40 ft-lb.

d. Refer to section IV for post-maintenance test requirements.

3-181. HYPERGOL MANIFOLD.

3-182. The hypergol manifold assembly may be removed as specified in paragraph 3-183. Repair of the hypergol manifold installed on the engine is limited to replacement of the fuel drain and purge flange-mounted quick-disconnects and reinstallation or replacement of the hypergol cartridge container and hypergol installed switch.

3-183. REMOVING HYPERGOL MANIFOLD. (See figure 3-52.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove thermal insulation frame 145477, if installed. (Refer to R-3896-6.)

NOTE

Residual fluids may be in lines and hypergol manifold.

c. Disconnect plug (1) as outlined in paragraph 3-14.

d. Remove tube (2). If hypergol manifold will be replaced, remove elbow (3), gasket (4), ring (5), and nut (6).

e. Disconnect hose(7), and remove seal (8).

f. Remove tube (9), O-ring (10), spacer (11), and O-ring (12). (The same parts are used at fuel duct end of tube.)

g. If hypergol manifold will be replaced, remove plug (13), gasket (14), adapter (15), and seal (16).

h. Remove tube (17). If hypergol manifold will be replaced, remove transducer (18) and gasket (19).

i. Disconnect tube (20), and remove seal (21).

j. Disconnect tube (22), and remove seal (23).

k. Disconnect tube (24) (detail A), and remove seal (25).

l. Disconnect line (26) (detail A), and remove seal (27).

m. Disassemble and remove retainer (28) (detail B). The retainer consists of matched parts. If one part requires replacement, the retainer must be replaced.

n. Remove bracket (29) (detail B).

o. Disconnect tube (30) (detail B) at fuel manifold, and remove seal (31).

p. Remove coupling (32), retainers (33), and O-ring (34); then remove tube (30), retainers (35), and O-ring (36).

q. Remove clamp (37).

r. Remove bracket (38) and hypergol manifold by removing bolts that attach bracket to fuel manifold. Bushing (39) may be loosened, if necessary.

s. Remove bolts that attach bracket (38) to hypergol manifold.

3-184. INSTALLING HYPERGOL MANIFOLD. (See figure 3-52.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne). Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Attach bracket (38) to hypergol manifold. Torque bolts to 150 ±5 in-lb. Safetywire bolts.

c. Install bracket (38) in place. Torque nuts to 125 ±5 in-lb. If bushings (39) were removed, they must be installed prior to installing bolts. Adjust bushings against bracket of fuel manifold, and torque bushing nuts to 200 ±10 in-lb. Safetywire bushings.

d. Install clamp (37). Torque nuts to 35 ±5 in-lb.

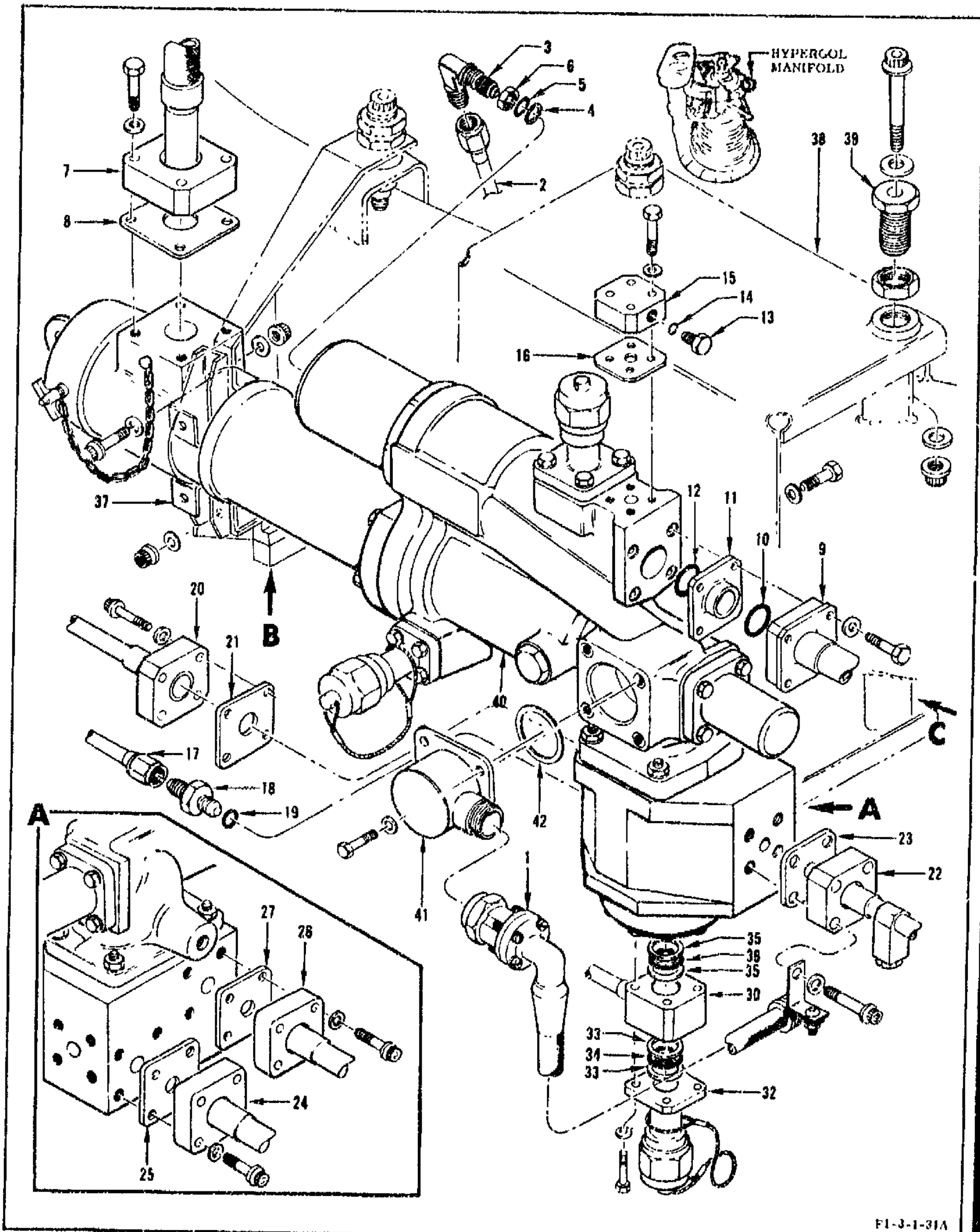
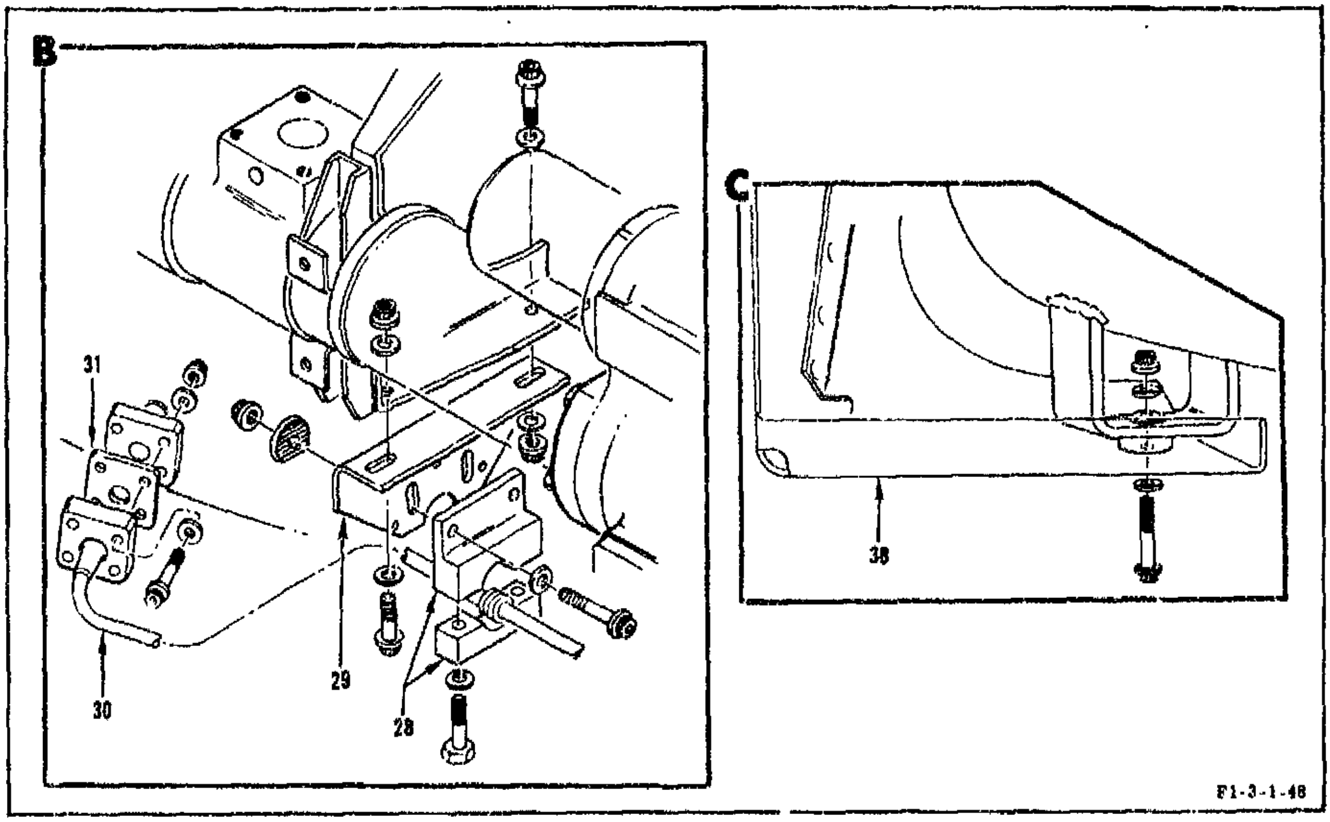


Figure 3-52. Hypergol Manifold (Sheet 1 of 2)



1	Plug	11	Spacer	21	Seal	31	Seal
2	Tube	12	O-ring	22	Tube	32	Coupling
3	Elbow	13	Plug	23	Seal	33	Retainer
4	Gasket	14	Gasket	24	Tube	34	O-ring
5	Ring	15	Adapter	25	Seal	35	Retainer
6	Nut	16	Seal	26	Line	36	O-ring
7	Hose	17	Tube	27	Seal	37	Clamp
8	Seal	18	Reducer	28	Retainer[a]	38	Bracket
9	Tube	19	Gasket	29	Bracket	39	Bushing
10	O-ring	20	Tube	30	Tube	40	Hypergol manifold
						41	Switch
						42	Packing

(a) Matched set

Figure 3-52. Hypergol Manifold (Sheet 2 of 2)

e. Lubricate (Method J) retainers (33, 35) and O-rings (34, 36) and connect tube (30) and coupling (32) to hypergol manifold (40). Cross-torque bolts to 75 ±5 in-lb. Safetywire bolts.

f. Aline ignition monitor valve sense tube (30) to thrust chamber fuel manifold. Install seal (31) and connect tube to manifold. Cross-torque nuts to 52 ±5 in-lb.

g. (Deleted)

h. On engines incorporating MD162 or MD163 change, install bracket (29) and retainer (28). Adjust position of parts so that no force is exerted on tube (30) after fasteners are tightened. Torque fasteners that attach bracket (29) to engine to 120 ±15 in-lb. Torque fasteners that attach retainer (28) to bracket (29) to 100 ±10 in-lb. Torque bolts of retainer to 85 ±10 in-lb. Safetywire retainer bolts.

i. Install seal (27), and connect line (26). Cross-torque bolts to 46 ±3 in-lb. Safetywire bolts.

j. Aline propellant valves open tube (24) to hypergol manifold (40) as outlined in paragraph 3-103; then install seal (25), and connect tube to hypergol manifold. Cross-torque bolts to 85 ±5 in-lb. Safetywire bolts.

k. Install seal (23), and connect tube (22) to hypergol manifold (40). Cross-torque bolts to 36 ±3 in-lb. Safetywire bolts.

l. Install seal (21), and connect tube (20) to hypergol manifold (40). Cross-torque bolts to 36 ±3 in-lb. Safetywire bolts.

m. If reducer (18) and gasket (19) were removed, lubricate (Method J) gasket and lubricate (Method A) reducer. Install gasket and reducer. Torque reducer to 100-150 in-lb.

n. Lubricate (Method G) tube (17). Lubricate (Method A) union and install tube (17). Hold reducer and torque tube coupling nuts to 270-345 in-lb.

o. If parts indexed (13 through 16) were removed, install seal (16) and adapter (15). Cross-torque bolts to 22 ±2 in-lb; then lubricate (Method J) gasket (14) and (Method A) plug (13). Install gasket and plug. Torque plug to 40-65 in-lb. Safetywire plug and bolts.

p. Aline igniter fuel supply tube (9) to hypergol manifold (40) or No. 1 fuel high-pressure duct as outlined in paragraph 3-104A.

q. Lubricate (Method K) 4 O-rings (10, 12) and install O-rings in flange and spacer grooves at each end of tube.

CAUTION

Spacers must not be rotated during assembly in tube or when tube is installed. Damage to O-rings may result.

qA. Aline markings on spacers and flanges and install spacers in tube.

qB. Carefully install tube. Make sure O-rings in grooves are in place, and cross-torque

qC. Safetywire bolts and remove markings from flange.

r. Install seal (8) and connect hose (7). Cross-torque bolts to 85 ±5 in-lb. Safetywire bolts.

s. If parts indexed (3 through 6) were removed, lubricate (Method J) gasket (4) and ring (5). Install elbow (3) and aline with tube (2). Torque nut (6) to 150-200 in-lb. Safetywire nut.

t. Lubricate (Method G) tube (2), and install tube. Torque tube coupling nuts to 270-345 in-lb.

u. Connect plug (1) as outlined in paragraph 3-15.

v. Install thermal insulation frame 145477 as outlined in R-3896-6.

w. Refer to section IV for post-maintenance test requirements.

3-185. HYPERGOL MANIFOLD CARTRIDGE CONTAINER.

3-186. The hypergol manifold cartridge container may be removed and reinstalled or replaced with the hypergol manifold installed on the engine.

3-187. REMOVING HYPERGOL MANIFOLD CARTRIDGE CONTAINER. (See figure 3-53.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect line (1), and remove seal (2).

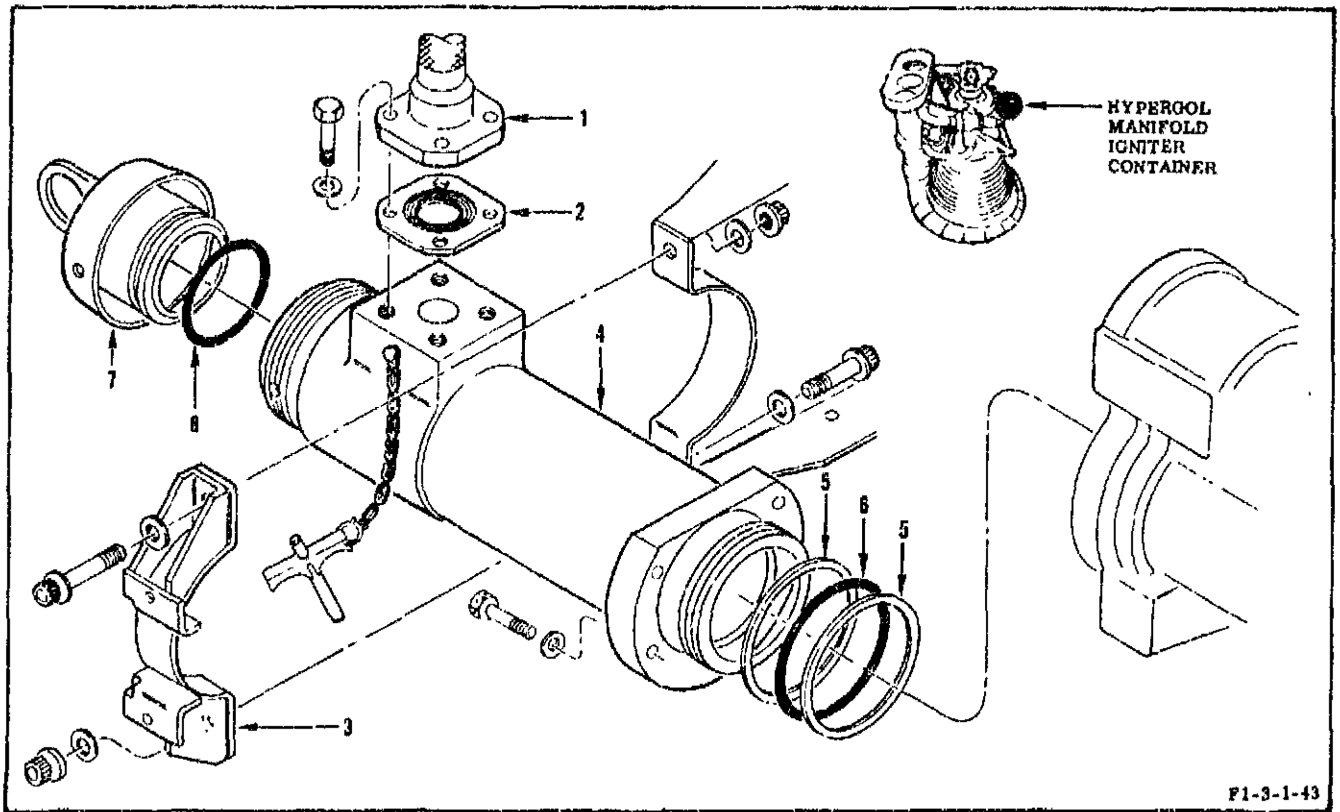
c. Remove clamp (3).

d. Remove container (4), retainer (5), and O-ring (6).

e. Remove closure (7) and packing (8) from container, if required. Retain closure.

3-188. INSTALLING HYPERGOL MANIFOLD CARTRIDGE CONTAINER. (See figure 3-53.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.



1 Line	3 Clamp	5 Retainer	7 Closure
2 Seal	4 Container	6 O-ring	8 Packing

Figure 3-53. Hypergol Manifold Cartridge Container

b. Lubricate (Method J) O-ring (6) with lubricant grease RB0140-012 (Rocketdyne), and install O-ring and retainers (5) on container (4).

c. Lubricate (Method Z) sliding surface of container (4) with lubricant grease RB0140-012 (Rocketdyne), and apply additional grease on O-ring (6).

d. Install container (4), and cross-torque bolts to 155-185 in-lb. Safetywire bolts.

e. Install clamp (3), and torque nuts to 35 ±5 in-lb.

f. Install seal (2), and connect line (1). Cross-torque bolts to 85 ±5 in-lb. Safetywire bolts.

g. If closure (7) and packing (8) were removed, lubricate (Method L) packing (8) with FS1281 grease (Dow Corning Corp) and install packing on closure (7). Install closure (7) and secure with retainer.

3-189. <u>HYPERGOL INSTALLED SWITCH.</u>

3-190. REMOVING HYPERGOL INSTALLED SWITCH. (See figure 3-52.)

a. Using method outlined in paragraph 3-14, disconnect plug (1) from hypergol installed switch.

b. Remove switch (41) and packing (42).

3-191. INSTALLING HYPERGOL INSTALLED SWITCH. (See figure 3-52.) Specified lubricating procedures (methods) are outlined in section I.

a. Lubricate (Method J) packing (42) with FS1281 grease (Dow Corning Corp).

b. Install packing and switch (41). Torque bolts to 27-33 in-lb. Safetywire bolts.

c. Install plug (1) using method outlined in paragraph 3-15.

d. Refer to section IV for post-maintenance test requirements.

3-191A. IGNITION MONITOR VALVE CAP.

3-191B. REMOVING IGNITION MONITOR VALVE CAP. (See figure 3-53A.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove bolts (1) and washers (2) attaching retainer (3) over tube (14); then remove retainer. (The retainer consists of matched parts. If one part requires replacement, the entire retainer must be replaced.)

c. Remove nuts (4), washers (5, 7), and bolts (6) attaching tube (14) to thrust chamber fuel manifold; then carefully remove seal (8).

d. Remove bolts (9) and washers (10) attaching coupling (11) and tube (14) to ignition monitor valve; then remove coupling and tube and retainers (12) and O-rings (13).

CAUTION

In the following step, diaphragm (19) and cover (20) may be damaged if allowed to drop out when cap (17) is removed.

e. Remove bolts (15) and washers (16) attaching cap (17) to ignition monitor valve; then carefully remove cap, packing (18), diaphragm (19), and cover (20).

3-191C. INSTALLING IGNITION MONITOR VALVE CAP. (See figure 3-53A.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne). Specified lubrication procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Measure and record thickness of diaphragm (19). Minimum allowable thickness is 0.0070 inch.

CAUTION

Laminations of diaphragm (19) must not be separated.

c. Lubricate (Method J) packing (18) and install in groove in face of cap (17); then place diaphragm (19) on cap. Diaphragm convolution must face into ignition monitor valve body.

d. If engine is in vertical position, center cover (20) in the installed position on diaphragm (19) and carefully install cap (17), diaphragm, and cover as an assembly.

e. If engine is in horizontal position, install cover (20); then install cap (17) and diaphragm (19).

f. Aline holes in cap (17) and diaphragm (19) with holes in ignition monitor valve body and secure with washers (16) and bolts (15). Torque bolts (15) to 50-60 in-lb above torque required to turn through locking device, using cross-torque method and in increments of one-third total torque until all bolts are torqued. Safetywire bolts.

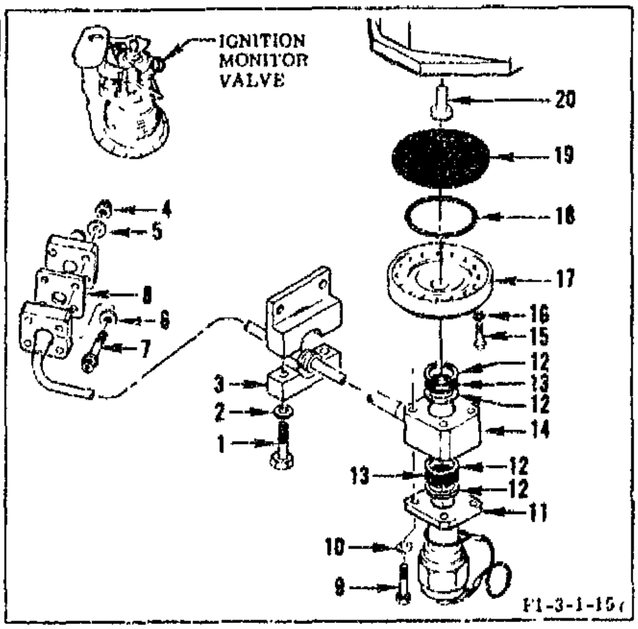
g. Lubricate (Method J) retainers (12) and O-rings (13). Install tube (14) and coupling (11) with washers (10) and bolts (9). Cross-torque bolts (9) to 75 ±5 in-lb.

h. Refer to paragraph 3-103 and aline tube (14) to thrust chamber fuel manifold.

i. Install seal (8) and secure tube (14) to thrust chamber fuel manifold with washers (5, 7), bolts (6), and nuts (4). Cross-torque nuts to 52 ±5 in-lb.

j. Safetywire bolts (9).

k. Install retainer (3) with washers (2) and bolts (1). Torque bolts to 85 ±10 in-lb. Safetywire bolts.



1	Bolt	11	Coupling
2	Washer	12	Retainer
3	Retainer	13	O-ring
4	Nut	14	Tube
5	Washer	15	Bolt
6	Bolt	16	Washer
7	Washer	17	Cap
8	Seal	18	Packing
9	Bolt	19	Diaphragm
10	Washer	20	Cover

Figure 3-53A. Ignition Monitor Valve Cap

3-192. ENGINE CONTROL VALVE.

3-193. REMOVING ENGINE CONTROL VALVE. (See figure 3-54.) This procedure removes the engine control valve and includes a dimensional check to determine if the engine supply tube requires removal. Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Provide a suitable container to catch residual fluids as equipment is disconnected.

c. Disconnect plugs (1, 2) as outlined in paragraph 3-14.

cA. In the following steps during installation of closures on engine control valve flanged ports, lubricate (Method A) closure fasteners with lubricant grease RB0140-012 (Rocketdyne).

NOTE

Steps d through j apply to engines not incorporating MD96 change.

d. Disconnect tube (3), and remove seal (4).

e. Disconnect tube (5), and remove seals (6, 8).

f. Disconnect plugs from transducers as outlined in paragraph 3-16.

g. Disconnect block (9) from valve, and remove transducer and adapter (7) as an assembly.

h. Disconnect tube (10), and remove seal (11).

i. Disconnect tube (12), and remove seals (13, 15).

j. Disconnect block (16) from valve, and remove transducer and adapter (14) as an assembly.

k. On engines incorporating MD96 change, disconnect tube (17), and remove seal (18).

l. Disconnect hose (19) and remove seal (20).

m. Remove line (21) and seals (22, 23).

n. On engines not incorporating MD150 or MD151 change, remove tube (24) and seal (25). If valve will be replaced, remove elbow (26), nut (27), ring (28), and gasket (29). On engines incorporating MD150 or MD151 change, plug (31) and seal (30) may be left installed.

o. Disconnect hose (32). If valve will be replaced, remove elbow (33), nut (34), ring (35), and gasket (36).

oA. Mark across flanges of tube (37) and spacer (38) using a marking method that can be removed. Disconnect tube at valve, and within 10 minutes, measure and record gap, offset, and angulation. See figure 3-33 for examples and maximum allowable limits.

oB. Rotate spacer, and repeat measurements until a maximum gap is obtained within limits. Mark across flanges for final acceptable condition, and remove any other markings.

CAUTION

If tube (37) is not removed, it must not be subjected to stresses since alinement may be affected or the duct inserts may be damaged.

NOTE

Step p is performed only if the condition specified in step oA cannot be obtained.

p. Mark across flanges and spacer at high-pressure duct end of tube, and remove tube (37), spacer (38), O-rings (39), spacer (41), and O-rings (40).

q. On engines incorporating MD96 change, disconnect line (42) and remove seal (43).

r. Disconnect hose (44). If valve will be replaced, remove reducer (45) and gasket (46).

s. Remove valve (49) from support (48) by removing bolts from inner side of support.

t. If support (48) requires removal, remove bushing (47) and support.

u. If engine control valve is removed for replacement with a spare valve, replace soft goods on removed valve before placing valve in spares inventory.

3-194. INSTALLING ENGINE CONTROL VALVE. (See figure 3-54.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne). Specified lubricating procedures (methods) are outlined in section I.

a. If installing a replacement engine control valve, verify that engine control valve preinstallation tests outlined in section I have been performed.

aA. Observe safety, and contamination and damage prevention requirements outlined in section I.

NOTE

Steps b through ac install the engine control valve if tube (37) was removed. Steps ad through bb install the engine control valve if tube (37) was not removed.

b. Assemble valve (49) to support (48). Do not torque bolts.

c. If support was removed, install valve and support. Aline support with hole 55 of lower tooling ring, and install bushing (47). Do not torque nuts.

d. On engines incorporating MD96 change, install seals (18, 43) and connect tube (17) and line (42). Cross-torque bolts to 85 ±5 in-lb. Safetywire bolts.

e. If support (48) was removed, torque nuts for support to 375 ±25 in-lb.

f. Loosen bolts that attach valve to support; then torque bolts to 350 ±10 in-lb. Safetywire bolts.

g. Aline engine supply tube (37) to engine control valve (49) or No. 2 fuel high-pressure duct as outlined in paragraph 3-104A.

h. Lubricate (Method K) 2 O-rings (39) and install in grooves of spacer (38).

i. Lubricate (Method K) 2 O-rings (40) and install in grooves of spacer (41) and flange groove.

CAUTION

Spacers must not be rotated during assembly in tube or when tube is installed, since damage to O-rings may result.

j. Aline markings on flanges and install spacers (38, 41) in tube.

k. Carefully install tube. Make sure O-rings in grooves are in place, and cross-torque bolts at valve end to 85 ±5 in-lb; then cross-torque bolts at duct end to 85 ±5 in-lb.

l. Safetywire bolts, and remove markings from flanges.

NOTE

Safetywiring and removal of markings may be performed following leak testing.

m. If reducer (45) and gasket (46) were removed, lubricate (Method J)gasket and lubricate (Method A) reducer (large end only). Install reducer and gasket. Torque reducer to 180-230 in-lb.

n. Connect hose (44) to reducer (45). Do not lubricate reducer threads. Torque hose coupling nut, and record torque value during last 1/2 turn before flare seats. Recorded torque must be 35-200 in-lb. Continue to torque coupling nut to 270-345 in-lb above recorded torque.

o. Lubricate (Method J) gasket (36) and ring (35) and lubricate (Method A) longer end of elbow (33). Assemble elbow (33), nut (34), ring (35), and gasket (36). Install elbow and aline for connection of hose (32). Torque nut (34) to 75-100 in-lb. Safetywire nut.

p. Connect hose (32) to elbow (33). Do not lubricate threads of elbow. Torque hose coupling nut, and record torque value during last 1/2 turn before flare seats. Recorded torque must be 35-300 in-lb. Continue to torque coupling nut to 180-230 in-lb above recorded torque.

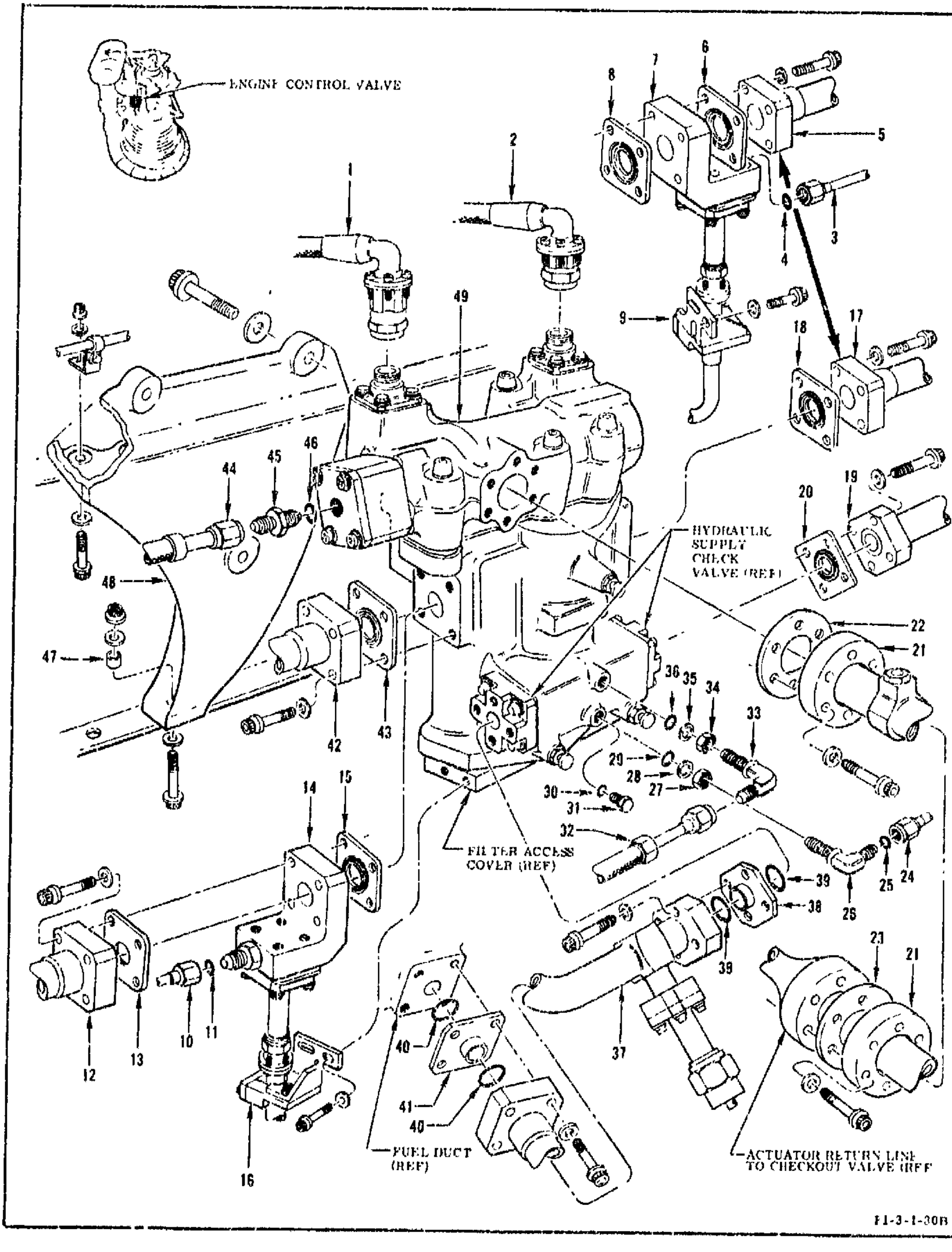


Figure 3-54. Engine Control Valve (Sheet 1 of 2)

1 Plug	13 Seal[a]	25 Seal[e]	37 Tube
2 Plug	14 Adapter[a]	26 Elbow[e]	38 Spacer
3 Tube[a]	15 Seal[a]	27 Nut[e]	39 O-ring
4 Seal[a]	16 Block[a]	28 Ring[e]	40 C-ring
5 Tube[a]	17 Tube[b]	29 Gasket[e]	41 Spacer
6 Seal[a]	18 Seal[b]	30 Gasket[f][g]	42 Line[b]
7 Adapter[a]	19 Hose	31 Plug[f]	43 Seal[b]
8 Seal[a]	20 Seal	32 Hose	44 Hose
9 Block[a]	21 Line	33 Elbow	45 Reducer
10 Tube[a]	22 Seal	34 Nut	46 Gasket[g]
11 Seal[a]	23 Seal	35 Ring	47 Bushing
12 Tube[a]	24 Tube[e]	36 Gasket[g]	48 Support
			49 Valve

(a) Engines not incorporating MD96 change
(b) Engines incorporating MD96 change
(e) Engines not incorporating MD150 or MD151 change
(f) Engines incorporating MD150 or MD151 change
(g) Allowable alternate packing (age controlled).

Figure 3-54. Engine Control Valve (Sheet 2 of 2)

q. If valve was replaced, lubricate (Method J) gasket (30) and lubricate (Method A) plug (31). Install gasket and plug (31). Torque plug to 30-40 in-lb. Safetywire plug.

r. On engines not incorporating MD150 or MD151 change, lubricate (Method J) gasket (29) and ring (28) and lubricate (Method A) longer end of elbow (26). Assemble elbow, nut (27), ring (28), and gasket (29). Install elbow and aline with tube (24). Torque nut (27) to 75-100 in-lb. Safetywire nut.

s. On engines not incorporating MD150 or MD151 change, lubricate (Method G) tube (24). Install seal (25) and tube (24). Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

t. Install line (21) and seals (22, 23). Cross-torque bolts at engine control valve to 100 ±5 in-lb. Cross-torque remaining bolts to 85 ±5 in-lb. Safetywire bolts.

u. Install hose (19) and seal (20). Cross-torque bolts to 85 ±5 in-lb. Safetywire bolts.

NOTE

Steps v through aa apply to engines not incorporating MD96 change.

v. Install seals (13, 15), adapter (14), and tube (12). Cross-torque bolts to 60 ±5 in-lb. Safetywire bolts.

w. Attach block (16) to valve. Torque bolts to 45 ±5 in-lb. Safetywire bolts.

x. Lubricate (Method G) tube (10). Install seal (11) and tube (10). Torque tube coupling nut to 160 ±10 in-lb. Safetywire coupling nut.

y. Install seals (8, 6), adapter (7), and tube (5). Cross-torque bolts to 60 ±5 in-lb. Safetywire bolts.

z. Attach block (9) to valve. Torque bolts to 45 ±5 in-lb. Safetywire bolts. Attach plugs to transducers as outlined in paragraph 3-17.

aa. Lubricate (Method G) tube (3). Install seal (4) and tube (3). Torque tube coupling nut to 160 ±10 in-lb. Safetywire coupling nut.

ab. Connect plugs (1, 2) as outlined in paragraph 3-15.

ac. Refer to section IV for post-maintenance test requirements.

CAUTION

Tube (37) must not be subjected to stress since alinement may be affected, or the duct inserts may be damaged.

NOTE

Steps ad through bb are used if tube (37) was not removed.

ad. Lubricate (Method K) 2 O-rings (39) and install in groove of spacer (38). Install and retain spacer in tube end with markings on flanges alined.

CAUTION

Extreme care must be used when installing the valve to prevent damaging sealing surfaces and to make sure that the spacer and O-rings remain in place.

ae. Carefully attach valve (49) to support (48). Tighten support-to-valve bolts so that valve can still be moved.

af. On engines incorporating MD96 change, install seal (43) and connect tube (42). Install bolts loosely. On engines not incorporating MD96 change, install parts indexed (12 through 15). Install bolts loosely.

ag. On engines incorporating MD96 change, install seal (18) and connect tube (17). Install bolts loosely. On engines not incorporating MD96 change, install parts indexed (5 through 8). Install bolts loosely.

ah. Install seal (20) and connect hose (19). Install bolts loosely.

ai. Install line (21) and seals (22, 23). Install bolts loosely.

aj. Cross-torque support-to-valve bolts to 350 ±10 in-lb.

ak. Cross-torque flange bolts for following parts to values indicated.

(1) Tube (5) (engines not incorporating MD96 change): 60 ±5 in-lb. Tube (17) (engines incorporating MD96 change): 85 ±5 in-lb.

(2) Hose (19): 85 ±5 in-lb.

(3) Tube (12) (engines not incorporating MD96 change): 60 ±5 in-lb. Line (42) (engines incorporating MD96 change): 85 ±5 in-lb.

(4) Line (21): 100 ±5 in-lb (engine control valve end), 85 ±5 in-lb (checkout valve end).

al. Check dimensions for tube (37). Dimensions must be within limits specified in figure 3-33.

am. Cross-torque flange bolts for tube (37) to 85 ±5 in-lb.

NOTE

Flange bolts for tube (37) may be safetywired following leak testing.

an. Safetywire all bolts torqued in steps aj through al.

ao. If reducer (45) and gasket (46) were removed, lubricate (Method J) gasket and lubricate (Method A) reducer (large end only). Install reducer and gasket. Torque reducer to 180-230 in-lb.

ap. Connect hose (44) to reducer (45). Do not lubricate reducer threads. Torque hose coupling nut, and record torque value during last 1/2 turn before flare seats. Recorded torque must be 35-200 in-lb. Continue to torque coupling nut to 270-345 in-lb above recorded torque.

aq. Lubricate (Method J) gasket (36) and ring (35) and lubricate (Method A) longer end of elbow (33). Assemble elbow (33), nut (34), ring (35), and gasket (36). Install elbow and aline for connection of hose (32). Torque nut (34) to 75-100 in-lb. Safetywire nut.

ar. Connect hose (32) to elbow (33). Do not lubricate threads of elbow. Torque hose coupling nut, and record torque value during last 1/2 turn before flare seats. Recorded torque must be 35-300 in-lb. Continue to torque coupling nut to 180-230 in-lb above recorded torque.

as. If valve was replaced, lubricate (Method J) gasket (30) and lubricate (Method A) plug (31). Install gasket and plug (31). Torque plug to 30-40 in-lb. Safetywire plug.

at. On engines not incorporating MD150 or MD151 change, lubricate (Method J) gasket (29) and ring (28) and lubricate (Method A) longer end of elbow (26). Assemble elbow, nut (27), ring (28), and gasket (29). Install elbow and aline with tube (24). Torque nut (27) to 75-100 in-lb. Safetywire nut.

au. On engines not incorporating MD150 or MD151 change, lubricate (Method G) tube (24). Install seal (25) and tube (24). Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

NOTE

Steps av through az apply to engines not incorporating MD96 change.

av. Attach block (16) to valve. Torque bolts to 45 ±5 in-lb. Safetywire bolts. Attach connector as outlined in paragraph 3-17.

aw. Lubricate (Method G) tube (10). Install seal (11) and tube (10). Torque tube coupling nut to 160 ±10 in-lb. Safetywire coupling nut.

ax. Install seals (8, 6), adapter (7), and tube (5). Cross-torque bolts to 60 ±5 in-lb. Safetywire bolts.

ay. Attach block (9) to valve. Torque bolts to 45 ±5 in-lb. Safetywire bolts. Attach connector to transducer as outlined in paragraph 3-17.

az. Lubricate (Method G) tube (3). Install seal (4) and tube (3). Torque tube coupling nut to 160 ±10 in-lb. Safetywire coupling nut.

ba. Connect plugs (1, 2) as outlined in paragraph 3-15.

bb. Refer to section IV for post-maintenance test requirements.

3-195. ENGINE AND GSE HYDRAULIC SUPPLY CHECK VALVES.

3-196. The engine and GSE hydraulic supply check valves of the engine control valve may be replaced with the engine control valve installed on the engine.

3-197. REMOVING ENGINE AND GSE HYDRAULIC SUPPLY CHECK VALVES. (See figure 3-55.) Specified lubricating procedures (methods) are outlined in section I.

NOTE

Steps a and b remove valve (3).
Steps c through e remove valve (11).

a. Remove seal (2). Remove cap that supports line at engine centerline.

b. Remove valve (3), retainers (4), and packing (5).

c. Disconnect tube (6) at fuel valve.

d. Disconnect tube (6) at valve. Remove tube (6), spacers (8, 10), and O-rings (7, 9).

e. Remove valve (11), retainers (12), and packing (13).

f. Lubricate (Method A) closure fasteners with lubricant grease RB0140-012 (Rocketdyne) before installing closures on threaded flanged ports of valves (3, 11) and on engine control valve.

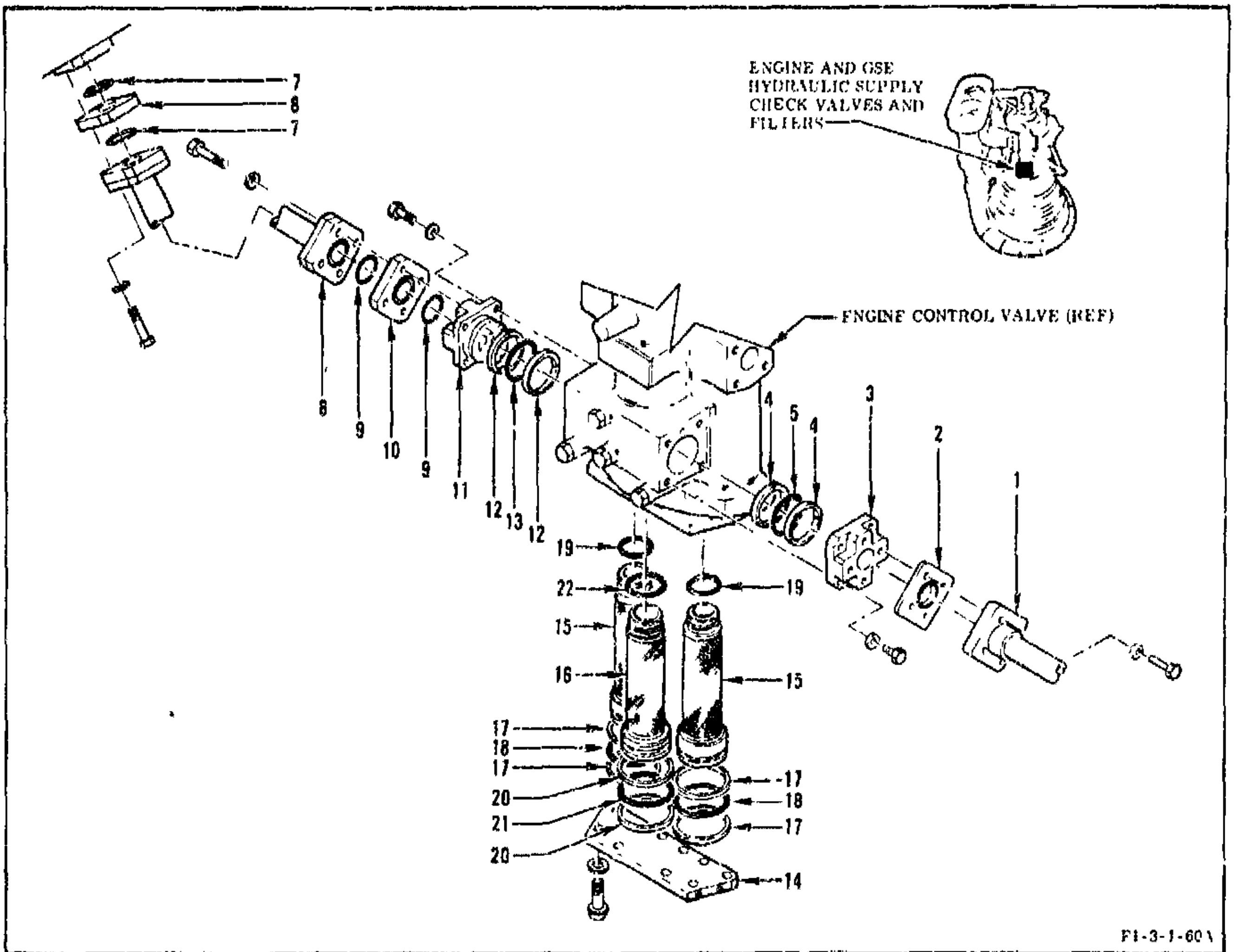
3-198. INSTALLING ENGINE AND GSE HYDRAULIC SUPPLY CHECK VALVES. (See figure 3-55.) Specified lubricating procedures (methods) are outlined in section I.

NOTE

Steps a through d install parts indexed (1 through 5). Steps e through h install parts indexed (6 through 13).

a. Lubricate (Method M) packing (5) with hydraulic fluid (MIL-H-5606). Install packing and retainers (4) on valve (3).

b. Install valve (3), and cross-torque bolts to 80-100 in-lb. Safetywire bolts.



1 Line	7 O-ring	13 Packing	19 Packing
2 Seal	8 Spacer	14 Cover	20 Retainer
3 Valve	9 O-ring	15 Filter	21 Packing
4 Retainer	10 Spacer	16 Filter	22 Packing
5 Packing	11 Valve	17 Retainer	
6 Tube	12 Retainer	18 Packing	

Figure 3-55. Engine and GSE Hydraulic Supply Check Valves and Filters

c. Install seal (2). Connect line (1), and cross-torque bolts to 85 ±5 in-lb. Safetywire bolts.

d. Install line support cap at engine centerline. Torque nuts to 45 ±2 in-lb.

e. Lubricate (Method M) packing (13) with hydraulic fluid (MIL-H-5606). Install packing and retainers (12) on valve (11).

f. Install valve (11), and cross-torque bolts to 80-100 in-lb. Safetywire bolts.

g. Aline engine supply tube (6) and spacers (8, 10) to valve (11) as outlined in paragraph 3-104A.

h. Lubricate (Method K) 2 O-rings (9) with lubricant grease RB0140-012 (Rocketdyne) and install in grooves of spacer (10).

i. Lubricate (Method K) 2 O-rings (7) with lubricant grease RB0140-012 (Rocketdyne) and install in grooves of spacer (8) and flange groove.

CAUTION

Spacers must not be rotated during assembly in tube or when tube is installed. Damage to O-rings may result.

iA. Aline markings on flanges and install spacers (8, 10) in tube.

1B. Carefully install tube. Make sure O-rings in grooves are in place, and cross-torque bolts at valve end to 85 ±5 in-lb; then cross-torque bolts at duct end to 85 ±5 in-lb.

1C. Safetywire bolts and remove markings from flanges.

j. Refer to section IV for post-maintenance test requirements.

3-199. ENGINE CONTROL VALVE FILTERS.

3-200. The engine control valve filters may be removed and replaced with the engine control valve installed on the engine.

3-201. REMOVING ENGINE CONTROL VALVE FILTERS. (See figure 3-55.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove cover (14).

c. Remove filters (15, 16) using a 3/8-24 threaded T-handle.

d. Remove retainers (17, 20) and packings (18, 19, 21, 22) from filters.

e. Lubricate (Method A) closure fasteners with lubricant grease RB0140-012 (Rocketdyne) before installing closure on engine control valve.

3-202. INSTALLING ENGINE CONTROL VALVE FILTERS. (See figure 3-55.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Lubricate packings (18, 19, 21, 22) with hydraulic fluid (MIL-H-5606) and install packings on filters (15, 16).

c. Install filters (15, 16) by hand or with a 3/8-24 threaded T-handle.

d. Install cover and torque bolts to 320-390 in-lb. Safetywire bolts.

e. Refer to section IV for post-maintenance test requirements.

3-202A. ENGINE CONTROL VALVE COVER PLATE AND RETURN PLUG.

3-202B. When hydraulic leakage is evident at the cover plate retaining the slave pilot valve and return plug in either the start solenoid end or stop solenoid end of the engine control valve, the cover plate may be removed and reinstalled with the engine control valve installed on the engine. Disassembly is limited to removing the cover plate and return plug to make inspections, measure specified diameters, and replace packing and retainers, and return plug if required. The slave pilot valve must not be disturbed more than the internal spring force will move the valve (O-ring must not leave cavity). Extreme care must be taken to prevent contaminants from entering the engine control valve during maintenance. All equipment used for measuring must be clean.

3-202C. REMOVING ENGINE CONTROL VALVE COVER PLATE AND RETURN PLUG. (See figure 3-55A.)

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause injury or death.

• 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.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect electrical power and vent hydraulic pressure from the engine.

c. Clean cover plate and adjacent area by handwiping with a clean, lint-free cloth moistened with trichloroethylene (MIL-T-27602) or cleaning compound (MIL-C-81302).

NOTE

Steps d through g remove and inspect parts from the start solenoid end of the engine control valve.

d. Uniformly loosen screws (1) and washers (2) that secure cover plate (3) on engine control valve, and remove cover plate. If it is evident during removal that the slave pilot valve and/or return plug (4) are being pushed from their bores, more than normal spring action of the slave pilot valve (1/4-inch maximum), loosen the cover plate only enough so that a visual inspection can be made of the slave pilot valve and return plug bores to define leakage source.

e. After determining leakage source, drain engine hydraulic system. If leakage is from the slave pilot valve bore, replace engine control valve. Refer to paragraph 3-192 for engine control valve removal and installation procedures. If leakage is from the return plug bore, remove return plug (4), packing (5), and retainers (6). A 4-40 screw may be used to remove return plug, if required.

f. Using a ball gage, or equivalent, measure return plug bore diameter. The diameter must be 0.249 (+0.002, -0.000) inch.

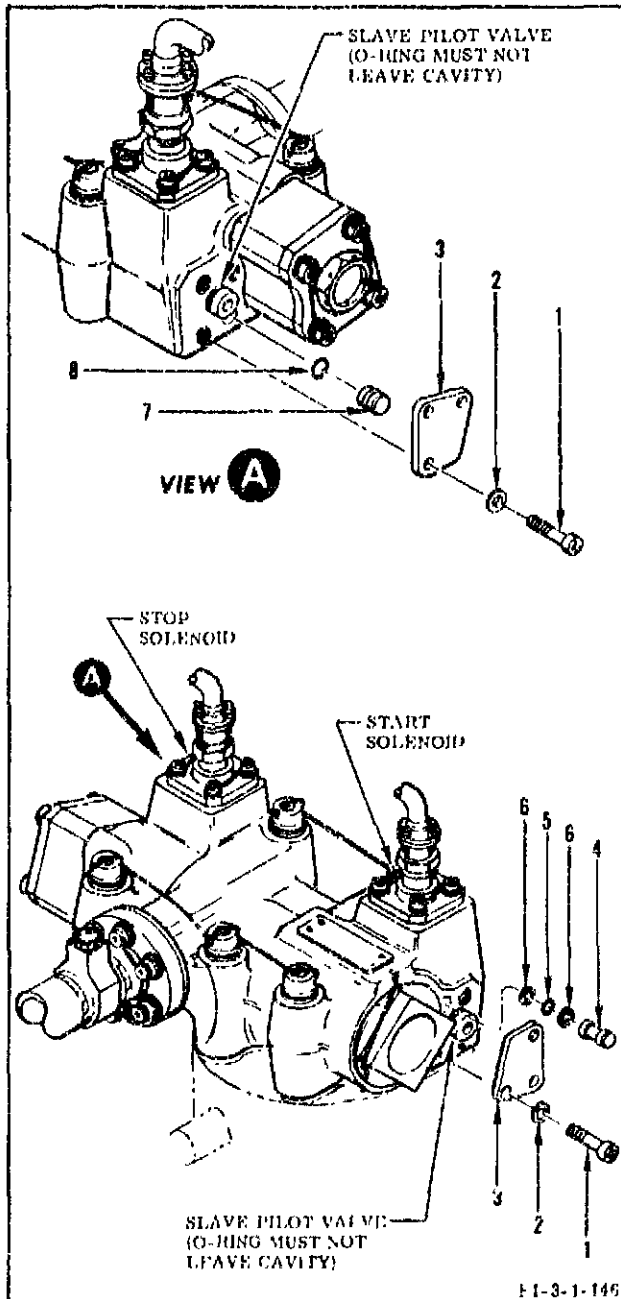
g. Visually inspect return plug bore for imperfections that could cause leakage. Imperfections in return plug bore will require replacement of engine control valve. Do not rework return plug bore, since contamination can be introduced downstream of filters. Refer to paragraph 3-192 for engine control valve removal and installation procedures.

NOTE

Steps h through k remove and inspect parts from the stop solenoid end of the engine control valve.

h. Uniformly loosen screws (1) and washers (2) that secure cover plate (3) on engine control valve, and remove cover plate. If it is evident during removal that the slave pilot valve and/or return plug (7) are being pushed from their bores, more than normal spring action of the slave pilot valve (1/4-inch maximum), loosen the cover plate only enough so that a visual inspection can be made of the slave pilot valve and return plug bores to define leakage source.

i. After determining leakage source, drain engine hydraulic system. If leakage is from the slave pilot valve bore, replace engine control valve. Refer to paragraph 3-192 for engine control valve removal and installation procedures. If leakage is from the return plug bore, remove return plug (7) and packing (8). An 8-32 screw may be used to remove return plug, if required.



1	Screw	5	Packing
2	Washer	6	Retainer
3	Cover plate	7	Return plug
4	Return plug	8	Packing

Figure 3-55A. Engine Control Valve Cover Plate and Return Plug

j. Using a ball gage, or equivalent, measure plug bore diameter. The diameter must be 0.375 (+0.002, -0.000) inch.

k. Visually inspect return plug bore for imperfections that could cause leakage. Imperfections in return bore will require replacement of engine control valve. Do not rework return plug bore, since contamination can be introduced downstream of filters. Refer to paragraph 3-192 for engine control valve removal and installation procedures.

3-202D. INSTALLING ENGINE CONTROL VALVE COVER PLATE AND RETURN PLUG. (See figure 3-55A.) The lubricant used in this procedure is hydraulic fluid (MIL-H-5606). Specified lubricating procedures (methods) are outlined in section I. Lubricate packings by method specified, and lubricate other parts by thoroughly wetting and allowing excess fluid to drain off. All equipment used for measuring, and parts that are installed, must be clean.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

NOTE

Steps b through d inspect and install parts on start solenoid end of engine control valve.

b. Measure the following dimensions on return plug (4):

(1) Return plug diameter at packing groove 0.139 (+0.000, -0.002) inch.

(2) Packing groove depth 0.0535 to 0.0550 inch.

c. Lubricate (Method M) new packing (5) and install new retainers (6) and packing (5) on return plug (4). Install return plug into engine control valve.

d. Install cover plate (3) using washers (2) and screws (1). Torque screws to 20-25 in-lb. Safetywire screws.

NOTE

Steps e through g inspect and install parts on stop solenoid end of engine control valve.

e. Measure the following dimensions on return plug (7):

(1) Return plug diameter at packing groove 0.271 (+0.000, -0.002) inch.

(2) Packing groove depth 0.0505 to 0.0520 inch.

f. Lubricate (Method M) new packing (8) and install on return plug (7). Install return plug into engine control valve.

g. Install cover plate (3) using washers (2) and screws (1). Torque screws to 20-25 in-lb. Safetywire screws.

h. Leak-test engine control valve-to-cover plate joint. (Refer to section IV for post-maintenance test requirements for engine control valve.)

3-202E. <u>ENGINE CONTROL VALVE OVERRIDE STOP AND GUIDE</u>.

3-202F. When hydraulic leakage is evident at the override port end of the engine control valve, the engine control valve may be disassembled while installed on the engine to replace packings and retainers indicated in figure 3-55B.

3-202G. REMOVING ENGINE CONTROL VALVE OVERRIDE STOP AND GUIDE. (See figure 3-55B.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect electrical power and vent hydraulic pressure from engine.

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause injury or death.

- 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.

c. Clean stop, guide, and adjacent area by handwiping with a clean, lint-free cloth moistened with trichloroethylene (MIL-T-27602) or cleaning compound (MIL-C-81302).

d. Disconnect hose (1).

e. Remove reducer (2) and gasket (3).

f. Obtain 2 pieces of 5/16-24 threaded stainless-steel stock, having a minimum length of 5 inches, and two 5/16-24 nuts.

g. Remove 2 screws (4) and washers (5), located 180 degrees apart. Lubricate (Method A) threaded stock and install pieces of threaded stock in place of screws. Fingertighten threaded stock a minimum of 5 turns or until threaded stock bottoms.

h. Install a 5/16-24 nut on each piece of threaded stock and tighten nuts to contact stop (6).

i. If leakage occurred between guide (13) and engine control valve, use pressure-sensitive tape (Federal Specification PPP-T-60), or equivalent, and securely tape stop (6) to guide (13) to permit removal of stop (6), internal parts (7 through 12), and guide (13) as an assembly.

j. Remove 2 remaining screws (4) and washers (5).

NOTE

If tape is securing stop (6) to guide (13), backing off the nuts in the following step will cause the tape to be loaded to approximately 15 pounds from the compression pre-load of spring (12).

k. Evenly back off nuts on threaded stock until spring compression pre-load against guide (13) is relaxed; then remove nuts.

l. If stop (6) and guide (13) are taped together, carefully remove the taped parts as an assembly.

m. If stop (6) and guide (13) are not taped together, carefully remove parts (6 through 13) in sequence.

n. Do not remove spring that contacts guide (13) from engine control valve.

3-202H. INSTALLING ENGINE CONTROL VALVE OVERRIDE STOP AND GUIDE. (See figure 3-55B.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Lubricate (Method M) packing (7) with hydraulic fluid (MIL-H-5606), and install packing and retainers (8) on guide (13).

c. Carefully install guide (13) on threaded stock in engine control valve.

d. If stop (6) and guide (13) are taped together, proceed to step h.

e. Lubricate (Method N) packing (10) with hydraulic fluid (MIL-H-5606) and install packing and retainers (11) on piston (9).

f. Lubricate (Method M) packing (7) with hydraulic fluid (MIL-H-5606) and install packing and retainers (8) on stop (6).

g. Install spring (12), piston (9), and stop (6) on threaded stock in engine control valve, seating spring and piston in guide (13).

h. Install 5/16-24 nuts on threaded stock in engine control valve and evenly tighten nuts until internal springs are compressed and guide (13) seats into engine control valve.

i. If stop (6) and guide (13) are taped together, remove tape.

j. Lubricate (Method A) 2 screws (4) with lubricant grease RB0140-012 (Rocketdyne) and install screws and 2 washers (5) fingertight.

k. Loosen nuts on threaded stock and remove both pieces of threaded stock.

l. Lubricate (Method A) remaining screws (4) with lubricant grease RB0140-012 (Rocketdyne) and install screws and washers (5) fingertight.

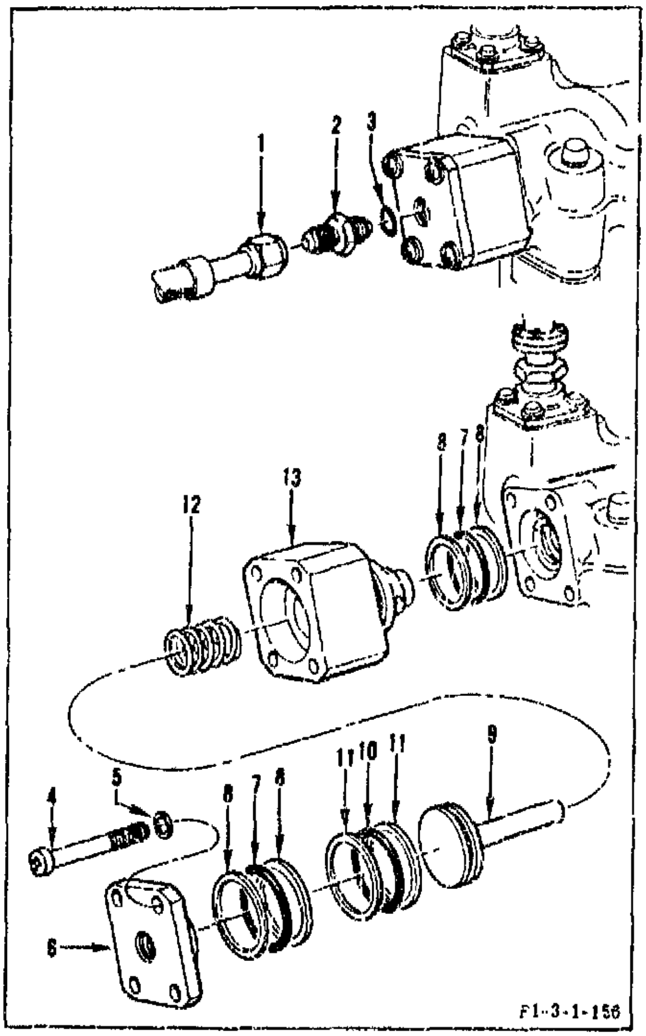
m. Cross-torque screws (4) to 100-140 in-lb. Safetywire screws.

n. Lubricate (Method J) gasket (3) and (Method A) threads of reducer (2) (large end only) with lubricant grease RB0140-012 (Rocketdyne).

o. Install gasket (3) and reducer (2). Torque reducer to 180-230 in-lb.

p. Connect hose (1) to reducer (2). Do not lubricate threads. Torque hose coupling nut, and record torque value during last 1/2 turn prior to seating of hose flare. Recorded torque must be 35-200 in-lb. Continue to torque coupling nut to 270-345 in-lb above recorded torque.

q. Leak-test engine control valve override joints. (Refer to section IV for post-maintenance test requirements.)



1	Hose	8	Retainer
2	Reducer	9	Piston
3	Gasket[a]	10	Packing
4	Screw	11	Retainer
5	Washer	12	Spring
6	Stop	13	Guide
7	Packing		

(a) Allowable alternate packing (age controlled).

Figure 3-55B. Engine Control Valve Override Stop and Guide

3-202J. FOUR-WAY SOLENOID VALVE.

3-202K. The four-way solenoid valve may be replaced with the engine control valve installed on the engine.

3-202L. REMOVING FOUR-WAY SOLENOID VALVE. (See figure 3-55C.) Lubricate (Method A) all closure fasteners used on valve inserts with lubricant grease RB0140-012 (Rocketdyne). Specified lubricating procedures (methods) are outlined in section I.

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

- 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.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect electrical power and vent hydraulic pressure from the engine.

c. Clean engine control valve and adjacent area by hardwiping with a clean, lint-free cloth moistened with trichloroethylene (MIL-T-27602) or cleaning compound (MIL-C-81302).

d. Provide a suitable container to catch residual fluid as equipment is disconnected.

e. Disconnect plugs (1, 2) as outlined in paragraph 3-14.

f. Disconnect hose (3) and remove reducer (4) and gasket (5).

g. Remove nuts (6), washers (7), and bolts (8) securing line (13) to actuator return line; then remove seal (9).

h. Remove bolts (10) and washers (11) securing line (13) to engine control valve; then remove line (13) and seal (12).

i. Enclose engine control valve in clean plastic sheet and strip (Federal Specification L-P-378, Type II), or equivalent. The enclosure must prevent entry of foreign objects or contamination from overhead structures, wind, or adjacent engine areas.

j. Remove bolts (14, 15) and washers (16) securing valve (17) to manifold.

k. Carefully remove valve (17) and seal (18) from manifold.

l. If four-way solenoid valve is removed for replacement with a spare valve, replace soft goods on removed valve before placing valve in spares inventory.

3-202M. INSTALLING FOUR-WAY SOLENOID VALVE. (See figure 3-55C.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne). Specified lubricating procedures are outlined in section I.

a. If installing a replacement four-way solenoid valve, verify that four-way solenoid valve preinstallation tests outlined in section I have been performed.

b. Position seal (18) and valve (17) on manifold; then secure valve to manifold with bolts (14, 15) and washers (16). Torque bolts to 320-390 in-lb. Safetywire bolts.

c. Install line (13) between valve (17) and actuator return line as follows:

(1) Loosely secure line (13) and seal (12) to valve (17) with bolts (10) and washers (11).

(2) Loosely secure line (13) and seal (9) to actuator return line with bolts (8), washers (7), and nuts (6).

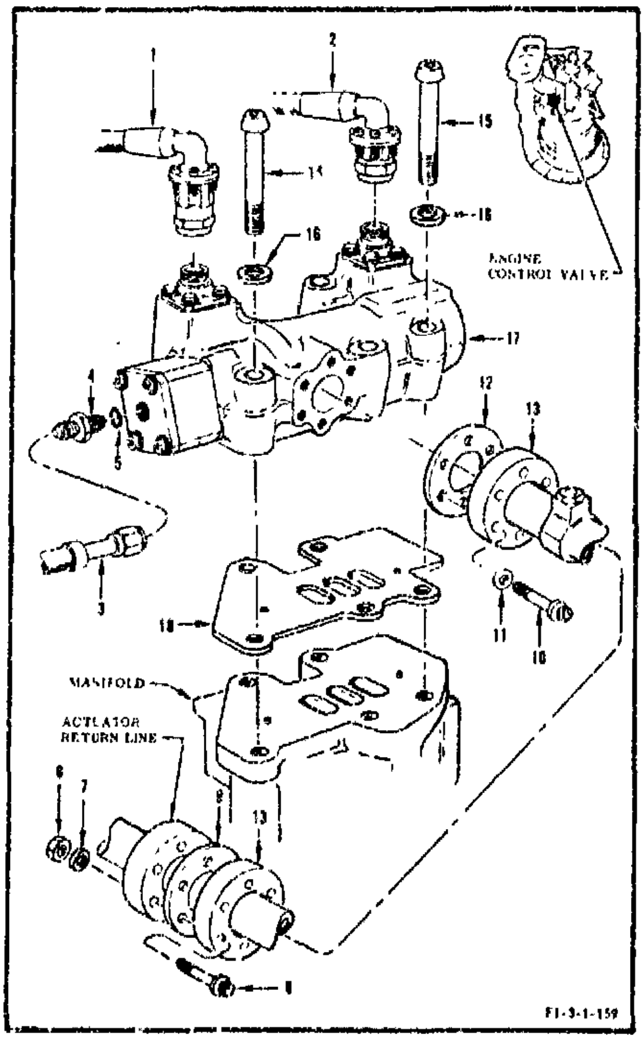
(3) Cross-torque bolts (10) to 100 ±5 in-lb. Safetywire bolts. Cross-torque nuts (6) to 85 ±5 in-lb.

d. Lubricate (Method J) gasket (5) and (Method A) large end of reducer (4); then install reducer and gasket. Torque reducer to 180-230 in-lb.

e. Connect hose (3) to reducer (4). Do not lubricate reducer threads. Torque hose coupling nut, and record torque value during last 1/2-turn before flare seats. Recorded torque must be 35-200 in-lb. Continue to torque coupling nut to 270-345 in-lb above recorded torque.

f. Connect plugs (1, 2) as outlined in paragraph 3-15.

g. Refer to section IV for post-maintenance test requirements.



1	Plug	10	Bolt
2	Plug	11	Washer
3	Hose	12	Seal
4	Reducer	13	Line
5	Gasket[a]	14	Bolt
6	Nut	15	Bolt
7	Washer	16	Washer
8	Bolt	17	Valve
9	Seal	18	Seal

(a) Allowable alternate packing (age controlled)

Figure 3-55C. Four-Way Solenoid Valve

3-203. REDUNDANT SHUTDOWN VALVE.

3-204. REMOVING REDUNDANT SHUTDOWN VALVE. (See figure 3-56.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect plug (1) as outlined in paragraph 3-14.

c. Remove tube (2).

d. If valve will be replaced, remove elbow (3), nut (4), ring (5), and gasket (6).

e. On engines incorporating MD142 change, remove tube (7) and seals (8).

f. Disconnect hose (9), and remove seal (10).

g. Disconnect hose (11), and remove seal (12).

h. Remove valve (13) from support.

i. If valve support requires removal, remove bolts that attach the 2 halves of support together, then remove bolts from tooling rings.

3-205. INSTALLING REDUNDANT SHUTDOWN VALVE. (See figure 3-56.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne). Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

aA. If valve support was removed, install halves of support to tooling rings of thrust chamber. Torque nuts to 375 ±25 in-lb. Torque bolts that attach support halves together to 45 ±5 in-lb.

b. Install valve (13). Cross-torque bolts to 90 ±5 in-lb.

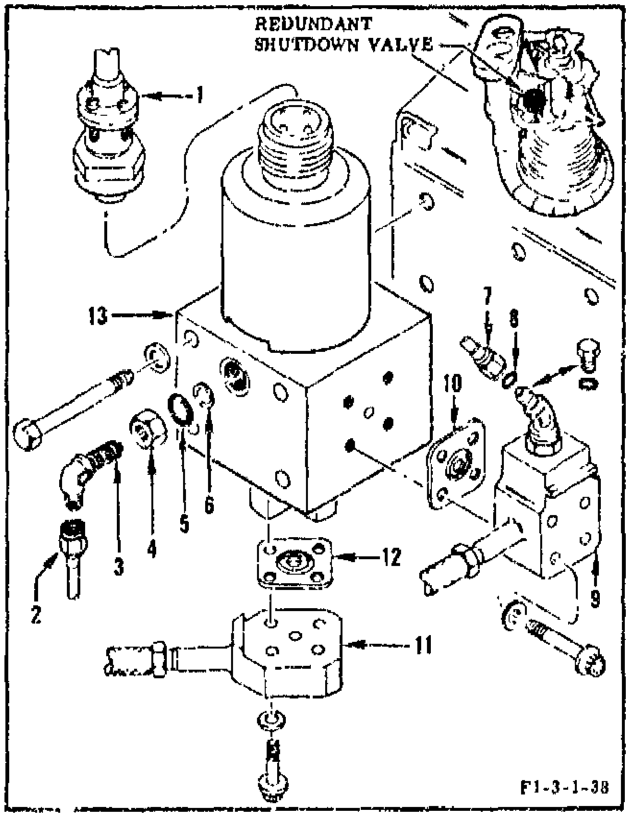
c. Install seal (12) and hose (11). Cross-torque bolts to 90 ±5 in-lb. Safetywire bolts.

d. Install seal (10) and hose (9). Cross-torque bolts to 90 ±5 in-lb. Safetywire bolts.

e. Lubricate (Method G) tube (7). Lubricate (Method A) unions for attaching tube (7). Install seals (8) and tube (7). Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

f. If parts indexed (3 through 6) were removed, lubricate (Method J) gasket (6) and lubricate (Method A) elbow (3). Install elbow (3), nut (4), ring (5), and gasket (6). Position elbows for tube (2), and torque nut (4) to 75-100 in-lb. Safetywire nut.

g. Lubricate (Method G) tube (2) and install tube. Torque tube coupling nuts to 160 ±25 in-lb. Safetywire coupling nuts.



1	Plug	8	Seal
2	Tube	9	Hose
3	Elbow	10	Seal
4	Nut	11	Hose
5	Ring	12	Seal
6	Gasket	13	Valve
7	Tube		

Figure 3-56. Redundant Shutdown Valve

h. Connect plug (1) as outlined in paragraph 3-15.

i. Refer to section IV for post-maintenance test requirements.

3-206. THRUST OK PRESSURE SWITCHES.

3-207. REMOVING THRUST OK PRESSURE SWITCHES. (See figure 3-57.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect plug (1) from applicable pressure switch, as outlined in paragraph 3-14.

c. Remove switch (2) and orifice plate (3).

3-208. INSTALLING THRUST OK PRESSURE SWITCHES. (See figure 3-57.)

a. If installing a replacement pressure switch, verify that pressure switch preinstallation tests outlined in section I have been performed.

aA. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install orifice plate (3) and switch (2). Torque smaller bolts to 90 ±10 in-lb. Torque larger bolts to 125 ±10 in-lb. Safetywire bolts.

c. Connect plug (1) to applicable pressure switch, as outlined in paragraph 3-15.

d. Refer to section IV for post-maintenance test requirements.

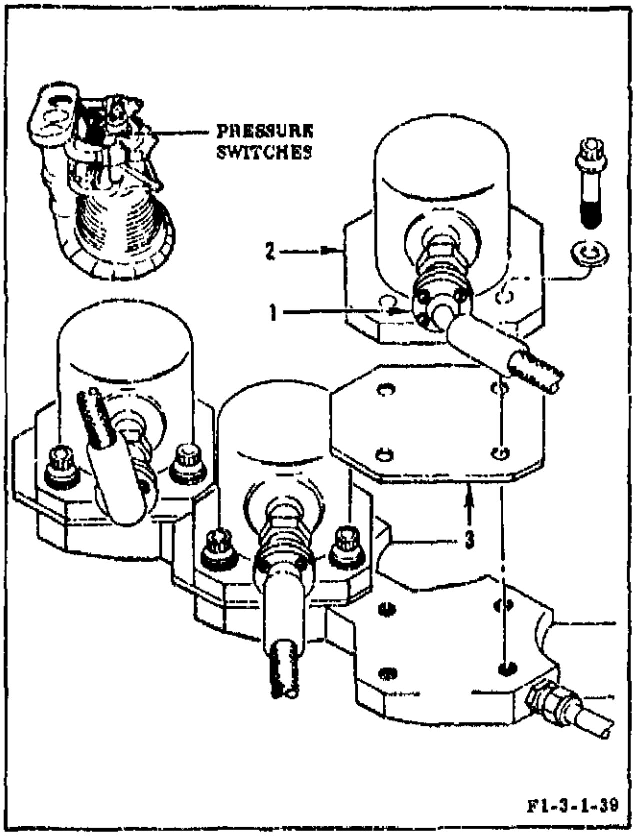
3-209. INERT PREFILL CHECK VALVE.

3-210. REMOVING INERT PREFILL CHECK VALVE. (See figure 3-58.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

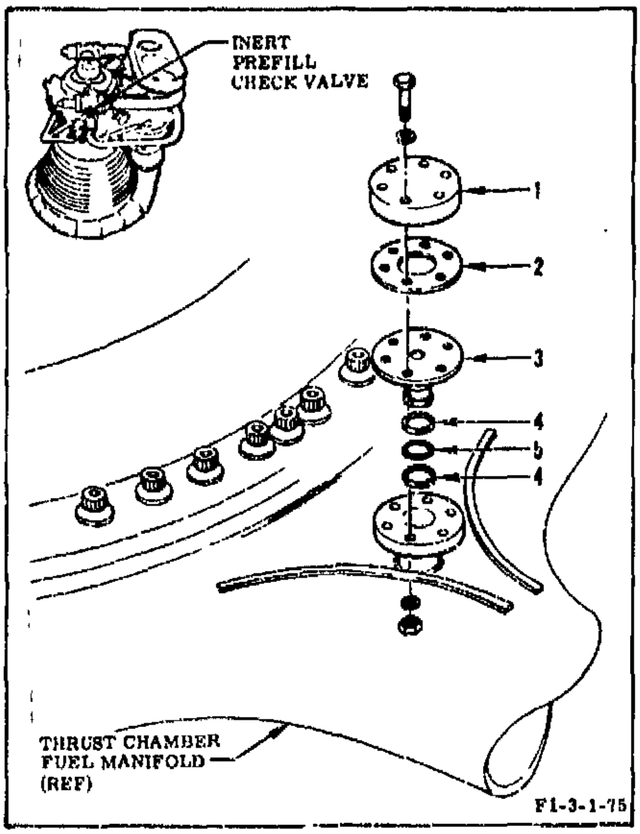
b. Remove plate (1), seal (2), and valve (3).

c. Remove retainers (4) and packing (5) from valve.



1 Plug 2 Switch 3 Orifice plate

Figure 3-57. Thrust OK Pressure Switches



1 Plate
2 Seal
3 Valve
4 Retainer
5 Packing

Figure 3-58. Inert Prefill Check Valve

3-211. INSTALLING INERT PREFILL CHECK VALVE. (See figure 3-56.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Lubricate (Method J) retainers (4) and packing (5) with lubricant grease RB0140-012 (Rocketdyne). Install parts on valve (3).

c. Install valve (3), seal (2), and plate (1).

d. Cross-torque nuts to 100 ±10 in-lb.

e. Refer to section IV for post-maintenance test requirements.

3-212. CHECKOUT VALVE.

3-213. REMOVING CHECKOUT VALVE. (See figure 3-59.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect plug (1) as outlined in paragraph 3-14.

c. Disconnect tube (2). If valve will be replaced, remove elbow (3), nut (4), ring (5), and gasket (6).

d. Disconnect hose (7), and remove seal (8).

e. Disconnect line (9), and remove seal (10).

f. Disconnect hose (11), and remove seal (12).

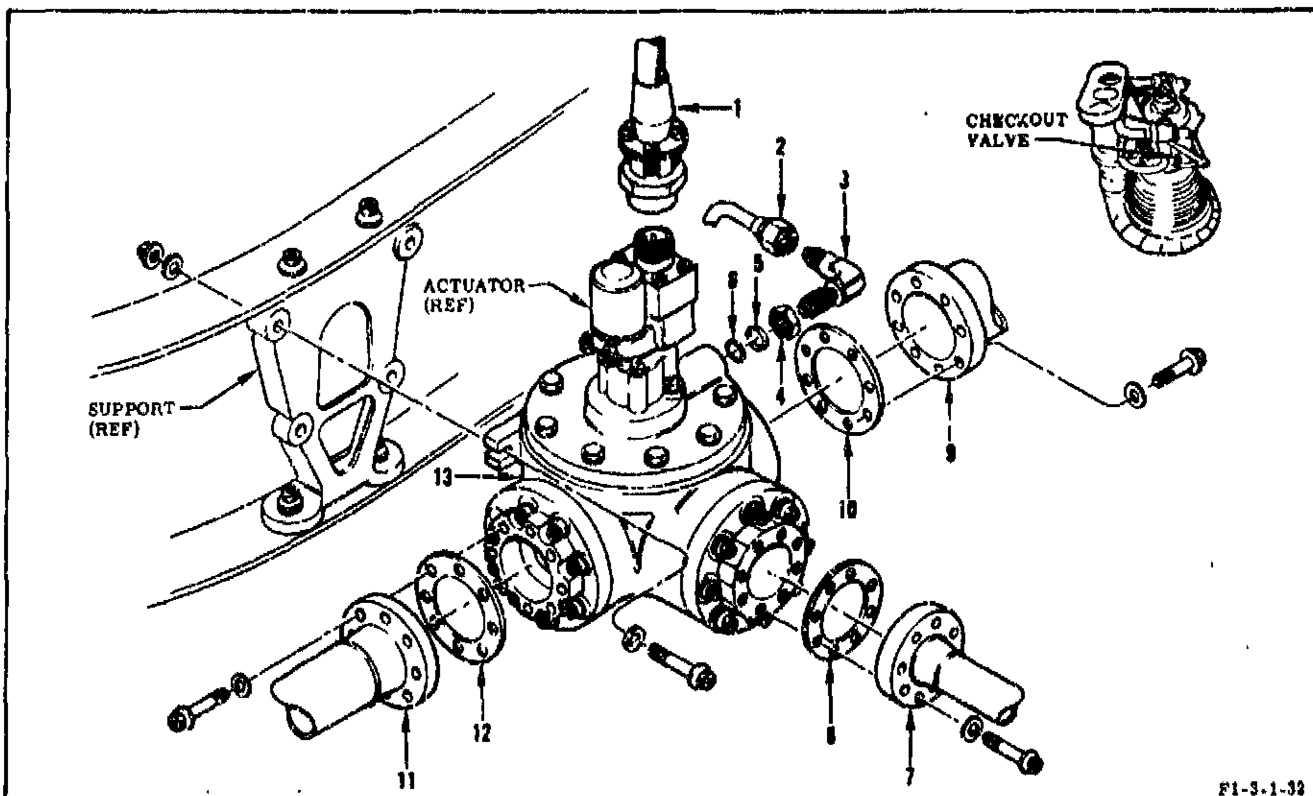
g. Separate valve (13) from support, and remove valve.

h. If valve support requires removal, remove bolts from tooling rings and remove support.

3-214. INSTALLING CHECKOUT VALVE. (See figure 3-59.) Specified lubricating procedures (methods) are outlined in section I. If the checkout valve is replaced, the replacement valve must have been functionally tested within the previous 6-month period.

a. If installing a replacement checkout valve, verify that checkout valve preinstallation tests outlined in section I have been performed.

aA. Observe safety, and contamination and damage prevention requirements outlined in section I.



1	Plug	4	Nut	7	Hose	10	Seal
2	Tube	5	Ring	8	Seal	11	Hose
3	Elbow	6	Gasket	9	Line	12	Seal
						13	Valve

Figure 3-59. Checkout Valve

aA. If valve support requires installing, aline support between thrust chamber tooling rings at holes numbered 45 and 47. Torque nuts to 220 ±20 in-lb.

b. Install valve (13), and secure to support. Torque nuts to 50 ±2 in-lb.

c. Install seal (12), and connect hose (11). Cross-torque bolts to 185 ±5 in-lb. Safetywire bolts.

d. Install seal (10), and connect line (9). Cross-torque bolts to 185 ±5 in-lb. Safetywire bolts.

e. Install seal (8), and connect hose (7). Cross-torque bolts to 75 ±5 in-lb. Safetywire bolts.

f. If parts indexed (3 through 6) were removed, lubricate (Method J) gasket (6) and (Method A) elbow (3) with lubricant grease RB0140-012 (Rocketdyne). Install gasket (6), ring (5), nut (4), and elbow (3). Aline elbow with tube (2), and torque nut (4) to 150-200 in-lb. Safetywire nut.

g. Lubricate (Method G) tube (2) using lubricant grease RB0140-012 (Rocketdyne). Install tube and torque coupling nut to 270-345 in-lb.

h. Connect plug (1) as outlined in paragraph 3-15.

i. Refer to section IV for post-maintenance test requirements.

3-215. CHECKOUT VALVE ACTUATOR.

3-216. REMOVING CHECKOUT VALVE ACTUATOR.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. See figure 3-59 for location of actuator, and disconnect plug as outlined in paragraph 3-14.

CAUTION

Electrical power simultaneously applied to pins A and B will damage equipment.

c. Make sure valve is in ground position. Apply 28 vdc as follows to obtain desired position:

(1) Ground position: pin B (+), pin E (-)

(2) Run position: pin A (+), pin E (-)

d. Remove power, then remove screws attaching actuator to valve cover; then remove actuator and remove packing from groove in actuator base.

3-217. INSTALLING CHECKOUT VALVE ACTUATOR. Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

aA. Connect a drain hose between quick-disconnect on checkout valve return hose and 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 when checking ball breakaway, running, and seating torques.

aB. Using ball position indicator T-7037831 and a suitable torque wrench, check that ball breakaway, running, and seating torques do not exceed 100 in-lb. Leave valve in ground position.

CAUTION

Electrical power simultaneously applied to pins A and B will damage equipment.

b. Make sure actuator is in ground position. If required, apply 28 vdc, as follows, to obtain desired position.

(1) Ground position: pin B (+), pin E (-)

(2) Run position: pin A (+), pin E (-)

bA. Lubricate (Method J) packing with lubricant grease RB0140-012 (Rocketdyne), and install packing in groove of actuator.

bB. Install actuator on valve cover and torque screws to 13-15 in-lb. Safetywire screws.

c. Connect plug as outlined in paragraph 3-15.

d. Refer to section IV for post-maintenance test requirements.

3-218. GAS GENERATOR FUEL DUCT.

3-219. REMOVING GAS GENERATOR FUEL DUCT. (See figure 3-60.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Support duct to prevent excessive deflection of flexible joints. Deflection must not exceed 6 degrees for complete duct.

c. Disconnect duct (1) at No. 2 fuel high-pressure duct, and remove and retain orifice plate (2).

d. Disconnect duct at gas generator ball valve, and remove seal (3) and deflector (4).

e. Lubricate (Method A) gas generator ball valve fuel inlet closure fasteners with lubricant grease RB0140-012 (Rocketdyne).

3-220. INSTALLING GAS GENERATOR FUEL DUCT. (See figure 3-60.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Position duct (1) for installation. Support duct to prevent excessive deflection of flexible joints. Deflection must not exceed 6 degrees for complete duct.

c. Install deflector (4) in end of duct. Install seal (3), and connect duct to ball valve. Cross-torque bolts to 550 ±10 in-lb. Safetywire bolts.

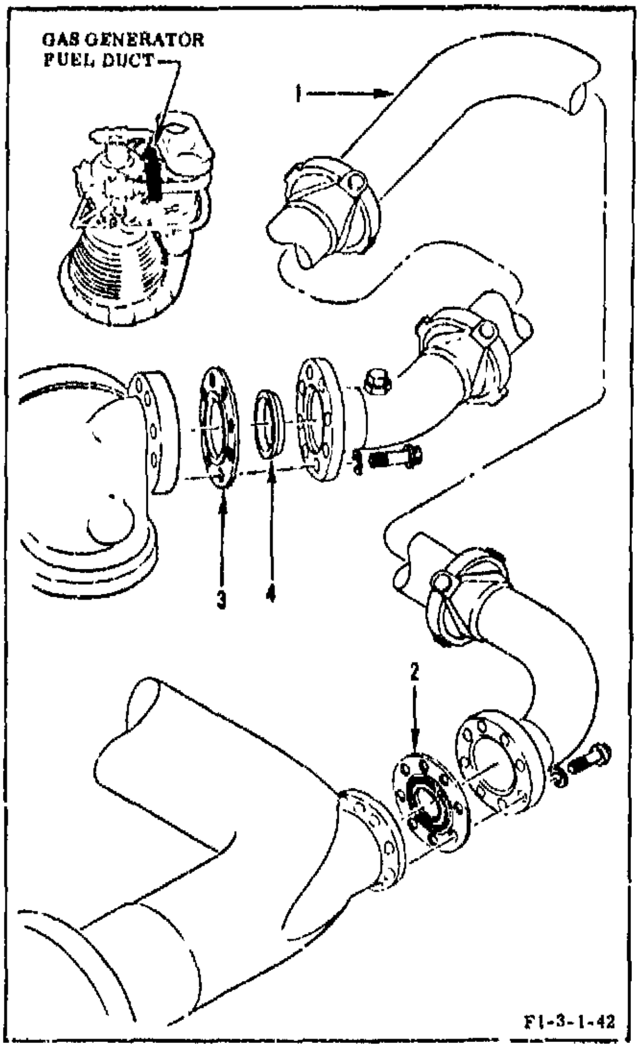
d. Install orifice plate (2). Cross-torque bolts to 280 ±10 in-lb. Safetywire bolts, and install an aluminum seal on lockwire.

dA. Apply a thin, even coat of corrosion preventative RB0210-016 (Rocketdyne) to gimbal yokes. Do not apply corrosion preventative to bellows.

NOTE

Corrosion preventative RB0210-016 must be thoroughly mixed at 70° to 95° F immediately prior to each application.

e. Refer to section IV for post-maintenance test requirements.



1 Duct
2 Orifice plate
3 Seal
4 Deflector

Figure 3-60. Gas Generator Fuel Duct

3-221. GAS GENERATOR OXIDIZER DUCT (DUCT END).

3-222. REMOVING GAS GENERATOR OXIDIZER DUCT (DUCT END). (See figure 3-61.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

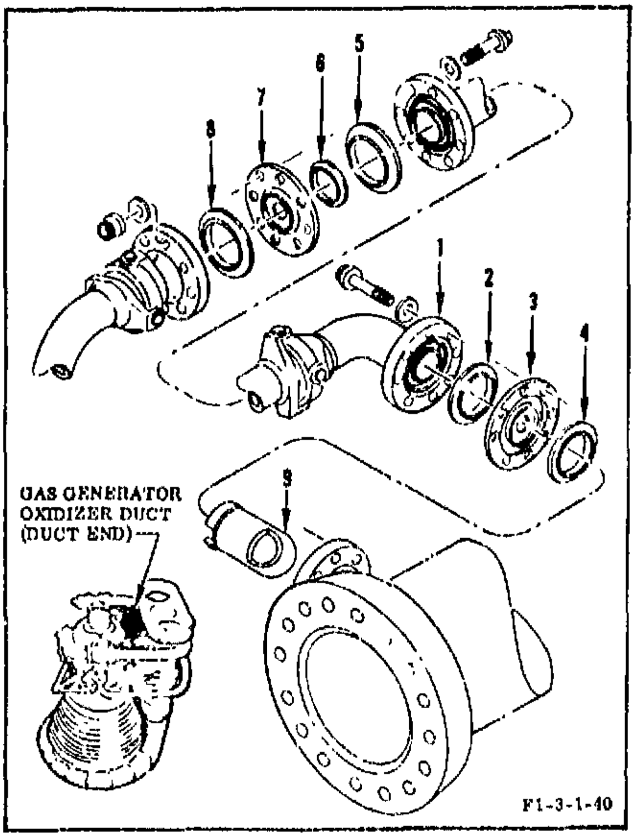
b. If duct will be replaced, remove thermal insulation insulators 145369-11 and 145370-11. (Refer to R-3896-6.)

c. Support duct to prevent excessive deflection of flexible joints. Deflection must not exceed 6 degrees for complete duct.

d. Disconnect duct (1) at oxidizer high-pressure duct, and remove seal (2), orifice plate (3), and seal (4). Retain orifice plate.

e. Disconnect duct, and remove seals (5, 6), orifice plate (7), and seal (8). Retain orifice plate.

f. Remove scoop (9).



1	Duct	6	Seal
2	Seal	7	Orifice plate
3	Orifice plate	8	Seal
4	Seal	9	Scoop
5	Seal		

Figure 3-61. Gas Generator Oxidizer Duct (Duct End)

3-223. INSTALLING GAS GENERATOR OXIDIZER DUCT (DUCT END). (See figure 3-61.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install scoop (9).

c. Install seals (5, 6), orifice plate (7), and seal (8). Secure flange, but do not torque fasteners.

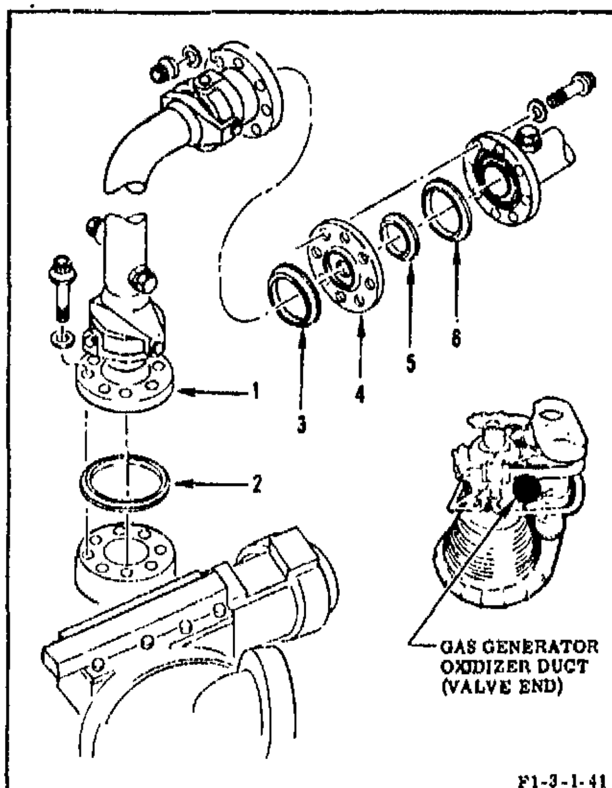
d. Install seals (2, 4) and orifice plate (3). Cross-torque bolts to 350 ±10 in-lb.

e. Cross-torque fasteners for remaining joint to 125 ±5 in-lb.

f. Safetywire bolts at both flanges, and install aluminum seals on lockwire.

g. If thermal insulation insulators were removed, reinstall as outlined in R-3896-6.

h. Refer to section IV for post-maintenance test requirements.



1	Duct	4	Orifice plate
2	Seal	5	Seal
3	Seal	6	Seal

Figure 3-62. Gas Generator Oxidizer Duct (Valve End)

3-224. GAS GENERATOR OXIDIZER DUCT (VALVE END).

3-225. REMOVING GAS GENERATOR OXIDIZER DUCT (VALVE END). (See figure 3-62.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. If duct will be replaced, remove thermal insulation insulators 145371 and 145372. (Refer to R-3896-6.)

c. Support duct to prevent excessive deflection of flexible joints. Deflection must not exceed 6 degrees of complete duct.

d. Disconnect duct (1) at valve, and remove seal (2).

e. Disconnect duct, and remove seal (3), orifice plate (4), and seals (5, 6). Retain orifice plate.

f. Lubricate (Method A) gas generator ball valve oxidizer inlet closure fasteners with lubricant grease RB0140-012 (Rocketdyne).

3-226. INSTALLING GAS GENERATOR OXIDIZER DUCT (VALVE END). (See figure 3-62.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install seals (3, 6), seal (5), orifice plate (4), and duct (1). Secure joint, but do not torque fasteners.

c. Install seal (2). Cross-torque bolts to 350 ±5 in-lb. Safetywire bolts.

d. Cross-torque nuts RD114-8003-2005 at orificed joint to 125 ±5 in-lb.

NOTE

Nuts RD114-8003-2005 must not be reused.

e. Safetywire bolts at orificed joint, and seal lockwire.

f. If thermal insulation insulators listed in paragraph 3-225 were removed, install as outlined in R-3896-6.

g. Refer to section IV for post-maintenance test requirements.

3-227. GAS GENERATOR BALL VALVE.

3-228. Special tools required consist of torque adapters T-5041242 and T-5029642.

3-229. REMOVING GAS GENERATOR BALL VALVE. (See figure 3-63.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect plug (1) as outlined in paragraph 3-14.

c. Remove duct (2) and seal (3) as outlined in paragraph 3-224.

d. Disconnect duct (4), and remove deflector (5) and seal (6).

dA. Lubricate (Method A) gas generator ball valve fuel inlet closure fasteners with lubricant grease RB0140-012 (Rocketdyne).

e. Remove tubes (7, 8).

f. Disconnect line (10), remove seal (11), and remove tube (12).

g. Remove valve (52) and seal (53).

h. (Deleted)

i. Remove clamps (15 16, 17).

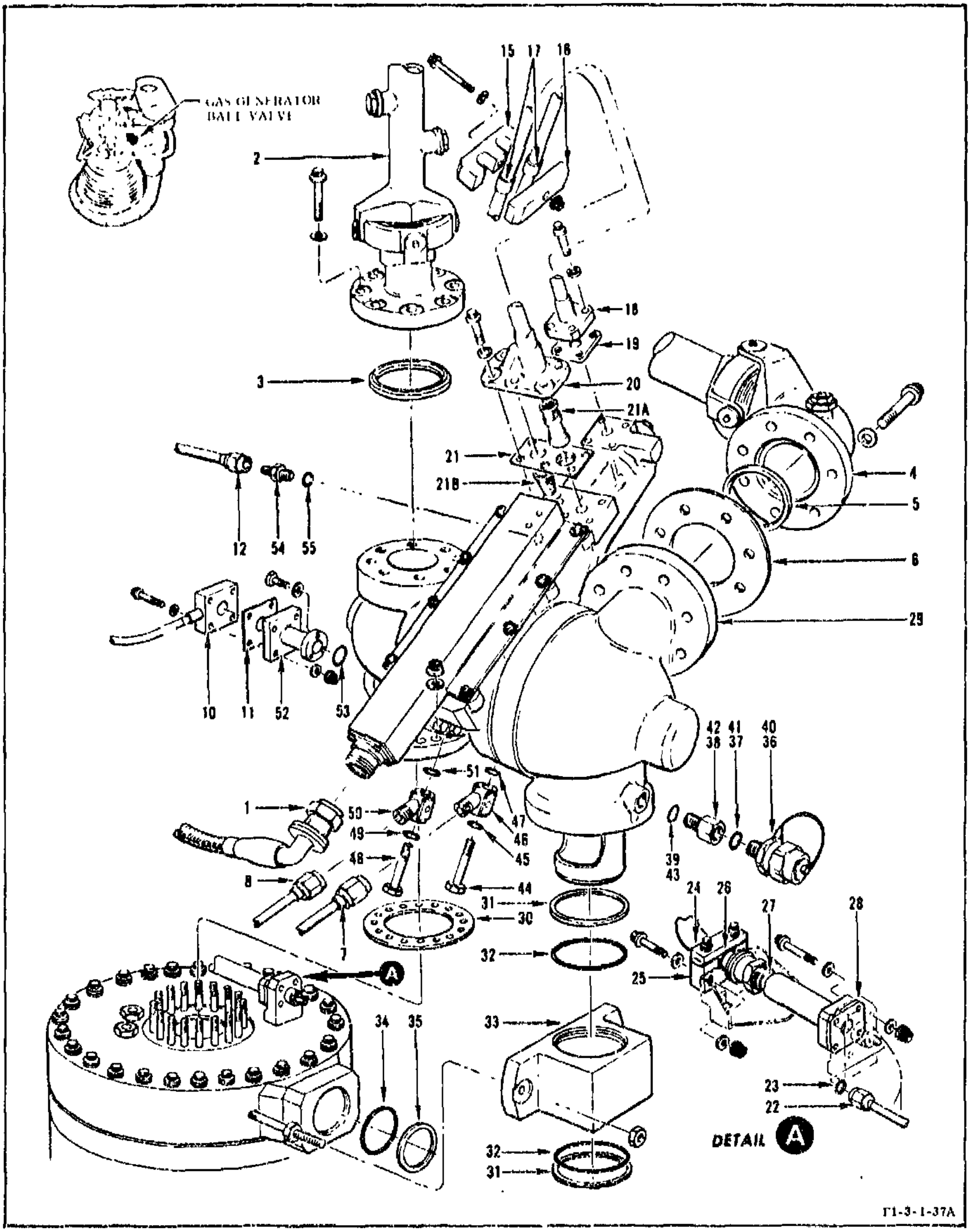


Figure 3-63. Gas Generator Ball Valve (Sheet 1 of 2)

1	Plug	15	Clamp	27	Transducer	41	Gasket[d]
2	Duct	16	Clamp	28	Seal	42	Adapter[d]
3	Seal	17	Clamp	29	Valve	43	Gasket[d]
4	Duct	18	Tube	30	Seal	44	Bolt
5	Deflector	19	Seal	31	Retainer	45	Seal
6	Seal	20	Tube	32	O-ring/packing	46	Elbow
7	Tube	21	Orifice plate	33	Housing	47	Seal
8	Tube	21A	Filter[b]	34	O-ring/packing	48	Bolt
9	(Deleted)	21B	Filter[b]	35	Retainer	49	Seal
10	Line	22	Tube	36	Nipple[c]	50	Elbow
11	Seal	23	Seal	37	Gasket[c]	51	Seal
12	Tube	24	Clamp	38	Bushing[c]	52	Valve
13	(Deleted)	25	Block	39	Gasket[c]	53	Seal
14	(Deleted)	26	Plug	40	Coupling[d]	54	Union
						55	Gasket

(b) Engines incorporating MD173 change
(c) Engines not incorporating MD168 change
(d) Engines incorporating MD168 change

Figure 3-63. Gas Generator Ball Valve (Sheet 2 of 2)

j. Disconnect tube (18), and remove seal (19).

k. On engines not incorporating MD173 change, disconnect tube (20), and remove orifice plate (21).

l. On engines incorporating MD173 change, move tube (20) in direction of least resistance a maximum of 3 inches, and remove orifice plate (21) and filters (21A, 21B).

m. Remove tube (22) and seal (23).

n. Remove parts indexed (24 through 26) as outlined in paragraph 3-16.

o. Remove transducer (27) and seal (28) as outlined in paragraph 3-65.

p. Disconnect valve (29) from injector. Prior to removing valve, line (18) and tube (20) may be deflected a maximum of 3 inches in the direction of least resistance for clearance required to remove valve. Carefully remove valve (29) and seal (30).

q. Remove retainers (31) and O-ring/packing (32) from housing (33).

r. Loosen inner nuts and remove outer nuts that retain housing (33); then remove housing and O-ring/packing (34) and retainer (35).

NOTE

The parts indexed (36 through 51 and 54 through 57) do not require removal if the valve will be reinstalled. If the valve will be replaced, remove the parts as outlined in step s through x.

s. On engines not incorporating MD168 change, remove nipple (36), gasket (37), bushing (38), and gasket (39). On engines incorporating MD168 change, remove coupling (40), gasket (41), adapter (42), and gasket (43).

t. Remove bolt (44), seal (45), elbow (46), and seal (47).

u. Remove bolts (48), seal (49), elbow (50), and seal (51).

v. (Deleted)

w. Remove union (54) and gasket (55).

x. If valve will be replaced, install protective closures. Lubricate (Method A) threads of closure RX-20845-21 and lubricate (Method J) packing (used with closure) using lubricant grease RB0140-012 (Rocketdyne).

3-230. INSTALLING GAS GENERATOR BALL VALVE. (See figure 3-63.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne) unless otherwise specified. Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

NOTE

Steps c through h install parts indexed (34 through 51 and 54 and 55) prior to installing valve (29). If the same valve is reinstalled and the parts were not removed, proceed with step i.

b. (Deleted)

c. Lubricate (Method J) gasket (55) and lubricate (Method A) union (54). Install seal and union, and torque union to 60-80 in-lb.

d. Lubricate (Method A) elbow (50) and bolt (48). Install bolts, elbow, and seals (49, 51). Aline elbow for tube (8). Torque bolt to 180-276 in-lb.

e. Lubricate (Method A) elbow (46), and bolt (44). Install elbow, bolt, and seals (45, 47). Aline elbow for tube (7). Torque bolt to 240-276 in-lb.

f. On engines incorporating MD168 change, lubricate (Method J) gaskets (41, 43) and lubricate (Method A) adapter (42) and coupling (40). Install gasket (43) and adapter (42). Torque adapter to 220 ±10 in-lb. Install gasket (41) and coupling (40). Torque coupling to 220 ±10 in-lb. Safetywire coupling to adapter and adapter to valve body.

CAUTION

Torquing the nipple without applying countertorque to the bushing will damage the bushing and valve body.

g. On engines not incorporating MD168 change, lubricate (Method J) gaskets (37, 39) and lubricate (Method A) bushing (38) and nipple (36). Install gasket (39) and bushing (38). Torque bushing to 57 ±8 in-lb. Install gasket (37) and nipple (36). Apply countertorque to bushing and torque nipple to 135 ±5 in-lb. Safetywire nipple and bushing.

h. Lubricate (Method J) retainer (35) and O-ring/packing (34) with FS1281 grease (Dow Corning Corp) and install in housing (33).

i. Lubricate (Method J) O-ring/packings (32) and retainers (31) with FS1281 grease (Dow Corning Corp) and install in housing (33).

j. Carefully install housing in injector, and install nuts on studs. Nuts on studs must remain loose to allow post of valve to aline housing (33).

k. Install seal (30), and carefully install valve (29). Using adapter T-5029642, cross-torque nuts to 150-172 in-lb.

l. Tighten nuts for housing (33) fingertight against housing. Safetywire nuts. Do not deflect housing position when tightening nuts.

m. Install transducer (27) and seal (28) using procedure outlined in paragraph 3-66.

n. Connect plug (26) and install block (25) and clamp (24) as outlined in paragraph 3-17.

o. Lubricate (Method G) tube (22) with thread compound C-5A (Felt Products). Install seal (23) and tube (22). Torque tube coupling nut to 160 ±10 in-lb. Safetywire coupling nut.

p. On engines not incorporating MD173 change, aline gas generator system open tube (20) to valve (29) as outlined in paragraph 3-103; then install orifice plate (21) and connect tube to valve. Cross-torque bolts to 85 ±5 in-lb. Safetywire bolts, and install an aluminum seal on lockwire.

CAUTION

When performing step q, care must be used while installing the orifice plate and securing tube (20) to make sure that flanges of both filters fit into the recesses of the orifice plate. If the filters are not properly seated, a gap greater than the seal thickness will exist. Damage to the filters and orifice plate, or flange leakage will result if the filters are not properly positioned while the flange bolts are tightened.

q. On engines incorporating MD173 change, aline gas generator system open tube (20) to valve (29) as outlined in paragraph 3-103; then install filters (21A, 21B) and orifice plate (21), and connect tube to valve. Cross-torque bolts to 85 ±5 in-lb. Safetywire bolts, and install an aluminum seal on lockwire.

r. Aline gas generator system close tube (18) to valve (29) as outlined in paragraph 3-103; then install seal (19) and connect tube to valve. Cross-torque bolts to 36 ±3 in-lb. Safetywire bolts.

s. Install clamps (15, 16, 17). Torque nut to 75 ±5 in-lb.

t. (Deleted)

u. Install seal (53) and valve (52). Using torque adapter T-5041242, cross-torque bolts to 45 ±5 in-lb. Safetywire bolts and install an aluminum seal on lockwire.

v. Lubricate (Method G) tube (12). Install tube, and torque coupling nut to 135-185 in-lb.

w. Install seal (11) and line (10). Cross-torque nuts to 100 ±5 in-lb.

x. (Deleted)

y. Lubricate (Method G) tube (8). Aline tube (8) to elbow (50). Torque bolt (48) to 180-276 in-lb. Install tube, and torque coupling nut to 135-185 in-lb.

z. Lubricate (Method G) tube (7). Aline tube (7) to elbow (46). Torque bolt (44) to 240-276 in-lb. Install tube, and torque coupling nut to 135-185 in-lb.

aa. Install deflector (5) and seal (6). Connect duct (4), and cross-torque bolts to 550 ±10 in-lb. Safetywire bolts.

ab. Install seal (3) and duct (2) as outlined in paragraph 3-226.

ac. Connect plug (1) as outlined in paragraph 3-15.

ad. Refer to section IV for post-maintenance test requirements.

3-231. GAS GENERATOR.

3-232. Equipment required consists of adapter 9024427 and fixture 9024918 from Handling Equipment Fixture Set G4068, torque adapter T-5041242, and special wrench T-5023955.

3-233. REMOVING GAS GENERATOR. (See figure 3-64.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove thermal insulation frame 145498. (Refer to R-3896-6.)

c. Disconnect plug (1) as outlined in paragraph 3-14.

d. Remove duct (2) and seal (3) as outlined in paragraph 3-225.

e. Disconnect duct (4), and remove deflector (5) and seal (6).

eA. Lubricate (Method A) gas generator ball valve fuel inlet closure fasteners with lubricant grease RB0140-012 (Rocketdyne).

f. Remove tubes (7, 8).

g. Disconnect line (10), and remove seal (11).

h. Remove tube (12).

i. (Deleted)

j. Remove clamps (15, 16, 17).

k. Disconnect tube (18), and remove seal (19).

l. On engines not incorporating MD173 change, disconnect tube (20), and remove orifice plate (21).

m. On engines incorporating MD173 change, move tube (20) in direction of least resistance a maximum of 3 inches, and remove orifice plate (21) and filters (21A, 21B).

n. Remove tube (22), seals (23), union (24), and seal (25).

o. Disconnect plug (28), and remove parts indexed (26, 27, 31) as outlined in paragraph 3-16.

p. Remove transducer (29) and seal (30) as outlined in paragraph 3-65.

q. Disconnect hose (32) from elbow. Remove bolt (33), seals (34), elbow (35), bushing (36), and gasket (37).

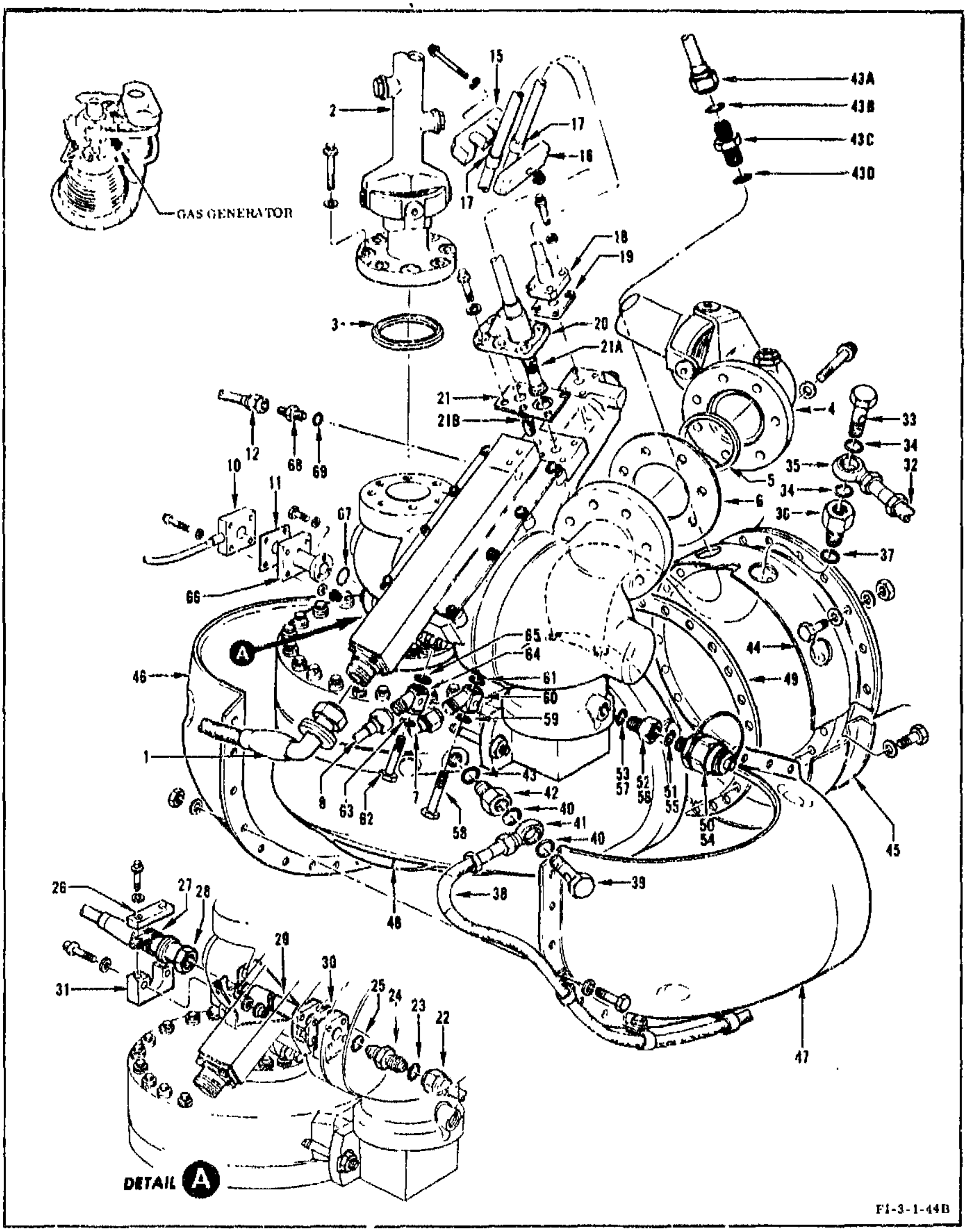


Figure 3-64. Gas Generator (Sheet 1 of 2)

1	Plug	21	Orifice plate	38	Hose	53	Seal[d]
2	Duct	21A	Filter[b]	39	Bolt	54	Coupling[e]
3	Seal	21B	Filter[b]	40	Seal	55	Seal[e]
4	Duct	22	Tube	41	Elbow	56	Adapter[e]
5	Deflector	23	Seal	42	Bushing	57	Seal[e]
6	Seal	24	Union	43	Gasket	58	Bolt
7	Tube	25	Seal	43A	Tube[c]	59	Seal
8	Tube	26	Clamp	43B	Seal[c]	60	Elbow
9	(Deleted)	27	Clamp	43C	Union[c]	61	Seal
10	Line	28	Plug	43D	Seal[c]	62	Bolt
11	Seal	29	Transducer	44	Shield	63	Seal
12	Tube	30	Seal	45	Shield	64	Elbow
13	(Deleted)	31	Block	46	Cover	65	Seal
14	(Deleted)	32	Hose	47	Cover	66	Valve
15	Clamp	33	Bolt	48	Gas generator	67	Seal
16	Clamp	34	Seal	49	Seal	68	Union
17	Clamp	35	Elbow	50	Nipple[d]	69	Seal
18	Tube	36	Bushing	51	Seal[d]		
19	Seal	37	Gasket	52	Bushing[d]		
20	Tube						

(b) Engines incorporating MD173 change
(c) Engines incorporating MD150 or MD151 change
(d) Engines not incorporating MD168 change
(e) Engines incorporating MD168 change

Figure 3-64. Gas Generator (Sheet 2 of 2)

r. Disconnect hose (38) from elbow. Remove bolt (39), seals (40), elbow (41), bushing (42), and gasket (43).

s. On engines incorporating MD150 or MD151 change, remove tube (43A), seal (43B), union (43C), and seal (43D).

t. Remove shields (44, 45).

u. Remove covers (46, 47).

v. Remove majority of bolts that attach gas generator (48) to turbine flange. Leave sufficient bolts to support gas generator.

w. Install adapter 9024427 on gas generator, and attach fixture 9024918 on adapter. (See figure 3-65.) Use proper lift points on fixture during handling.

x. Support gas generator, and remove remaining bolts that attach gas generator to turbine flange. Remove seal (49, figure 3-64), and carefully remove gas generator.

CAUTION

The gas generator assembly weighs approximately 218 pounds.

NOTE

Parts indexed (50 through 69) do not require removal if gas generator will be reinstalled. If gas generator will be replaced, remove parts as outlined in steps y through ad.

y. On engines not incorporating MD168 change, remove nipple (50), seal (51), bushing (52), and seal (53).

z. On engines incorporating MD168 change, remove coupling (54), seal (55), adapter (56), and seal (57).

aa. Remove bolt (58), seal (59), elbow (60), and seal (61).

ab. Remove bolt (62), seal (63), elbow (64), and seal (65).

ac. Remove valve (66) and seal (67).

ad. Remove union (68) and seal (69).

ae. If valve will be replaced, install protective closures. Lubricate (Method A) threads of closure RX-20845-21 and lubricate (Method J) packing (used with closure) using lubricant grease RB0140-012 (Rocketdyne).

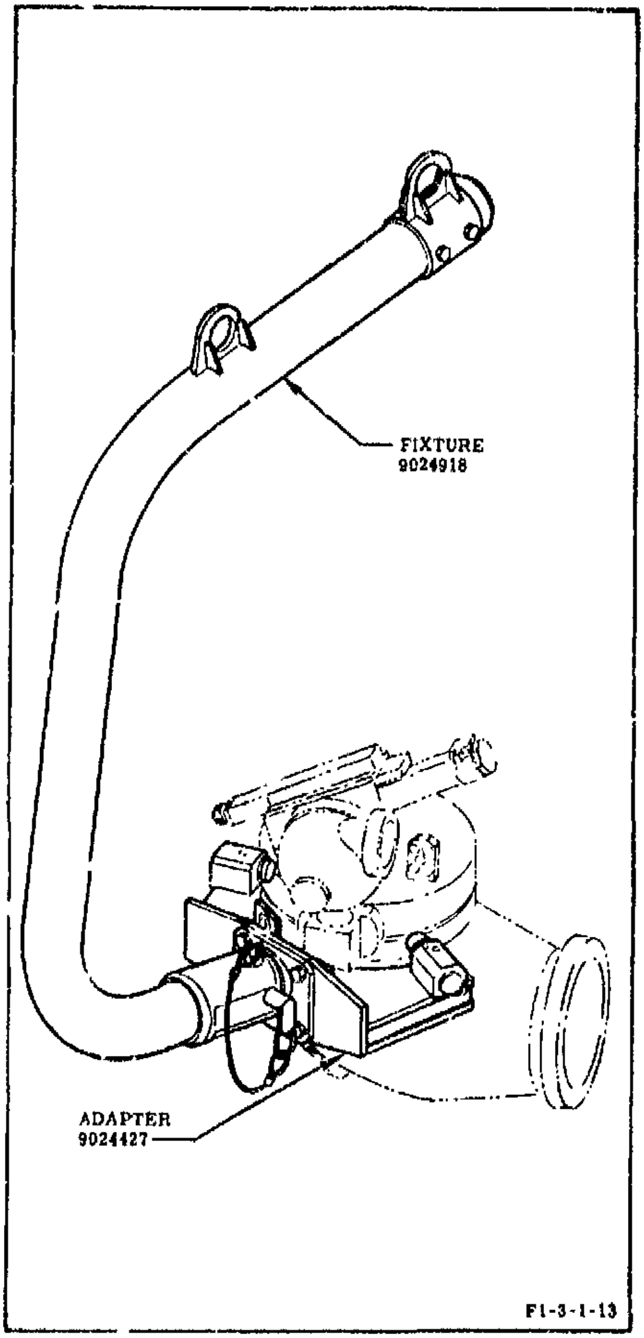


Figure 3-65. Handling Gas Generator

3-234. INSTALLING GAS GENERATOR. (See figure 3-64.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne) unless otherwise noted. Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

NOTE

Steps b through h install parts indexed (50 through 69) prior to installing the gas generator. If the same gas generator is reinstalled and parts were not removed, proceed to step i.

b. (Deleted)

c. Lubricate (Method J) seal (69) and lubricate (Method A) union (68). Install seal and union, and torque union to 60-80 in-lb.

d. Install seal (67) and valve (66). Using torque adapter T-5041242, cross-torque bolts to 45 ±5 in-lb. Safetywire bolts, and install an aluminum seal on lockwire.

e. Lubricate (Method A) elbow (64) and bolt (62). Install seals (63, 65), elbow, and bolt. Aline elbow for tube (8), and torque bolt to 180-276 in-lb.

f. Lubricate (Method A) elbow (60) and bolt (58). Install seals (59, 61), elbow, and bolt. Aline elbow for tube (7). Torque bolt to 240-276 in-lb.

g. On engines incorporating MD168 change, lubricate (Method J) seals (55, 57), and lubricate (Method A) adapter (56) and coupling (54). Install seal (57) and adapter. Torque adapter to 220 ±10 in-lb. Install seal (55) and coupling (54). Torque coupling to 220 ±10 in-lb. Safetywire coupling to adapter and adapter to valve body.

CAUTION

Torquing the nipple (50) without applying countertorque to the bushing will damage the bushing and body.

h. On engines not incorporating MD168 change, lubricate (Method J) seals (51, 53) and lubricate (Method A) bushing (52) and nipple (50). Install seal (53) and bushing. Torque bushing to 57 ±8 in-lb. Install seal (51) and nipple (50). Apply countertorque to bushing and torque nipple to 135 ±5 in-lb. Safetywire nipple and bushing.

i. Install adapter 9024427 on gas generator (48), and attach fixture 9024918 on adapter. (See figure 3-65.) Use proper lift points of fixture during handling.

CAUTION

The gas generator assembly weighs approximately 218 pounds.

j. Position gas generator for installation. Install seal (49, figure 3-64), secure joint, and remove handling equipment. Using special wrench T-5023955, cross-torque bolts to 930 ±10 in-lb. Safetywire bolts.

k. Install covers (46, 47), and attach supports for hoses (32, 38) to applicable cover fasteners. Torque fasteners to 25 ±5 in-lb.

l. Install shields (44, 45). Torque fasteners to 110 ±10 in-lb.

m. On engines incorporating MD150 or MD151 change, lubricate (Method A) union (43C) with thread compound C-5A (Felt Products). Install union and seal (43D). Torque union to 55-80 in-lb.

n. On engines incorporating MD150 or MD151 change, lubricate (Method G) tube (43A). Install tube and seal (43B). Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nut.

o. Lubricate (Method A) bushing (42) with thread compound C-5A (Felt Products), and install with gasket (43). Torque bushing to 100 ±8 in-lb.

p. Lubricate (Method A) elbow (41) and bolt (39) with thread compound C-5A (Felt Products). Install elbow, seals (40), and bolt. Position elbow for hose (38). Apply countertorque to bushing (42), and torque bolt to 140 ±10 in-lb. Safetywire bolt.

q. Connect hose (38) to elbow. Record running torque during last one-half turn of coupling nut prior to seating of hose tubing flare. Running torque must be within 50-300 in-lb. Continue to torque coupling nut to 135-185 in-lb above recorded running torque.

r. Lubricate (Method A) bushing (36) with thread compound C-5A (Felt Products) and install with gasket (37). Torque bushing to 100 ±8 in-lb.

s. Lubricate (Method A) elbow (35) and bolt (33) with thread compound C-5A (Felt Products). Install seals (34), elbow, and bolt. Apply countertorque to bushing and torque bolt to 140 ±10 in-lb. Safetywire bolt.

t. Connect hose (32) to elbow. Torque hose coupling nut as outlined in step q. Make sure that surface of coupling nut clears shield (44) by 0.030 inch minimum.

u. Install transducer (29) and seal (30) using procedure outlined in paragraph 3-66.

v. Install plug (28) and parts indexed (26, 27, 31) as outlined in paragraph 3-17.

w. Lubricate (Method A) union (24) with thread compound C-5A (Felt Products) and install with seal (25). Torque union to 55-80 in-lb.

x. Lubricate (Method G) tube (22) with thread compound C-5A (Felt Products). Install seal, and torque tube coupling nut to 160 ±10 in-lb. Safetywire coupling nut.

y. On engines not incorporating MD173 change, aline gas generator system open tube (20) to gas generator (48) as outlined in paragraph 3-103; then install orifice plate (21) and connect tube to gas generator. Cross-torque bolts to 85 ±5 in-lb. Safetywire bolts, and install an aluminum seal on lockwire.

CAUTION

When performing step z, care must be used while installing orifice plate and securing tube (20) to make sure that flanges of both filters fit into the recesses of the orifice plate. If filters are not properly seated, a gap greater than the seal thickness will exist. Damage to filters and orifice plate, or flange leakage will result if the filters are not properly positioned while the flange bolts are tightened.

z. On engines incorporating MD173 change, aline gas generator system open tube (20) to gas generator (48) as outlined in paragraph 3-103; then install filters (21A, 21B) and orifice plate and connect tube (20) to gas generator. Cross-torque bolts to 85 ±5 in-lb. Safetywire bolts, and install an aluminum seal on lockwire.

aa. Aline gas generator system close tube (18) to gas generator (48) as outlined in paragraph 3-103; then install seal (19) and connect tube to gas generator. Cross-torque bolts to 36 ±3 in-lb. Safetywire bolts.

ab. Install clamps (15, 16, 17). Torque nut to 75 ±5 in-lb.

ac. (Deleted)

ad. Lubricate (Method G) tube (12). Install tube, and torque coupling nut to 135-185 in-lb.

ae. Install seal (11) and line (10). Cross-torque nuts to 100 ±5 in-lb.

af. (Deleted)

ag. Lubricate (Method G) tube (8). Attach to elbow (64), and torque coupling nut to 135-185 in-lb.

ah. Lubricate (Method G) tube (7). Attach tube to elbow (60), and torque coupling nut to 135-185 in-lb.

ai. Install deflector (5) and seal (6). Connect duct (4), and cross-torque bolts to 550 ±10 in-lb. Safetywire bolts.

aj. Install seal (3) and duct (2) as outlined in paragraph 3-226.

ak. Connect plug (1) as outlined in paragraph 3-15.

al. Reinstall thermal insulation frame 115498. (Refer to R-3896-6.)

am. Refer to section IV for post-maintenance test requirements.

3-235. GAS GENERATOR BALL VALVE POSITION SWITCH.

3-236. REMOVING GAS GENERATOR BALL VALVE POSITION SWITCH. (See figure 3-66.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect gas generator ball valve position switch plug P53 (1) using method outlined in paragraph 3-14.

c. (Deleted)

d. Remove screws and washers that secure cover (4). Carefully remove cover (4) and switch (8) so that shims (5) located between finger and foot of switch (8) can be easily removed without dropping them into actuator cavity.

e. Remove shims (5).

f. Remove pin (6) from foot of switch (8); then remove screws, washers, lug (7), switch (8), and packing (9) from cover (4).

3-237. INSTALLING GAS GENERATOR BALL VALVE POSITION SWITCH (See figure 3-66.)

a. If installing a replacement position switch, verify that position switch preinstallation test outlined in section I has been performed.

aA. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Insert packing (9) in groove of cover (4); then install switch (8) in cover and secure with screws, washers, and lug (7). Torque screws to 6-8 in-lb.

NOTE

Steps c through e determine the correct thickness of shims (5) to be installed between finger and foot of switch (8).

c. Measure distance between base of cover (4) and flat surface of foot on switch (8) with check fixture T-5037832. Record as dimension A.

d. Measure distance between flat surface of ball valve housing and top of surface of finger with check fixture T-5037832. Record as dimension B.

e. Using the following formula and dimensions obtained in steps c and d, determine correct thickness of shim (5) to be installed:

$$C - (A - B) = T$$

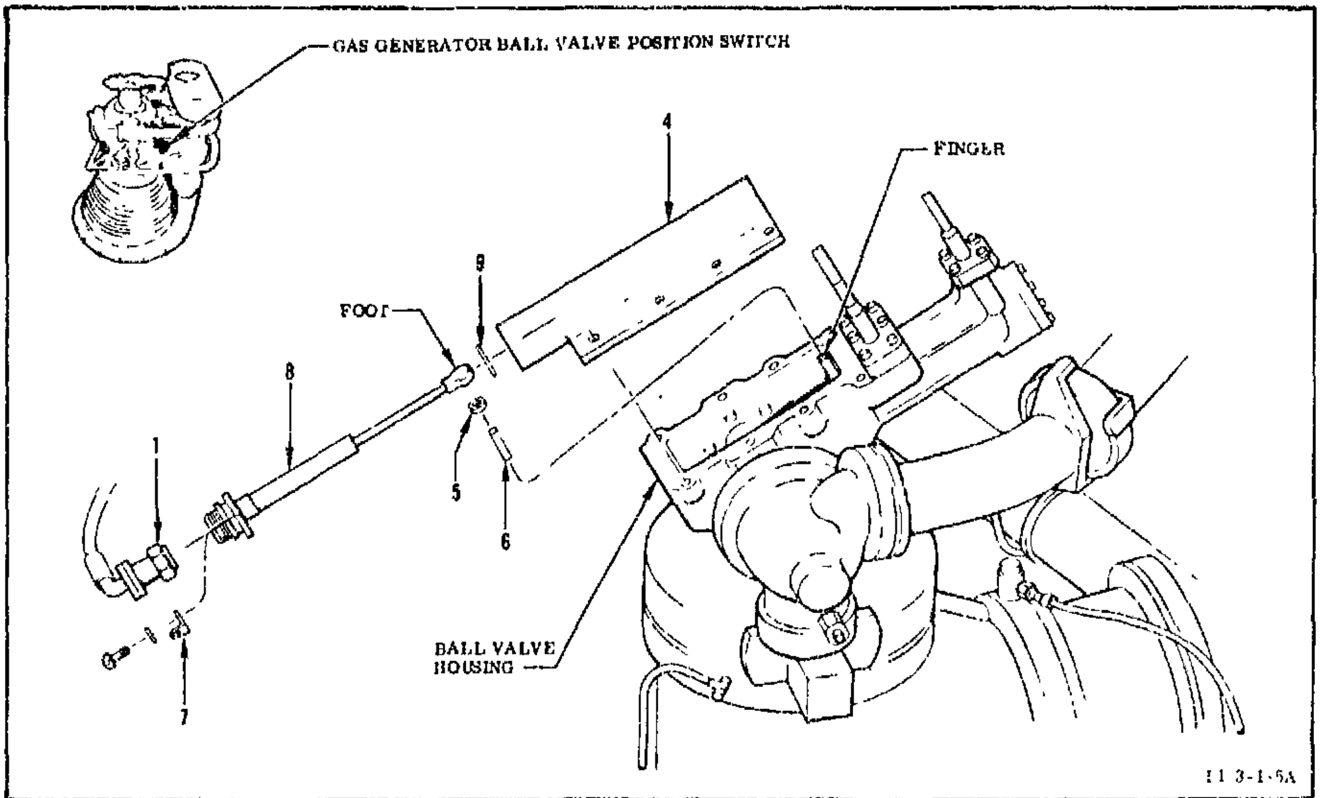
where

A = dimension from base of cover (4) to flat surface of foot of switch (8)

B = dimension from flat surface of ball valve housing to top surface of finger

C = required clearance between foot of switch (6) and finger: 0.020 ±0.005 inch

T = thickness of shims to be installed



1	Plug	6	Pin
2	(Deleted)	7	Lug
3	(Deleted)	8	Switch
4	Housing cover	9	Packing
5	Shim		

Figure 3-66. Gas Generator Ball Valve Position Switch

f. Remove necessary laminations from shims (5) to obtain dimension T as determined in step e.

g. Press pin (6) into foot of switch (8); then temporarily install cover (4) on ball valve housing to determine that pin (6) is slip-fit into finger. Remove cover (4).

h. Place correct number of shims (5), determined in step e, on pin (6). Holding shims in place, install cover (4) on ball valve housing. Secure cover to housing with screws and washers. Torque screws to 6-8 in-lb.

i. (Deleted)

j. Connect plug (1) as outlined in paragraph 3-15.

k. Refer to section IV for post-maintenance test requirements.

3-238. GAS GENERATOR OXIDIZER PURGE CHECK VALVE.

3-239. Torque adapter T-5041242 is required during installation.

3-240. REMOVING GAS GENERATOR OXIDIZER PURGE CHECK VALVE. (See figure 3-64.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect line (10), and remove seal (11).

c. Remove valve (66) and seal (67).

3-241. INSTALLING GAS GENERATOR OXIDIZER PURGE CHECK VALVE. (See figure 3-64.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install seal (67) and valve (66). Using torque adapter T-5041242, cross-torque bolts to 45 ±5 in-lb. Safetywire bolts and install aluminum seal on lockwire.

c. Install seal (11) and connect line (10). Cross-torque nuts to 100 ±5 in-lb.

3-242. <u>ELECTRICAL CABLE SUPPORT POST.</u>

3-243. REMOVING ELECTRICAL CABLE SUPPORT POST. (See figure 3-67.)

a. Remove door (6).

b. Remove bolts and nuts from interface panel, and remove plate (5).

c. Support post (1), and remove bolts from outer flange of interface panel; then remove post, washer (4), shims (3), and spacer (2).

3-244. INSTALLING ELECTRICAL CABLE SUPPORT POST. (See figure 3-67.)

a. Remove pin MS9245-35, washer 651690-19, spacer 651690-17 (2), and 4 shims 651690-23 (3) from support post (1). Retain for reinstallation in step e.

b. Temporarily install support post (1) on engine interface panel with bolt RD111-4009-0808, washer RD153-5002-0008, washer RD153-1002-0008, and nut RD114-8005-1008. Tighten nut, but do not torque.

NOTE

Bolt RD111-4009-0810 may be used in place of bolt RD111-4009-0808 if two additional washers are used (one washer RD153-5002-0008 under the bolthead and one washer RD153-1002-0008 under the nut).

c. Temporarily install spacer (2) and shims (3) between support post (1) and interface panel, and remove shim laminations, as necessary, to obtain a clearance of 0.005 inch maximum between support post (1) and interface panel at final installation. (See figure 3-67, view A.)

d. Remove spacer (2), required shims (3), and attaching part temporarily installed in step b.

e. Assemble spacer (2), required shims (3), and washer 651690-19 (4) to support post (1) with pin MS9245-35.

f. Install support post (1) and secure to interface panel with bolt RD111-4009-0808, washer RD153-5002-0008, washer RD153-1002-0008, and nut RD114-8005-1008. Torque nut to 740 ±75 in-lb.

NOTE

Bolt RD111-4009-0810 may be used in place of bolt RD111-4009-0808 if two additional washers are used (one washer RD153-5002-0008 under the bolthead and one washer RD153-1002-0008 under the nut).

g. Install plate 651591 (5) and secure to support post with 2 washers LD153-0013-0002 and 2 bolts RD111-1010-6417. Torque bolts to 90 ±10 in-lb.

h. Install 2 bolts RD111-1009-0412 and 2 washers LD153-0013-0002 that secure support post (1) to interface panel. Torque bolts to 90 ±10 in-lb. Safetywire bolts.

i. Install 3 bolts RD111-1010-6417, 3 washers LD153-0013-0002 (under boltheads, 3 washers RD153-1002-0004 (under nuts), and 3 nuts RD114-8005-1004 that secure support post (1) to interface panel. Torque nuts to 75 ±7 in-lb.

j. Install 2 screws NAS1102C4-40 and 2 nuts RD114-8005-1004 that secure support post (1) to interface panel. Torque nuts to 85 ±5 in-lb.

k. Install door 651592 (6) and secure to support post (1) with 12 screws AN520C10R14 and 12 washers LD153-0010-0008.

l. If required, adjust dimension of bearing to interface panel flange. (See figure 3-67.) Torque jamnut RD114-8009-0001 to 900 ±90 in-lb.

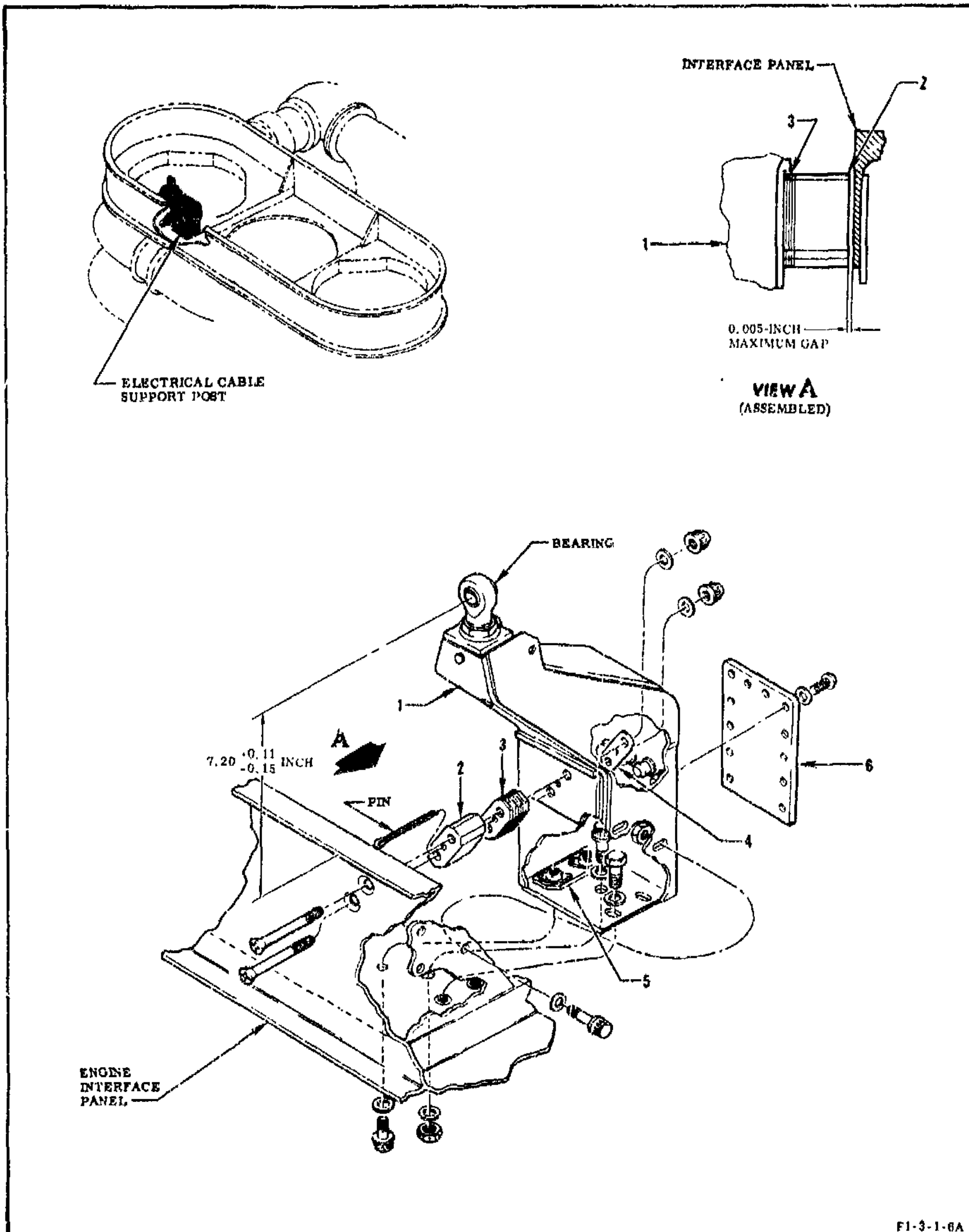


Figure 3-67. Electrical Cable Support Post (Sheet 1 of 2)

1	Post	3	Shims	5	Plate
2	Spacer	4	Washer	6	Door

Figure 3-67. Electrical Cable Support Post (Sheet 2 of 2)

3-245. INTERFACE PANEL TO OXIDIZER INLET INSULATION SEAL.

3-246. REMOVING INTERFACE PANEL TO OXIDIZER INLET INSULATION SEAL. (See figure 3-68.)

a. Remove fasteners and channels (1, 2).

b. Remove seals (3).

3-247. INSTALLING INTERFACE PANEL TO OXIDIZER INLET INSULATION SEAL. (See figure 3-68.)

a. Place 2 channels 651586 (1) and 2 channels 651587 (2) in position around interface panel opening.

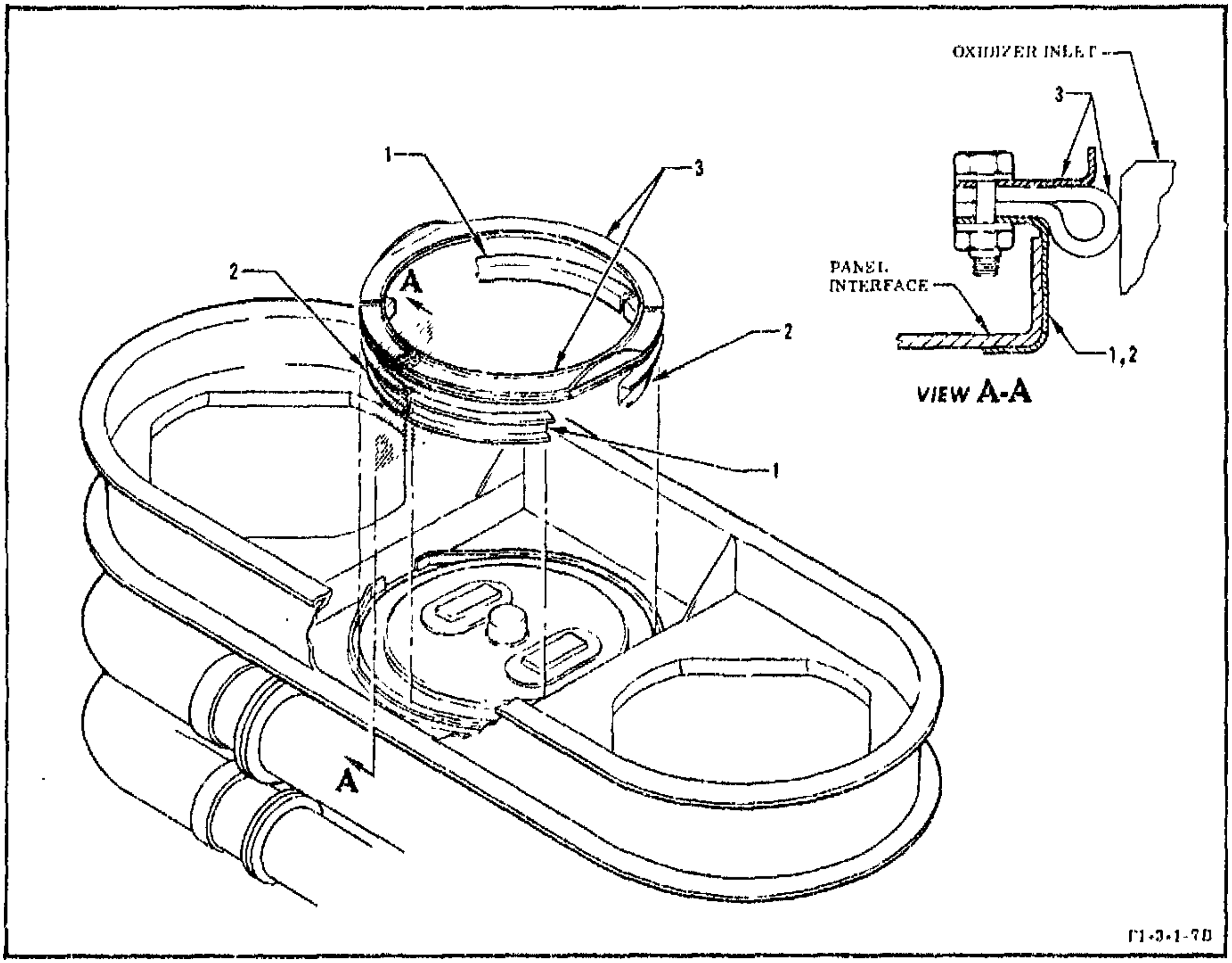
b. Install 2 seals 651588 (3), and secure seals and channels using 10 bolts NAS1003-3A, 10 washers RD153-1003-0006, 10 washers RD153-5004-0003, and 10 nuts RD114-8003-1003. Torque nut to 24-30 in-lb.

3-248. INTERFACE PANEL.

3-249. Equipment required consists of sling 9024915 from Component Handling Fixture Set G4068 and alinement fixture T-5039202.

3-250. REMOVING INTERFACE PANEL. (See figure 3-69.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.



1	Channel	2	Channel	3	Seal

Figure 3-68. Interface Panel to Oxidizer Inlet Insulation Seal

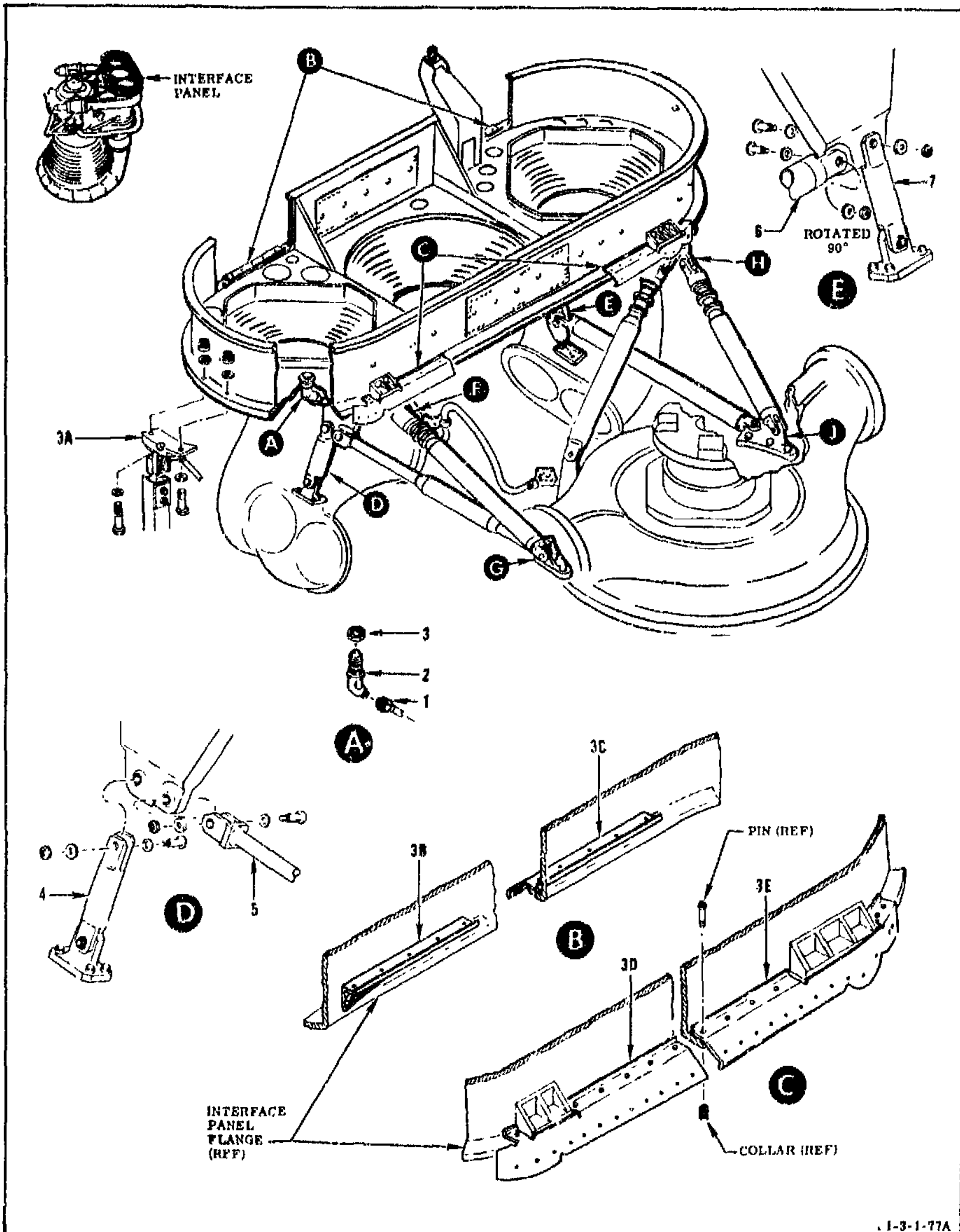
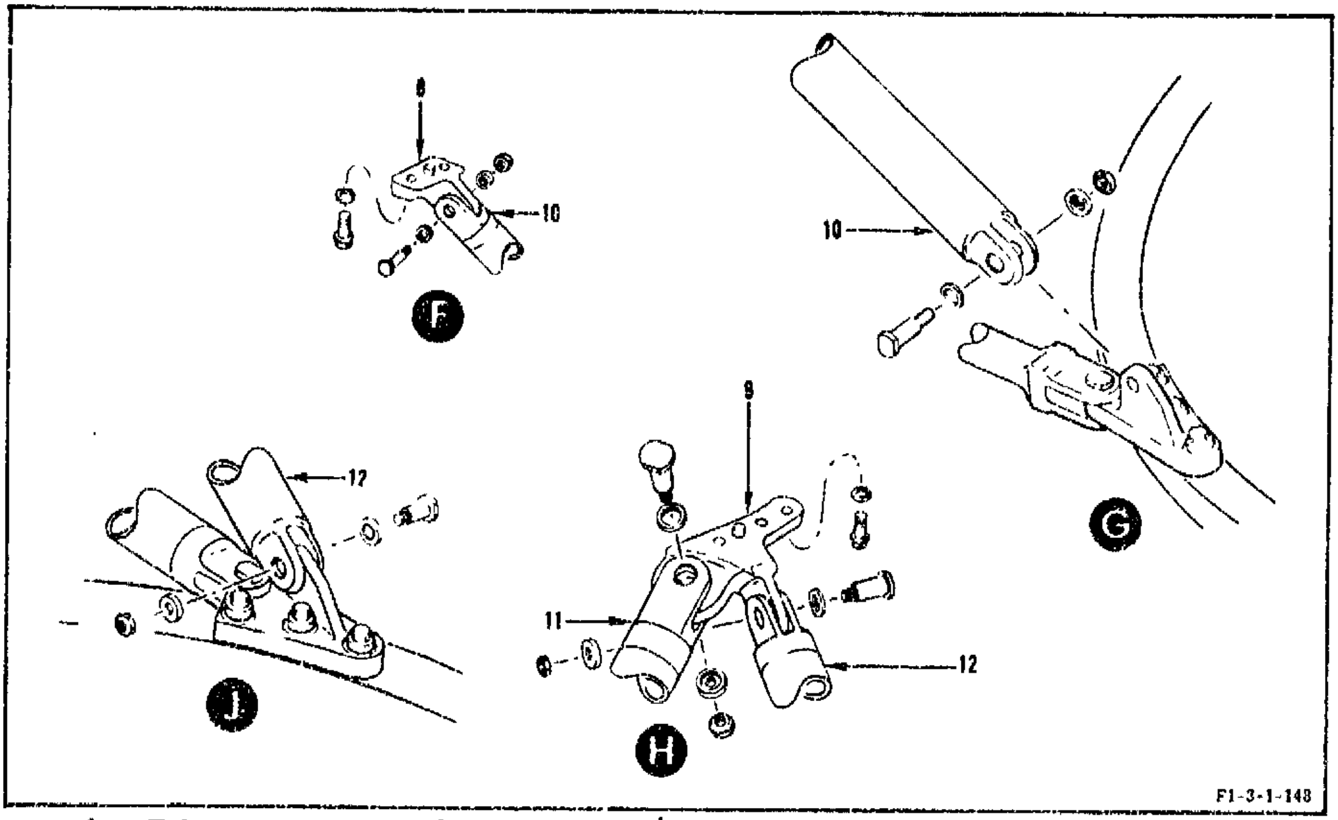


Figure 3-69. Interface Panel (Sheet 1 of 2)



1	Tube	3C	Bracket	5	Strut	9	Bracket
2	Adapter	3D	Bracket	6	Strut	10	Strut
3	Nut	3E	Bracket	7	Strut	11	Strut
3A	Bracket	4	Strut	8	Bracket	12	Strut
3B	Bracket						

Figure 3-69. Interface Panel (Sheet 2 of 2)

b. Disconnect thermal insulation insulator 145532-11 from interface panel. (Refer to R-3896-6.)

c. If insulating boots from fuel inlet elbows to interface panel are installed, loosen clamps that hold boots to interface panel.

d. Disconnect tube (1), and remove nut (3) and adapter (2).

dA. Disconnect thermal insulation bracket (3A) from interface panel. Retain attaching hardware.

dB. Remove thermal insulation brackets (3B through 3E), as required, to install sling 9024915.

e. Disconnect engine control and flight instrumentation harness receptacles from panel.

f. Install sling 9024915 on interface panel, and support panel. (See figure 3-70.)

CAUTION

The interface panel weighs approximately 413 pounds.

g. Loosen bolts that attach brackets (8, 9, figure 3-69).

h. Disconnect struts (4 through 7) from interface panel. Support struts to prevent damaging engine equipment.

i. Remove bolts from brackets (8, 9). Each bracket contains a pin that engages a hole in the interface panel. If required, use a plastic or rawhide hammer to separate brackets from interface panel. Make sure that struts and brackets are supported and interface panel is prevented from swinging.

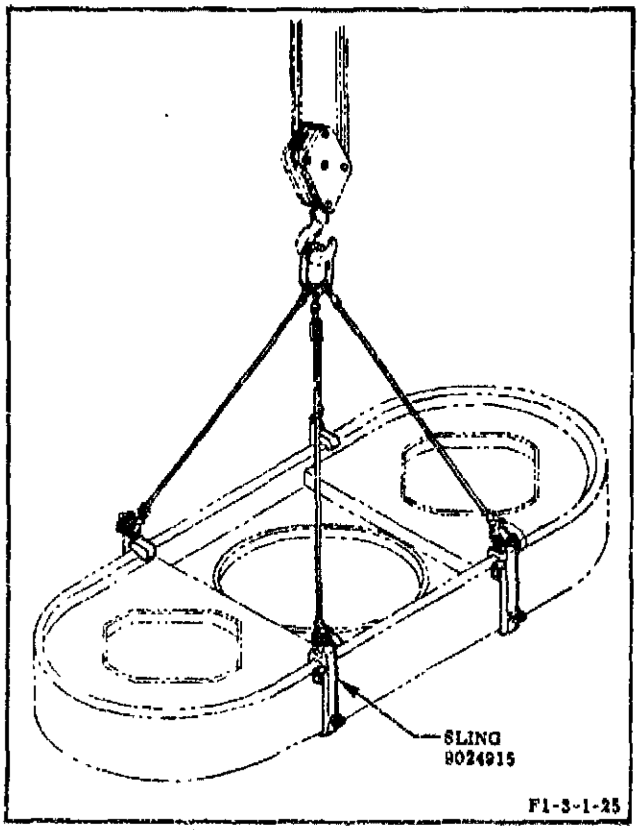


Figure 3-70. Handling Interface Panel

j. Carefully manipulate interface panel and remove panel from engine.

k. If interface panel will be replaced, remove the following components (if installed) from interface panel.

(1) Electrical cable support post. (Refer to paragraph 3-243.)

(2) Interface panel to oxidizer inlet insulation seal. (Refer to paragraph 3-246.)

WARNING

Primer (MIL-P-8585) is flammable and must not be used near heat, sparks or open flame. It is toxic. Inhalation of its vapors or prolonged contact with the primer can cause serious bodily harm. In case of prolonged exposure, immediately obtain fresh air and wash skin with soap and water.

l. If interface panel will be replaced, remove brackets (8, 9) from engine struts (10 through 12) and attach them to rejected panel. Apply one coat of zinc chromate primer (MIL-P-8585) to inside diameter of threaded holes in panel; then install bracket bolts while primer is wet. Torque bolts to 600 ±30 in-lb.

3-251. INSTALLING INTERFACE PANEL. (See figure 3-69.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

NOTE

Steps b through d are performed if the interface panel is a replacement.

b. Install interface panel to oxidizer inlet seal. (Refer to paragraph 3-247.)

c. Install electrical cable support post. (Refer to paragraph 3-244.)

d. Remove brackets (8, 9) and attach to respective engine struts. (See strut attachment method in figure 3-69.) Lubricate pins with gear grease (MIL-G-23827). Apply lubricant using Method Z outlined in section I. Make sure pins and washers are correct size for each connection. Torque nuts to 35 ±5 in-lb.

CAUTION

The interface panel weighs approximately 413 pounds. Extreme care must be used when positioning the panel on the engine, to prevent damage to the engine.

e. Attach sling 9024915 to panel, and hoist panel into position for installation. (See figure 3-70.) Using extreme care, position panel on engine. Guide electrical and instrumentation receptacles through applicable openings as panel is positioned.

WARNING

Primer (MIL-P-8585) is flammable and must not be used near heat, sparks or open flame. It is toxic. Inhalation of its vapors or prolonged contact with the primer can cause serious bodily harm. In case of prolonged exposure, immediately obtain fresh air and wash skin with soap and water.

f. Attach brackets (8, 9) to panel. Coat inside of threaded boltholes with zinc chromate primer (MIL-P-8585), and install bolts while primer is wet. Torque bolts to 600 ±30 in-lb. Remove excess primer.

g. Attach struts (4 through 7) to panel. Lubricate pins with gear grease (MIL-G-23827). Apply lubricant using Method Z outlined in section I. Make sure that pins and washers are correct size for each connection. Torque nuts to 35 ±5 in-lb. Safetywire all strut connections by safetywiring nut to head of pin.

h. Remove sling.

i. Using lubricant grease RB0140-012 (Rocketdyne), lubricate forward threads of adapter (2) for installing nut (3). Apply lubricant using Method A outlined in section I. Install adapter (2), aline for tube (1), and torque nut (3) to 550-650 in-lb.

j. Connect tube to adapter. Record running torque of tube coupling nut during last 1/2 turn of coupling nut prior to seating of tube flare. Torque must be 50-200 in-lb. Continue to torque coupling nuts to 270-345 in-lb above recorded running torque.

k. Attach engine control and flight instrumentation harness receptacles to interface panel. Torque fasteners to 70 ±5 in-lb.

l. Attach fuel inlet elbow boots to interface panel. Torque clamp screws to 20 ±2 in-lb. Safetywire screws.

NOTE

Steps m through q aline the interface panel.

m. Remove covers from fuel inlet elbows, and install alinement fixture T-5039202 on inlet elbow flanges.

NOTE

Fixture and engine mating surfaces must be clean.

n. Rotate alinement fixture to determine relation of centers of interface panel cutouts to centers of fuel inlet elbow flanges. Maximum allowable displacement is 0.350 inch. Record dimensions.

o. If required, adjust centers within tolerance by loosening jamnuts of struts (10, 11, 12) and adjust strut lengths to meet alinement requirements.

p. Torque jamnuts to 300 ±30 in-lb. Safetywire jamnuts.

q. Remove alinement fixture, and install covers on fuel inlet elbows.

r. Reinstall thermal insulation brackets (3B through 3D) using HI-LOCK pins HL30-8-18 and HI-LOCK collars HL194W-8 (HI Shear Corp).

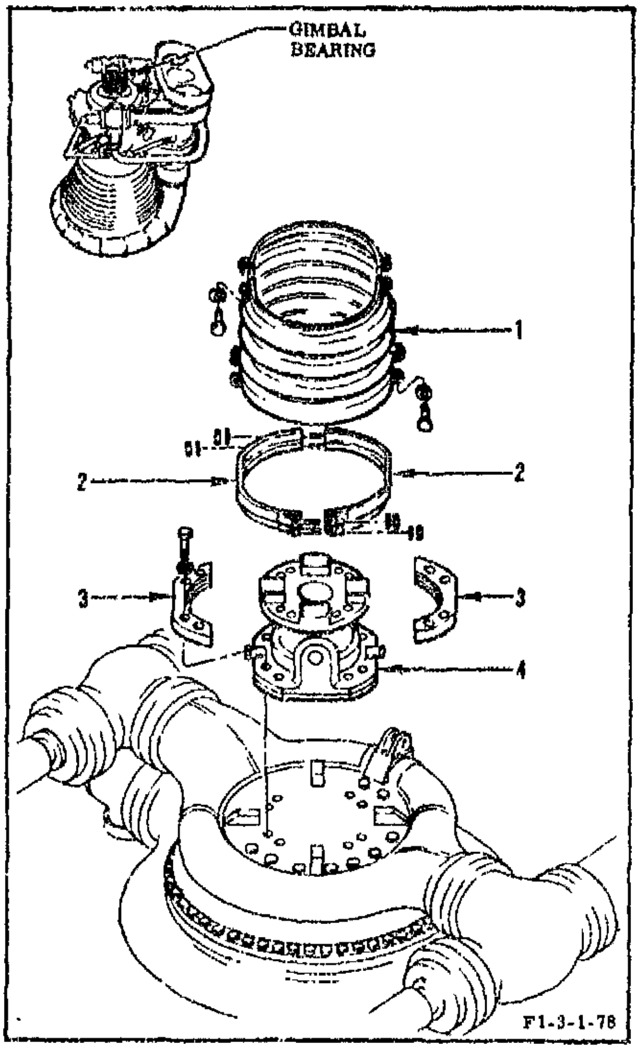
s. Reinstall thermal insulation bracket (3E) using HI-LOCK pins HL30-8-18, HL30-8-19, and HI-LOCK collars HL194W-8 (HI Shear Corp). Pins HL30-8-19 are used in outermost holes.

t. Attach thermal insulation bracket (3A) to interface panel flange. Torque nuts to 68 ±7 in-lb.

u. Attach thermal insulation insulator 145332-11 to interface panel. (Refer to R-3896-6.)

3-252. GIMBAL BEARING.

3-253. The gimbal bearing (figure 3-71) is removed and installed as an assembly. Equipment required consists of adapter 9024906 and fixture 9024912 from Component Handling Fixture Set G4068 and four Gimbal Bearing Locks G4059. (See figure 3-72 for handling equipment and figure 3-73 for replacement criteria.)



1	Boot	3	Flange
2	Pan	4	Gimbal

Figure 3-71. Gimbal Bearing

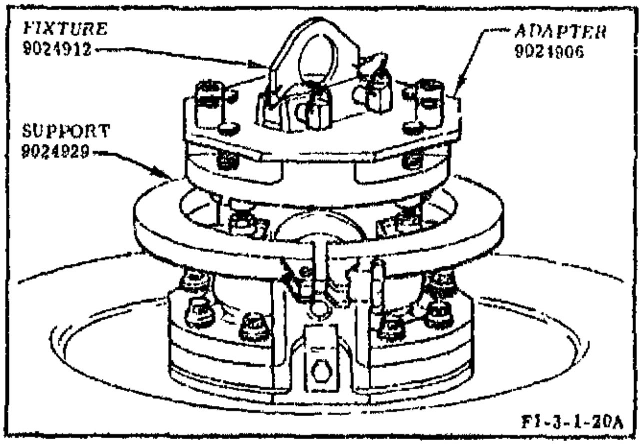


Figure 3-72. Handling Gimbal Bearing

3-254. REMOVING GIMBAL BEARING. (See figure 3-71.)

a. Remove gimbal boot (1) and pan (2).

aA. Remove gimbal locks G4059, if installed.

b. Loosen X_G axis adjusting bolts from welded lugs. (See figure 3-75.)

c. Install adapter 9024906 from Component Handling Fixture Set G4068 on gimbal face, and torque bolts to a minimum of 200 in-lb. (See figure 3-72.)

d. Attach fixture 9024912 to adapter and support gimbal.

e. Remove gimbal attaching bolts and half-spherical gimbal flanges (3, figure 3-71).

CAUTION

The gimbal weighs approximately 426 pounds.

f. Hoist gimbal (4) clear and lower to a clean, prepared surface. Remove fixture and adapter.

3-255. INSTALLING GIMBAL BEARING. (See figure 3-71.)

a. Install adapter 9024906 on gimbal face. (See figure 3-72.) Torque bolts to a minimum of 200 in-lb. Attach fixture 9024912 to adapter.

CAUTION

The gimbal weighs approximately 426 pounds.

b. Hoist gimbal (4, figure 3-71) into position, and install half-spherical gimbal flanges (3). Torque bolts to 30 ±10 ft-lb. Final torque (300 ±10 ft-lb) will be accomplished during alinement.

c. Remove handling equipment, and install 4 Gimbal Bearing Locks G4059.

d. Perform gimbal alinement as outlined in paragraph 3-256, if required.

e. Install pan (2) and boot (1) following any required gimbal alinement. Torque pan screws to 8-10 in-lb. Safetywire screws. Torque nuts for pan T-bolts to 40 ±5 in-lb. Tighten screws of boot clamps until boot snap fasteners can be closed.

3-256. ALINING GIMBAL BEARING.

3-257. The gimbal bearing (figure 3-71) is alined whenever maintenance tasks have disturbed the delivered alined position of the gimbal, dome, or injector. See figure 3-73 for alinement requirements, figure 3-74 for preliminary alinement of the gimbal seat to plate, figure 3-75 for gimbal axes and reference locations, and figure 3-76 for alinement tools. Equipment required consists of Gimbal Bearing Locks G4059, holding fixture T-5037454, and check fixture T-5037452.

3-258. PARALLELING GIMBAL BEARING TO THRUST CHAMBER INJECTOR.

NOTE

Steps a and b are performed only when the gimbal is a replacement and requires adjustment to the delivered alined position.

a. Measure plate-to-seat dimensions as shown in figure 3-74. If necessary, adjust to 0.220 to 0.280 inch using the Z_G axis adjusting bolt. (See figure 3-75 for axis and alinement pin locations.)

NOTE

The minimum adjustment is 1/12 turn, due to the 12-point lock, and moves the gimbal 0.007 inch along the axis.

b. Measure from sides of gimbal to adjustment lugs on dome. If the difference between measurements exceeds 0.030 inch, adjust to within this tolerance, using the X_G axis adjustment bolts.

NOTE

A 1/6 turn of the X_G axis adjusting bolts moves the gimbal 0.014 inch along the axis.

c. For access to alinement pin D, support heat exchanger lines, remove cover of heat exchanger duct dome bracket, and remove heat exchanger customer duct dome support and bracket as an assembly.

Measured Resultant Lateral Displacement (Inch)	Delivered Resultant Lateral Displacement Reported in Log Book (Inch)	Resultant Gimbal Adjustment Factor Reported in Log Book (Inch)	Component Replacement Capability	Procedure for Component Replacement
0.0000 to 0.2400	0.0000 to 0.2400	0	a and/or b and/or c or d	C
			a and/or b and/or c and/or d	A
0.2401 to 0.3200	0.2401 to 0.3200	0	a and/or b and/or c	C
			a and/or b and/or c and/or d	A
0.3201 to 0.6100	0.1201 to 0.4100	0.2000	b	C
			a and/or b and/or c and/or d	B
0.6101 to 0.6400	0.3801 to 0.4100	0.2300	a and/or b and/or c and/or d	B

Component Replacement Capability

(a) Remove and reinstall dome and/or injector to thrust chamber without removing gimbal from dome.
(b) Remove, disassemble, and reinstall gimbal to dome (with or without gimbal disassembly).
(c) Replace dome (with reinstallation of original gimbal).
(d) Replace gimbal only.

Procedure for Component Replacement

(A) Use alinement equipment after reassembly for centering gimbal. Record new gimbal adjustment settings.
(B) Use alinement equipment after reassembly for centering gimbal. Record new gimbal settings. Readjust gimbal on X_G and Z_G axes by gimbal adjustment factors in log book.
(C) No special equipment required. Readjust gimbal, if applicable, to same settings as in log book.

Figure 3-73. Component Replacement Criteria

NOTE

The position of the threaded bushings in the support and the bolts in the slotted holes of the support and bracket must not be disturbed.

d. Remove Gimbal Bearing Locks G4059, and install holding fixture T-5037454 ring, screw jacks, and plate, with screw jacks retracted. Position notch in ring toward turbopump oxidizer inlet.

e. Adjust screw jacks to position gimbal face approximately parallel with injector.

NOTE

Measurements may be taken through holes E, F, G, and H (figure 3-75) to approximately parallel gimbal interface.

f. Install check fixture T-5037452 on holding fixture.

g. With dial indicator in position No. 1 (figure 3-76), measure distances to forward surfaces of alinement pins A and B (figure 3-75). Record dimensions.

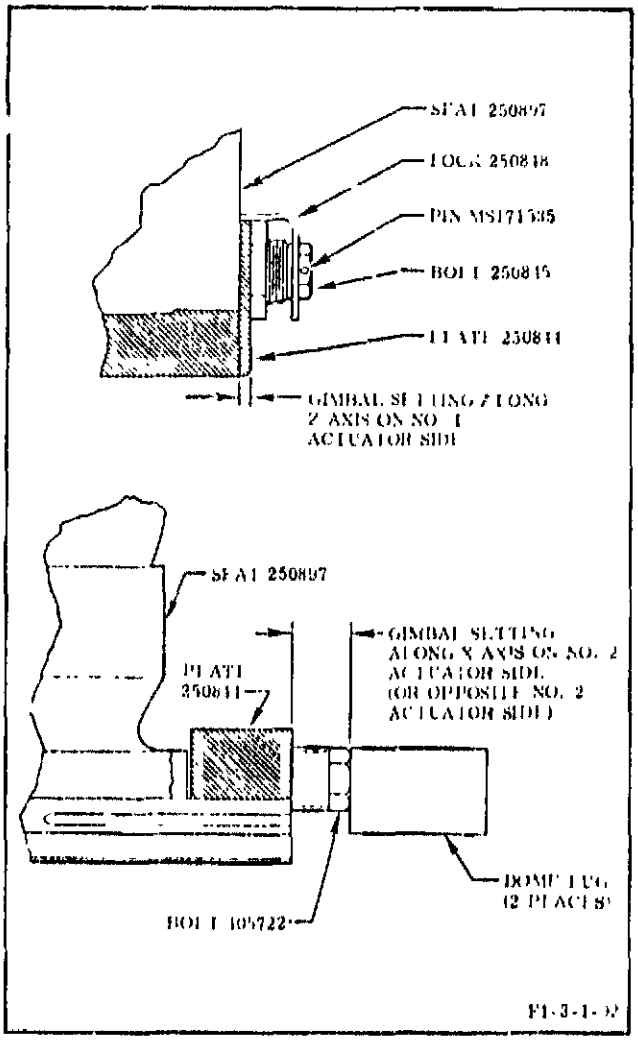


Figure 3-74. Adjusting Gimbal Bearing

h. If difference between dimensions exceed 0.005 inch, adjust screw jacks of holding fixture, as necessary, to obtain parallelism within tolerance noted.

i. Repeat step g, and record final values for each position.

j. Repeat steps g through i with alinement pins C and D. (See figure 3-75.)

k. Measure and record final dial indicator readings for each alinement pin location.

l. Remove handling equipment, and install 4 Gimbal Bearing Locks G4059.

NOTE

The fixtures may be left installed if centering and alining the gimbal (paragraphs 3-259 and 3-260) is required.

m. Install heat exchanger customer duct support and bracket.

n. Torque bolts at dome boltheads to 300 ±10 in-lb.

o. Torque nuts for bracket bolts at fuel manifold to 170 ±10 in-lb.

p. Install bracket cover, and torque bolts to 25 ±5 in-lb. Safetywire bolts.

3-259. CENTERING GIMBAL BEARING TO ENGINE CENTERLINE. Compliance with the requirements of paragraph 3-258 must precede performance of this procedure.

a. If not already installed from paragraph 3-258, install holding fixture T-5037454 and check fixture T-5037452.

b. Using dial indicator in position No. 2 (figure 3-76), measure and record distances to outer diameter of alinement pins A and B (figure 3-75).

c. If difference between the dimensions recorded exceeds 0.010 inch, adjust X_G axis adjusting bolts to obtain a $+X_G$ or $-X_G$ difference within tolerance indicated. Record plus or minus difference.

NOTE

A 1/6 turn of the X_G axis adjusting bolts moves the gimbal 0.014 inch along the axis.

d. Repeat step b with alinement pins C and D.

e. If difference between dimensions recorded exceeds 0.010 inch, adjust Z_G axis adjusting bolt to obtain a $+Z_G$ or $-Z_G$ difference within tolerance indicated. Record plus or minus difference.

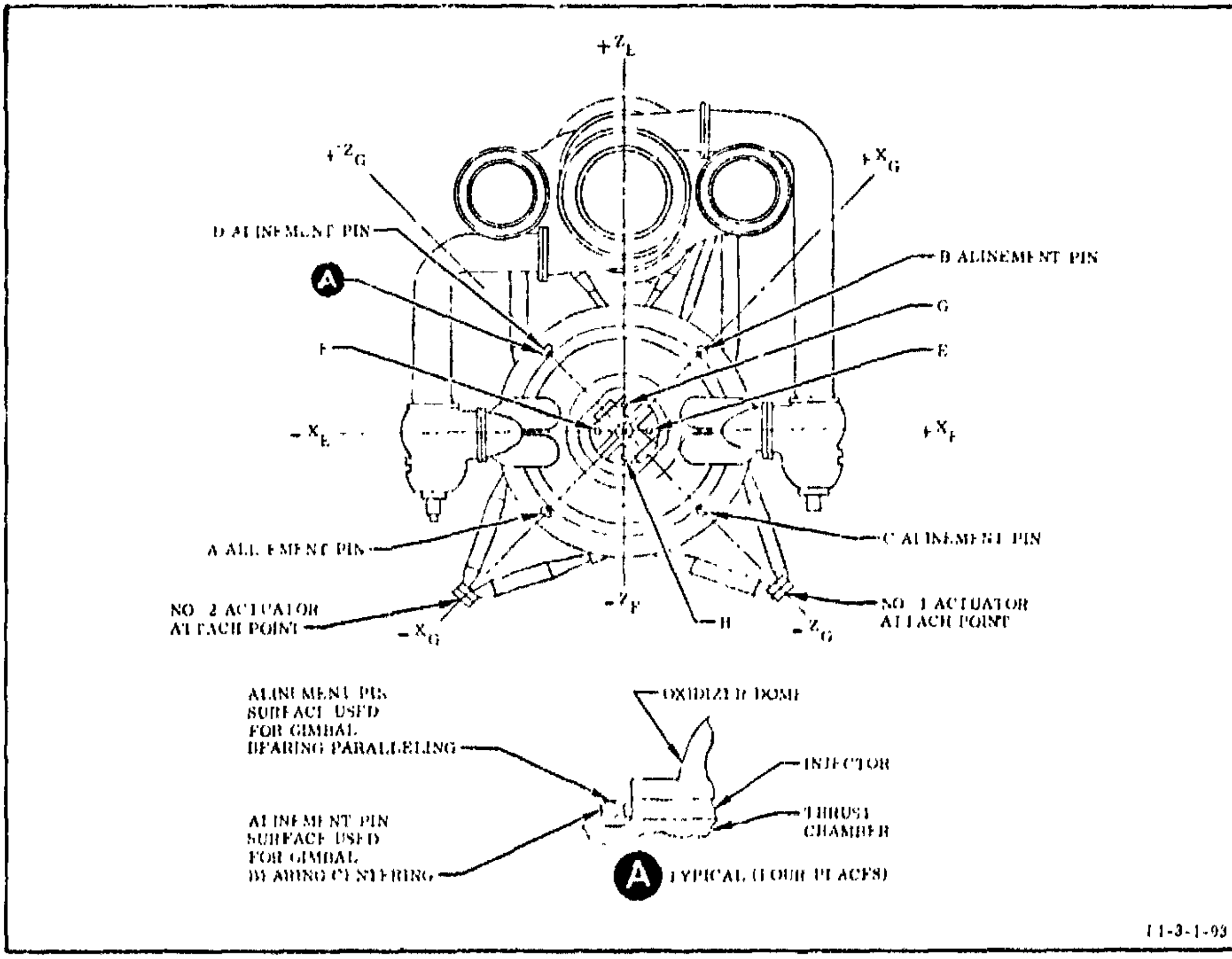


Figure 3-75. Alining Gimbal Bearing

NOTE

A 1/12 turn of the Z_G axis adjusting bolt moves the gimbal 0.007 inch along the axis.

f. Repeat steps b through e, and record final plus or minus dimensional differences.

3-260. GIMBAL BEARING FINAL ALINEMENT. The final alinement places the centerline of the gimbal in the delivered engine position. Compliance with the requirements of paragraphs 3-258 and 3-259 must precede the performance of this procedure.

a. Obtain values for the following from engine acceptance data sheet in Engine Log Book:

(1) Resultant gimbal factor

(2) X_G component gimbal adjustment factor

(3) Z_G component gimbal adjustment factor

b. Remove handling equipment, and install Gimbal Bearing Locks G4059.

c. Obtain value for gimbal setting along Z_G axis on No. 1 actuator side by measuring distance from plate to etched cross on seat of gimbal. Record measurement.

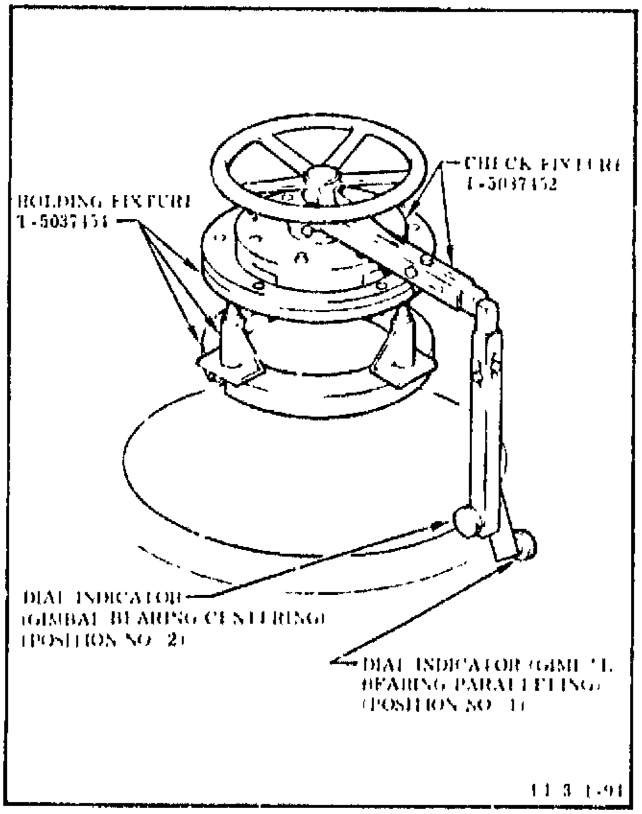


Figure 3-76. Gimbal Bearing Alinement Tools

d. Obtain value for gimbal setting along X_G axis on No. 2 actuator side by measuring distance between dome lug nearest No. 2 actuator side and plate of gimbal. Record measurement.

e. Obtain value for gimbal setting along X_G axis opposite No. 2 actuator side by measuring distance between dome lug opposite No. 2 actuator side and plate. Record measurement.

f. Move gimbal according to gimbal factors obtained in step a.

g. Repeat steps c through e, and record new values in Engine Log Book.

h. Install lock and pin on Z_G axis adjusting bolt.

i. Torque flange bolts to 300 ±10 ft-lb.

j. Repeat steps c through e, and make sure that values were not changed during bolt torquing. If a changed value exceeds ±0.010 inch, retorque flange bolts to 300 ±10 ft-lb; repeat procedure until settings remain in tolerance after final torquing.

k. Safetywire X_G axis and Z_G axis adjusting bolts.

l. Install boot pan and boot as outlined in paragraph 3-255.

3-261. ASSOCIATED ENGINE EQUIPMENT.

3-262. This procedure is performed when indicated by other procedures in this section. The associated equipment must be removed to accomplish any oxidizer dome removal either singularly or in combination with the gimbal bearing and/or the thrust chamber injector. Equipment required consists of Turbopump Support G4083 and sling 9024915.

3-263. REMOVING ASSOCIATED ENGINE EQUIPMENT. (See figure 3-77.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove wrap around lines as outlined in paragraph 3-91.

c. Remove the following thermal insulation components. Retain attaching parts. Insulator 145532 may be cleared, as required, with brackets 145188, 145286, and 145614 partially assembled. (Refer to R-3896-6 for part locations.)

(1) Frame 145477

(2) Frame 145325

(3) Bracket 145290

(4) Clamps 145255

(5) Tie rod 145305

(6) Bracket 145344

(7) Bracket 145188

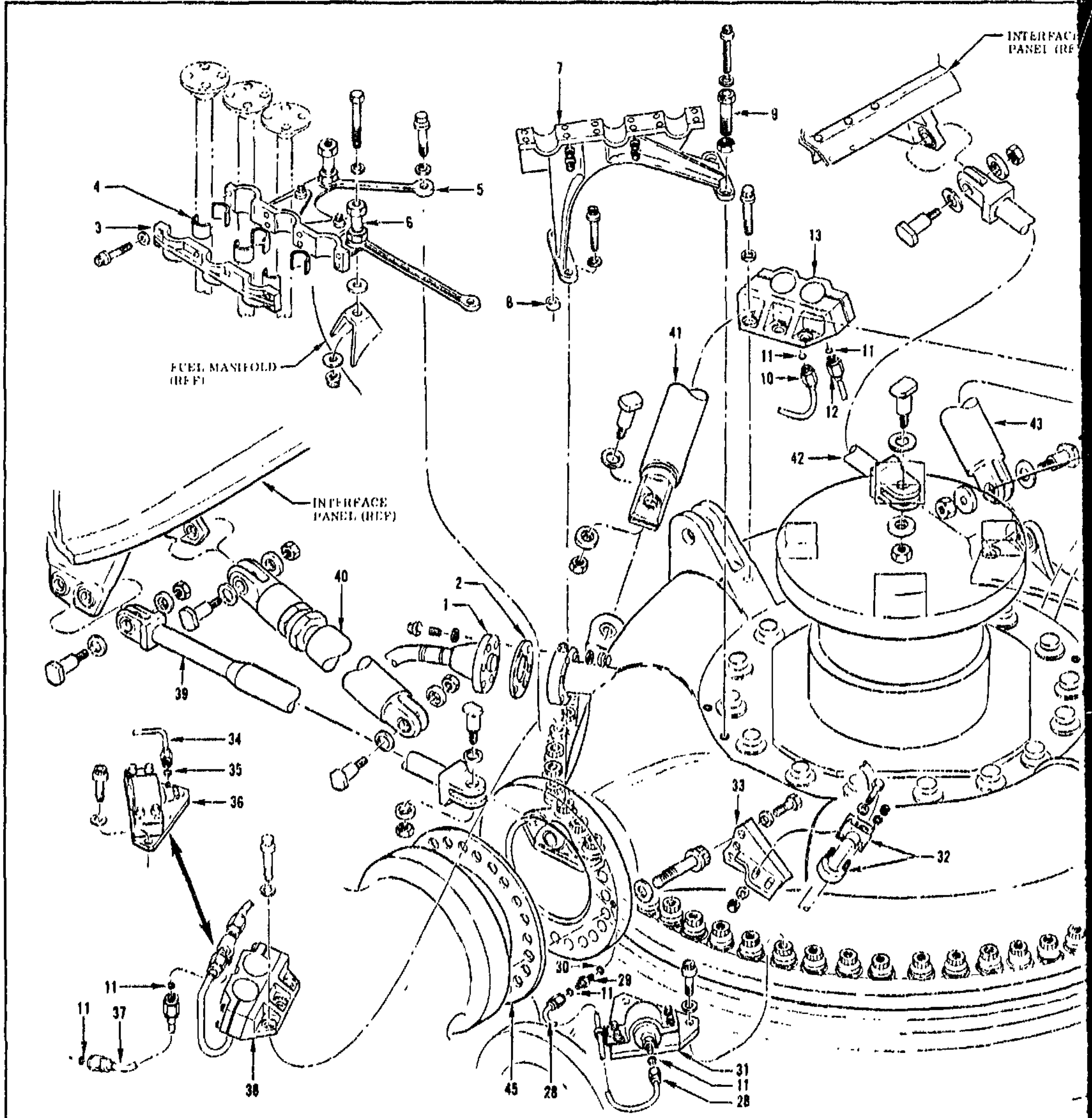
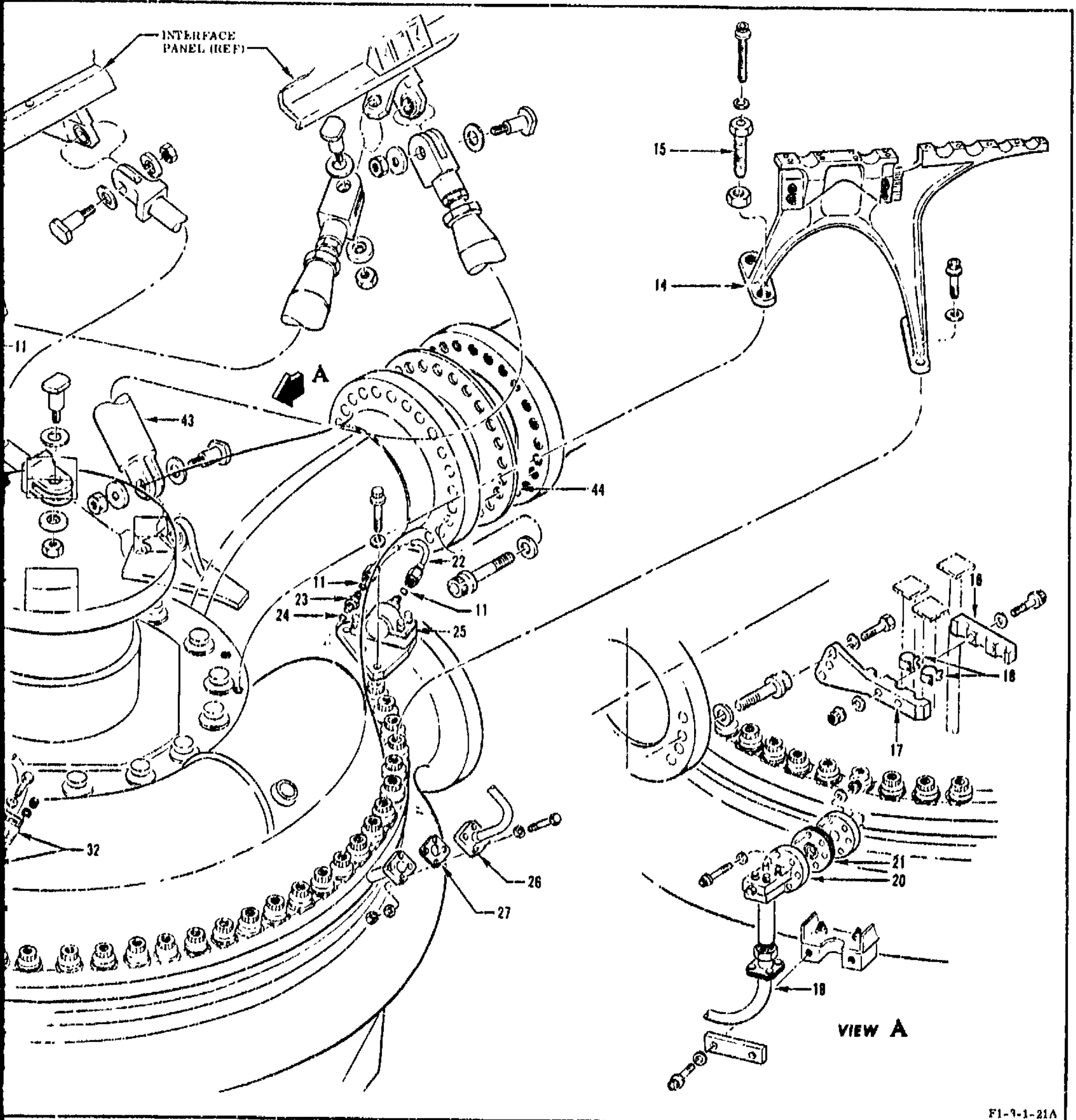


Figure 3-77. Associated Engine Equipment (Sheet 1 of 2)


INTERFACE
PANEL (REF)
15
14
11
A
43
44
22
11
23
24
11
25
16
18
17
32
21
20
26
27
19
VIEW A

F1-3-1-21A

1	Check valve	12	Tube[a]	24	Gasket	36	Support[d]
2	Pressure-actuated seal	13	Bracket[a]	25	Support[a]	37	Tube[a]
3	Cover	14	Support	26	Hose	38	Bracket[a]
4	Liner	15	Bushing	27	Seal	39	Strut
5	Support	16	Cover	28	Tube	40	Strut
6	Bushing	17	Support	29	Union	41	Strut
7	Support	18	Clamp	30	Gasket	42	Strut
8	Spacer	19	Plug	31	Support[a]	43	Strut
9	Bushing	20	Adapter	32	Retainer[b][c]	44	Pressure-actuated seal
10	Tube[a]	21	Seal	33	Bracket[c]	45	Pressure-actuated seal
11	Seal	22	Tube	34	Tube[d]		
		23	Union	35	Seal[d]		

(a) Engines incorporating MD150 or MD151 change
(b) Matched set
(c) Engines incorporating MD162 or MD163 change
(d) Engines not incorporating MD150 or MD151 change

Figure 3-77. Associated Engine Equipment (Sheet 2 of 2)

(8) Bracket 145286

(9) Bracket 145614

(10) Insulator 145532

d. Disconnect check valve (1), and remove seal (2).

e. Remove cover (3). Liners (4) may be left installed.

f. Remove support (5) without disturbing bushings (6) or adjusting support to bracket.

g. Remove support (7) and spacer (8). Do not disturb bushings (9).

h. On engines incorporating MD150 or MD151 change, disconnect tubes (10, 12), remove seals (11), and remove bracket (13).

i. Remove support (14) without disturbing bushings (15).

j. Measure and record extension of purge lines from line interfaces to support (17); then remove cover (16) and support (17). Clamps (18) may be left installed on lines.

k. If thrust chamber injector is to be removed, disconnect plug (19) as outlined in paragraph 3-16.

l. Remove adapter (20) with transducer attached, and remove seal (21).

m. Remove tube (22) and seals (11). If thrust chamber injector will be replaced, remove union (23) and gasket (24).

n. On engines incorporating MD150 or MD151 change, remove support (25).

o. Disconnect hose (26), and remove seal (27).

p. Remove tube (28) and seals (11). If thrust chamber injector will be replaced, remove union (29) and gasket (30).

q. On engines incorporating MD150 or MD151 change, remove support (31).

r. On engines incorporating MD162 or MD163 change, remove retainer (32), and bracket (33).

NOTE

Retainer (32) consists of matched parts. If one part is damaged, the complete retainer must be replaced.

s. On engines not incorporating MD150 or MD151 change, remove tube (34), seal (35), and support (36).

t. On engines incorporating MD150 or MD151 change, remove tube (37), seals (11), and bracket (38).

CAUTION

Tension on the interface panel sling must maintain the interface panel in the level position. Excessive tension can damage engine electrical harnesses.

u. Support interface panel using sling 9024915 from Component Handling Fixture Set G4068. (See figure 3-70.)

v. Remove struts (40 through 43).

NOTE

Strut (39) cannot be removed until the oxidizer dome is partly removed.

w. Install Turbopump Support G4083 using instructions provided on support.

CAUTION

The oxidizer valves may be supported against the fuel valves. Personnel must not exert their weight on unsupported oxidizer valves because alinement may be affected.

x. Disconnect No. 1 and No. 2 oxidizer valves from oxidizer dome, and remove pressure-actuated seals (44, 45).

3-264. INSTALLING ASSOCIATED ENGINE EQUIPMENT. (See figure 3-77.) Lubricants used in this procedure must be applied using specified lubricating procedures (methods) outlined in section I.

a. Observe safety, and contamination and damage prevention requirements as outlined in section I.

b. Install pressure-actuated seals (44, 45), and attach No. 1 and No. 2 oxidizer valves to oxidizer dome. Cross-torque bolts to 1,150-1,250 in-lb. Safetywire bolts.

c. Make sure that oxidizer duct and oxidizer valve flanged joints are secured on at least one side of engine; then remove Turbopump Support G4083, and reinstall fasteners removed to install support. Cross-torque nuts to 1,150-1,250 in-lb.

d. Install struts (40 through 43). Lubricate (Method Z) pins with gear grease (MIL-G-23827), and torque nuts for pins to 35 ±5 in-lb. Safetywire nuts to heads of pins.

NOTE

Strut (39) was installed during installation of the oxidizer dome.

e. Remove sling 9024915.

f. If unions (23, 29) and gaskets (24, 30) were removed, lubricate (Method A) unions with thread compound C-5A (Felt Products) and install gaskets and unions. Torque unions to 55-80 in-lb. Safetywire unions.

g. On engines not incorporating MD150 or MD151 change, install support (36) on dome bolts numbered 7, 39, and 23. Torque attaching bolts to 35 ±5 in-lb; then lubricate (Method G) tube (34) with lubricant grease RB0140-012 (Rocketdyne) and install seals (35) and tube. Torque tube coupling nuts to 160 ±10 in-lb. Safetywire bolts and coupling nuts.

h. On engines incorporating MD150 or MD151 change, install the following supports and brackets at numbered oxidizer dome bolts as indicated. Torque attaching bolts to 75 ±5 in-lb and safetywire bolts.

(1) Bracket (38): dome bolts 7, 39, and 23.

(2) Support (31): dome bolts 22, 42, and 14.

(3) Support (25): dome bolts 57, 32, and 53.

(4) Bracket (13): dome bolts 29, 59, and 9.

i. On engines incorporating MD150 or MD151 change, lubricate (Method G) tubes (22, 28) with thread compound C-5A (Felt Products). Install seals (11) and tubes. Torque coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

j. On engines incorporating MD150 or MD151 change, lubricate (Method G) tubes (10, 12, 37) with lubricant grease RB0140-012 (Rocketdyne). Install seals (11) and tubes. Torque tube coupling nuts to 160 ±10 in-lb. Safetywire coupling nuts.

k. Install bracket (33), and torque bolts to 175 ±15 in-lb. Safetywire bolts.

l. Install retainer (32) so that no stress is exerted on line. Torque nuts attaching retainer to bracket to 75 ±10 in-lb. Torque nuts of retainer to 25 ±5 in-lb.

m. Install seal (27) and connect hose (26). Cross-torque nuts to 85 ±5 in-lb.

n. If thrust chamber injector was disturbed, install seal (21) and adapter (20). Connect plug (19) to transducer as outlined in paragraph 3-17; then cross-torque nuts attaching adapter to 100 ±10 in-lb.

o. Make sure clamps (18) are installed on lines; then install support (17). Adjust support to dimensions recorded during removal for extension of lines and torque bolts to 100 ±5 in-lb.

p. Install cover (16). Torque nuts to 75 ±5 in-lb.

q. Install support (14). Torque bolts through bushings (15) to 85 ±5 in-lb. Torque outer bolts to 350 ±25 in-lb. Safetywire bolts. If bushings (15) or bracket attached to support (14) were disturbed, support and bracket must be adjusted as outlined in paragraph 3-267. Torque for bushing nuts is 150 ±20 in-lb. Safetywire nuts and bushings.

r. Install spacer (8) and support (7). A minimum of 0.010 inch must be maintained between the support and the dome torus. A maximum of three washers RD153-1002-0006 may be installed under the support at the dome flange to obtain the required clearance. Torque bolts through bushings to 85 ±5 in-lb. Torque outer bolts to 300 ±10 in-lb. Safetywire bolts. If bushings (9) or bracket attached to support (7) were disturbed, the support and bracket must be alined as outlined in paragraph 3-265.

s. Install support (5). Torque bolts at dome flange to 300 ±10 in-lb. Torque nuts to 170 ±10 in-lb. Safetywire bolts at dome flange. If bushings (6) or bracket attached to support (5) were disturbed, support and bracket must be alined as outlined in paragraph 3-269.

t. Install liners (4) and cover (3). Torque nuts for cover bolts to 25 ±5 in-lb.

u. Install pressure-actuated seal (2) and check valve (1). Cross-torque bolts to 255 ±5 in-lb.

v. Check alinement of interface panel as outlined in paragraph 3-251.

w. Reinstall thermal insulation components listed in paragraph 3-263. Install components as outlined in R-3896-6.

x. Install wrap-around lines as outlined in paragraph 3-92.

y. Refer to section IV for post-maintenance test requirements.

3-265. ALINING HEAT EXCHANGER CUSTOMER DUCT SUPPORT AND BRACKET (See figure 3-78.)

3-266. Equipment required for alinement consists of holding fixture T-5037454, alinement tool T-5039113, and Gimbal Bearing Locks G4059.

NOTE

> The parallel surface of the gimbal bearing interface may be used in this procedure only when any required gimbal adjustments have been completed.

a. If not already installed, install heat exchanger customer duct support and bracket. Torque bolts in dome bolthead to 300 ±10 in-lb. Torque support bolts to dome face to 85 ±5 in-lb. Safetywire bolts.

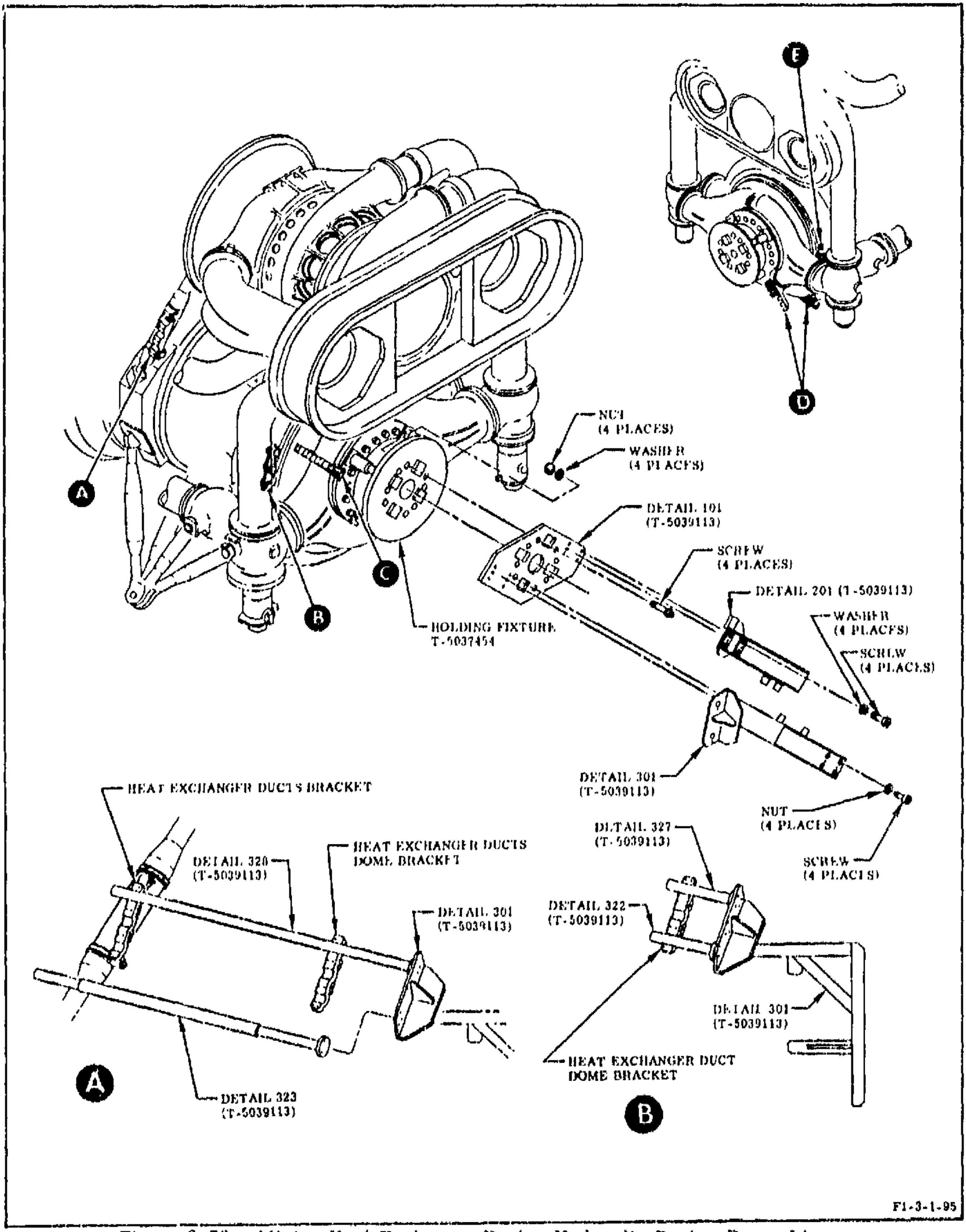


Figure 3-78. Alining Heat Exchanger Ducts, Hydraulic Ducts, Purge Lines, and Support Brackets (Sheet 1 of 2)

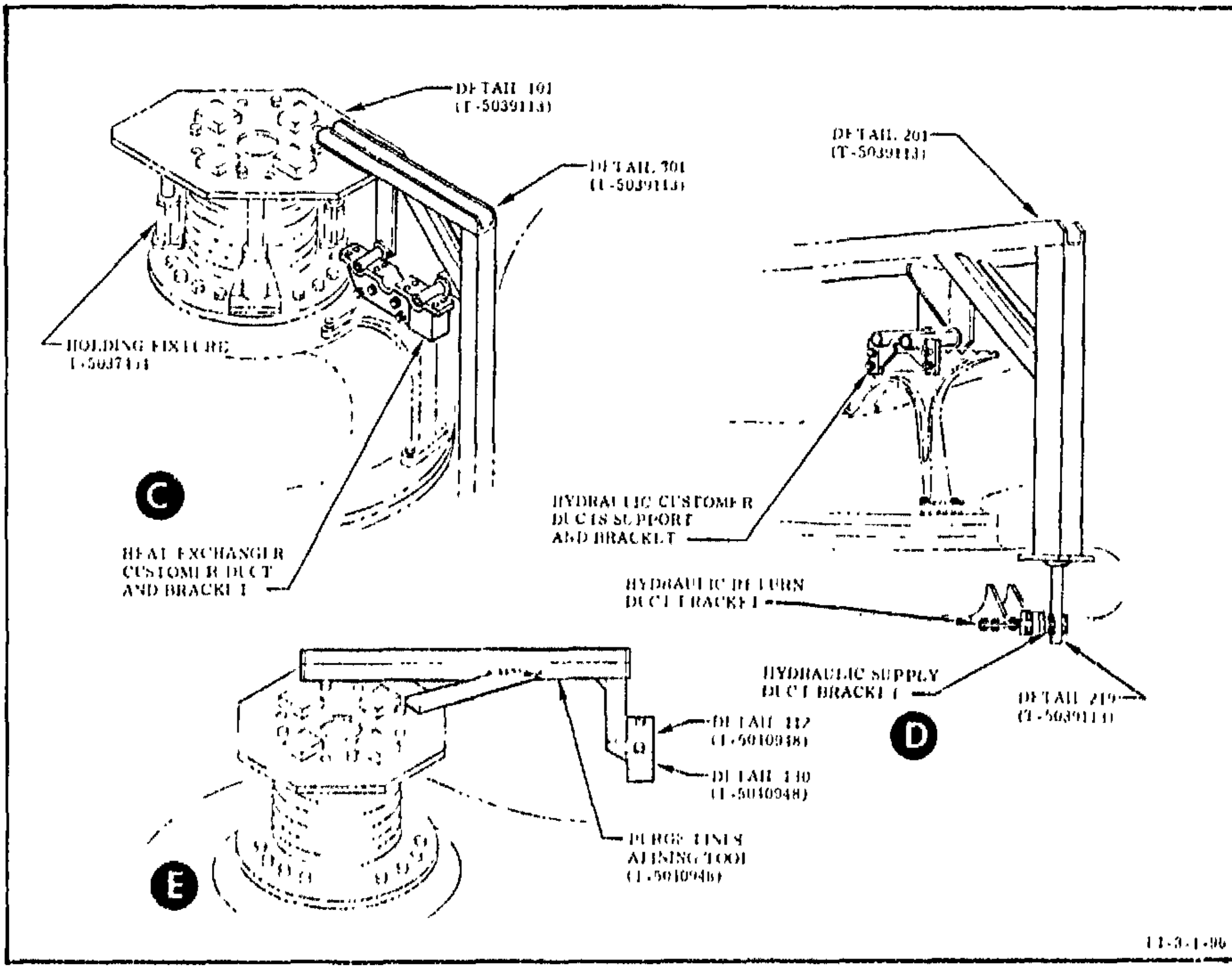


Figure 3-78. Alining Heat Exchanger Ducts, Hydraulic Ducts, Purge Lines, and Support Brackets (Sheet 2 of 2)

b. Parallel gimbal interface as outlined in paragraph 3-258. Leave holding fixture T-5037454 installed.

c. Install detail 101 of alinement tool T-5039113 on tool plate that is installed on gimbal bearing interface. (See figure 3-78, detail C, for tooling.)

d. Install detail 301 of alinement tool on detail 101.

e. Aline bracket to details 303 and 306 of detail 301 of alinement tool, using bracket-to-support adjusting bolts and adjustable bushings of support. Torque nuts for bracket bolts to 95 ±5 in-lb. Torque bushing nuts to 150 ±50 in-lb. Safetywire bolts, bushings, and nuts.

f. Remove alining equipment, and install 4 Gimbal Bearing Locks G4059.

NOTE

If the hydraulic customer duct support is installed and requires alinement (paragraph 3-267), the alining equipment may be left installed.

3-267. ALINING HYDRAULIC CUSTOMER DUCT SUPPORT AND BRACKET. (See figure 3-78.)

3-268. Equipment required for alinement consists of holding fixture T-5037454, alinement tool T-5039113, and Gimbal Bearing Locks G4059.

NOTE

The parallel surface of the gimbal bearing interface may be used in this procedure only when any required gimbal adjustments have been completed.

a. If not already installed, install hydraulic customer duct support and bracket. Torque bolts in dome boltheads to 300 ±10 in-lb. Torque support bolts to dome face to 85 ±5 in-lb. Safetywire bolts.

b. Parallel gimbal bearing (paragraph 3-258). Leave holding fixture T-5037454 installed.

c. Install detail 101 of alinement tool T-5039113 on tool plate that is installed on gimbal bearing interface. (See figure 3-78, detail D, for tooling.)

d. Install detail 201 of alinement tool on detail 101.

e. Aline bracket to detail 210, using bracket-to-support adjusting bolts and adjustable bushings of support. Torque nuts for bracket bolts to 130 ±10 in-lb. Torque bushing nuts to 150 ±20 in-lb. Safetywire bolts, bushings, and nuts.

f. Remove alining equipment, and install 4 Gimbal Bearing Locks G4059.

3-269. ALINING HEAT EXCHANGER DUCTS SUPPORTS AND BRACKETS. (See figure 3-78.)

3-270. Equipment required for alinement consists of holding fixture T-5037454, alinement tool T-5039113, and Gimbal Bearing Locks G4059.

a. Aline heat exchanger ducts supports and brackets if position of any of the following has been disturbed:

(1) Heat exchanger ducts dome support to heat exchanger dome bracket (adjustment bolts)

(2) Turbopump heat exchanger strut support.

(3) Heat exchanger bracket (at strut support)

b. (Deleted)

c. Parallel gimbal bearing as outlined in paragraph 3-258. Leave holding fixture T-5037454 installed.

d. Install detail 101 of alinement tool T-5039113 on tool plate that is installed on gimbal bearing interface. (See figure 3-78, details A and B, for tooling.)

e. Install detail 301 of alinement tool on detail 101. Use stubs (details 322, 323, 327, 329) of alinement tool with detail 301 to simulate heat exchanger ducts.

f. Adjust heat exchanger dome bracket to stubs by loosening bolts attaching it to heat exchanger ducts dome support. Torque nuts to 130 ±10 in-lb. Safetywire boltheads, and seal lockwire.

g. Adjust turbopump heat exchanger strut support so that attached brackets aline to stubs Torque strut support nuts to 155 ±5 in-lb. Torque duct support bracket nuts to 100 ±10 in-lb. Safetywire boltheads, and seal lockwire.

h. Remove alining equipment, and install 4 Gimbal Bearing Locks G4059.

3-271. ALINING GROUND SUPPLY HYDRAULIC DUCT AND CHECKOUT VALVE-TO-HYDRAULIC RETURN DUCT. (See figure 3-78.)

3-272. Equipment required for alinement consists of holding fixture T-5037454, alinement tool T-5039113, and Gimbal Bearing Locks G4059.

NOTE

The parallel surface of the gimbal bearing interface may be used in this procedure only when any required gimbal adjustments have been completed.

a. Parallel gimbal interface as outlined in paragraph 3-258. Leave holding fixture T-5037454 installed.

b. Install detail 101 of alinement tool T-5039113 on tool plate on gimbal bearing interface. (See figure 3-78, detail D, for tooling.)

c. Install detail 201 of alinement tool to detail 101.

CAUTION

If the flanges do not aline to the tool, the cover, clamp, support, and bracket bolts must be loosened, to prevent stress on the hoses.

d. Secure duct flanges t[illegible] ol face.

NOTE

If the hydraulic supply duct is not installed, detail 219 of the alinement tool is installed on detail 201 to aline the duct supply bracket.

e. Secure hydraulic supply duct support by torquing nuts to 90 +5 in-lb. Safetywire bolts, and seal lockwire.

f. Secure hydraulic supply duct bracket and hydraulic return duct support bracket by torquing nuts to 110 +10 in-lb. Safetywire bolts, and seal lockwire.

g. Secure hydraulic support duct bracket clamp by torquing nut to 40 +5 in-lb.

h. Secure hydraulic return duct support cover by torquing nuts to 30 +2 in-lb.

i. Remove alining equipment, and install 4 Gimbal Bearing Locks G4059.

3-273. ALINING NO. 1 OXIDIZER VALVE DOME PURGE LINE AND PUMP SEAL PURGE LINE. (See figure 3-78.)

3-274. Equipment required for alinement consists of holding fixture T-5037454, alinement tool T-5040948, and Gimbal Bearing Locks G4059.

NOTE

The parallel surface of the gimbal bearing interface may be used in this procedure only when any required gimbal adjustments have been completed.

a. Parallel gimbal bearing interface as outlined in paragraph 3-258. Leave fixture T-5037454 installed.

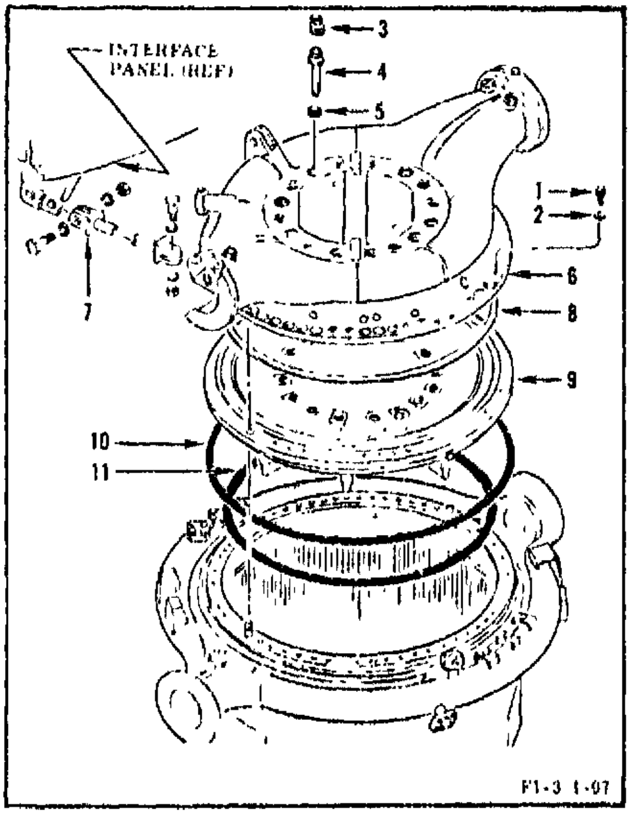
b. Install alinement tool T-5040948. (See figure 3-78, detail E.) If Gimbal Bearing Locks G4059 are used instead of holding fixture T-5037454, attach tool T-5040948 to gimbal bearing interface and add detail 130 behind detail 112.

c. Aline purge line interfaces to tool face by adjusting brackets. Torque nuts on cover of support to 75 +5 in-lb. Torque bolts of support at oxidizer dome flange boltheads to 100 +5 in-lb. Safetywire bolts.

d. Remove alining equipment, and install 4 Gimbal Bearing Locks G4059.

3-275. GIMBAL BEARING, OXIDIZER DOME, AND THRUST CHAMBER INJECTOR.

3-276. This procedure removes and installs the gimbal bearing, oxidizer dome, and thrust chamber injector as an assembly (see figure 3-79). Equipment required consists of adapter 9024906, support 9024929, and fixture 9024912 from Component Handling Fixture Set G4068, and alinement pins T-5039454. (See figure 3-80 for handling equipment.)



1 Bolt	5 Seal	8 Gasket
2 Washer	6 Oxidizer dome	9 Injector
3 Plug		10 Seal
4 Bolt	7 Strut	11 Seal

Figure 3-79. Gimbal Bearing, Oxidizer Dome, and Thrust Chamber Injector

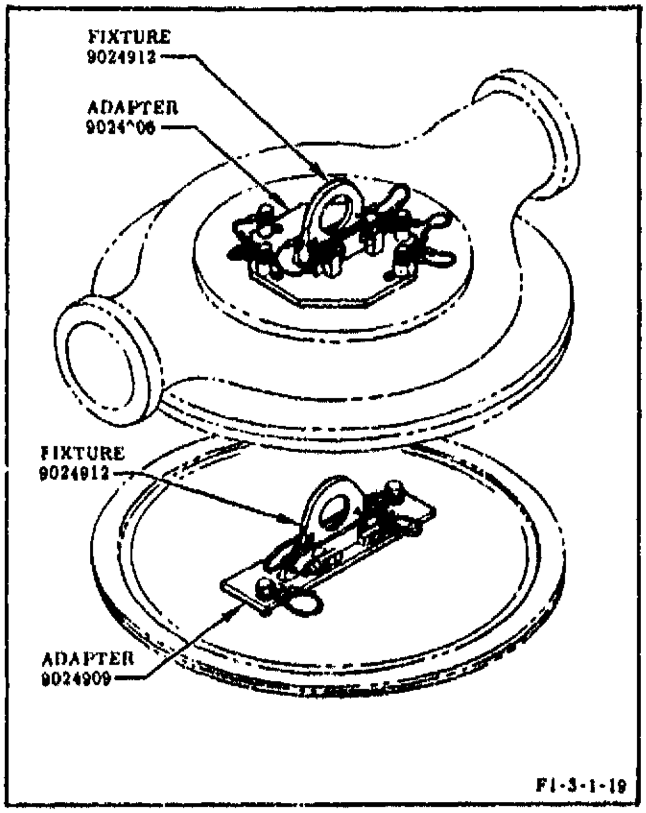


Figure 3-80. Handling Gimbal Bearing, Oxidizer Dome, and Thrust Chamber Injector

3-277. REMOVING GIMBAL BEARING, OXIDIZER DOME, AND THRUST CHAMBER INJECTOR. (See figure 3-79.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove associated engine equipment as outlined in paragraph 3-263.

c. Remove Gimbal Bearing Locks G4059, if installed.

d. Install adapter 9024906 on gimbal bearing interface; then attach fixture 9024912 to adapter. (See figure 3-80.) Torque adapter bolts to 600 in-lb minimum.

dA. Install support 9024929 on gimbal bearing.

e. Remove bolts (1, figure 3-79) and washers (2). Remove plugs (3), and slightly loosen bolts (4).

f. Disconnect strut (7).

CAUTION

The assembly weighs approximately 3,200 pounds.

- The thrust chamber injector must not be set on the injector baffles. Damage to the baffles or clogging of orifice holes may result.

g. Carefully hoist gimbal bearing, oxidizer dome (6), and injector (9) until strut (7) can be removed; then raise assembly, remove seals (10, 11), and place assembly on a clean, prepared surface with support against injector face or flange. Support material used must not damage injector surfaces.

h. Remove bolts (4) and seals (5), lift oxidizer dome from injector, and remove gasket (8).

i. Remove handling equipment, and install Gimbal Bearing Locks G4059.

NOTE

Handling the injector in a flat position requires adapter 9024909 and fixture 9024912. Adapter bolts must be torqued to 500 in-lb minimum.

j. Lubricate (Method A) oxidizer dome inlet closure fasteners with lubricant grease RB0140-012 (Rocketdyne).

3-278. INSTALLING GIMBAL BEARING, OXIDIZER DOME, AND THRUST CHAMBER INJECTOR. (See figure 3-79.) Specified lubricating procedures (methods) are outlined in section I.

WARNING

Component Handling Fixture Set G4068 must be operated by authorized personnel trained in the use of the equipment.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove Gimbal Bearing Locks G4059, if installed.

c. Install adapter 9024906 on gimbal bearing interface. (See figure 3-80.) Torque bolts to 600 in-lb minimum. Attach fixture 9024912 to adapter.

d. Install support 9024929 on gimbal.

CAUTION

The oxidizer dome and gimbal bearing weighs approximately 2,000 pounds.

e. Install gasket (8, figure 3-79) on injector (9) and carefully lower oxidizer dome on injector. Make sure that dome and injector indexing holes are alined. The index holes are located between the flange boltholes on the centerline of the oxidizer dome inlets.

f. Lubricate (Method A) bolts (4) with lubricant grease RB0140-012 (Rocketdyne). Lubricate (Method R) seals (5) with fluorinated oil Krytox 143 AZ (Du Pont) or lubricant grease RB0140-012 (Rocketdyne). Install seals and bolts in inner row of holes of dome. Cross-torque bolts in sequence indicated by numbers stamped in oxidizer dome to one-third of final torque. Final torque is 685 ±35 ft-lb.

g. Install seal (11) in thrust chamber.

CAUTION

The assembly weighs approximately 3,200 pounds.

h. Lift assembly, lubricate (Method K) seal (10) with FS1281 grease (Dow Corning Corp), and install seal on injector.

i. Aline assembly with index pins on thrust chamber and, as assembly is lowered, install strut (7) and temporarily secure strut at interface panel. Support most of assembly weight with crane until alinement pins are installed.

j. Obtain numbers of 2 flange boltholes used for alinement from Rigid-Duct Spacer Dimensions form in Engine Log Book.

k. Using 2 alinement pins T-5030454, back off expansion nuts of pins; then back off bolts (4).

l. Using a suitable flat washer under the expansion nuts, install alinement pins in applicable holes until pins bottom out. Release weight of assembly, and torque expansion nuts to 350 ±35 in-lb.

m. Install strut (7) attaching hardware. Lubricate (Method Z) pins with gear grease (MIL-G-23827). Torque nuts to 35 ±5 in-lb. Safetywire nuts to head of pins.

n. Remove handling equipment, and install 4 Gimbal Bearing Locks G4059.

o. Lubricate (Method A) bolts (1) and lubricate (Method F) flat sides of washers (2) with lubricant grease RB0140-012 (Rocketdyne). Install bolts and washers in the dome flange holes as indicated:

(1) Bolts 201599-5; holes numbered 11 and 41.

(2) Bolts 201599-3; holes numbered 21, 31, 37, and 58.

(3) Bolts 201599; remaining flange holes except those with pins installed.

p. Tighten sufficient bolts (1) to maintain assembly in position. Remove alinement pins and install applicable bolt and washer combination.

q. Cross-torque bolts (1) to one-third final torque in sequence indicated by numbers stamped in oxidizer dome. Repeat torque sequence in one-third increments following numerical sequence of numbers stamped in dome until bolts (1) are torqued to 425 ±25 ft-lb and bolts (4) are torqued to 685 ±35 ft-lb. Repeat torque sequence, as required, until all bolts have reached specified torque; then, following same torque sequence, back off first bolt (1) one-half turn and torque it to 335 ±15 ft-lb. Repeat for each bolt (1). Safetywire bolts (1).

r. Lubricate (Method A) plugs (3) with lubricant grease RB0140-012 (Rocketdyne). Install plugs and torque to 105 ±5 ft-lb. Safetywire plugs.

s. Aline gimbal bearing as outlined in paragraph 3-256.

t. Install associated engine equipment as outlined in paragraph 3-264.

3-279. GIMBAL BEARING AND OXIDIZER DOME.

3-280. This procedure removes and installs the gimbal bearing and oxidizer dome as an assembly without removing the thrust chamber injector. Replacement of the oxidizer dome does not affect engine calibration. Equipment required consists of adapter 9024906, support 9024929, and fixture 9024912 from Component Handling Fixture Set G4068, and alinement pins T-5039454. (See figure 3-80 for handling equipment.)

3-281. REMOVING GIMBAL BEARING AND OXIDIZER DOME. (See figure 3-79.) Specified lubricating procedures (methods) are outlined in section I.

WARNING

Component Handling Fixture Set G4068 must be operated by authorized personnel trained in the use of the equipment.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove associated engine equipment as outlined in paragraph 3-263.

c. Remove Gimbal Bearing Locks G4059, if installed.

d. Install adapter 9024906 on gimbal bearing interface; then attach fixture 9024912 to adapter. (See figure 3-80.) Torque adapter bolts to 600 in-lb minimum, and install support 9024929 on gimbal.

e. Remove bolts (1, figure 3-79), washers (2), plugs (3), bolts (4), and seals (5).

f. Disconnect strut (7).

CAUTION

The assembly weighs approximately 2,000 pounds.

g. Carefully hoist gimbal bearing and oxidizer dome (6) until strut (7) can be removed; then raise assembly, and place on a clean, prepared surface.

h. Remove gasket (8).

i. Remove handling equipment and install Gimbal Bearing Locks G4059.

j. Lubricate (Method A) oxidizer dome inlet closure fasteners with lubricant grease RB0140-012 (Rocketdyne).

3-282. INSTALLING GIMBAL BEARING AND OXIDIZER DOME. (See figure 3-79.) Specified lubricating procedures (methods) are outlined in section I.

WARNING

Component Handling Fixture Set G4068 must be operated by authorized personnel trained in the use of the equipment.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove Gimbal Bearing Locks G4059, if installed.

c. Install adapter 9024906 on gimbal bearing interface. Torque bolts to 600 in-lb minimum. Attach fixture 9024912 to adapter.

d. Install support 9024929 on gimbal.

e. Install gasket (8) on injector.

CAUTION

The assembly weighs approximately 2,000 pounds.

f. Lift gimbal bearing and oxidizer dome and aline assembly with index pins on thrust chamber. As assembly is lowered, install strut (7) and temporarily secure strut at interface panel. Support most of assembly weight with crane until alinement pins are installed.

g. Obtain numbers of 2 flange boltholes used for alinement from Rigid-Duct Spacer Dimensions form in Engine Log Book.

h. Using 2 alinement pins T-5939454, back off expansion nuts of pins; use a suitable flat washer under expansion nuts. Install alinement pins in applicable holes until pins bottom out. Release weight of assembly, and torque expansion nuts to 350 ±35 in-lb.

i. Install strut (7) attaching hardware. Lubricate (Method Z) pins with gear grease (MIL-G-23827). Torque nuts to 35 ±5 in-lb. Safetywire nuts to head of pins.

j. Remove handling equipment and install 4 Gimbal Bearing Locks G4059.

k. Lubricate (Method A) bolts (4) with lubricant grease RB0140-012 (Rocketdyne). Lubricate (Method R) seals (5) with fluorinated oil Krytox 143AZ (Du Pont) or lubricant grease RB0140-012 (Rocketdyne). Install seals and bolts in inner row of holes.

l. Lubricate (Method A) bolts (1) and lubricate (Method F) flat sides of washers (2) with lubricant grease RB0140-012 (Rocketdyne). Install bolts and washers in the dome flange holes as indicated:

(1) Bolts 201599-5; holes numbered 11 and 41.

(2) Bolts 201599-3; holes numbered 21, 31, 37, and 58.

(3) Bolts 201599; remaining flange holes except those with pins installed.

m. Tighten sufficient bolts (1, 4) to maintain assembly in position. Remove alinement pins and install applicable bolt and washer combination.

n. Cross-torque bolts (4) to one-third final torque, in sequence indicated by numbers stamped in oxidizer dome. Repeat torque sequence in one-third increments following numerical sequence of numbers stamped in dome until bolts (1) are torqued to 425 ±25 ft-lb and bolts (4) are torqued to 685 ±35 ft-lb. Repeat torque sequence, as required, until all bolts have reached specified torque; then, following same torque sequence, back off first bolt (1) one-half turn and torque it to 335 ±15 ft-lb. Repeat for each bolt (1). Safetywire bolts (1).

o. Lubricate (Method A) plugs (3) with lubricant grease RB0140-012 (Rocketdyne). Install plugs and torque to 105 ±5 ft-lb. Safetywire plugs.

p. Aline gimbal bearing as outlined in paragraph 3-256.

q. Install associated engine equipment as outlined in paragraph 3-264.

3-283. OXIDIZER DOME AND THRUST CHAMBER INJECTOR.

3-284. This procedure removes and installs the oxidizer dome and thrust chamber injector as an assembly when the gimbal bearing is not installed. Replacement of the oxidizer dome does not affect engine calibration. Replacement of the injector affects engine calibration. Equipment required consists of adapter 9024906, support 9024929, and fixture 9024912 from Component Handling Fixture Set G4068 and alinement pins T-5039454. (See figure 3-80 for handling equipment.)

3-285. REMOVING OXIDIZER DOME AND THRUST CHAMBER INJECTOR. (See figure 3-79.) Specified lubricating procedures (methods) are outlined in section I.

WARNING

Component Handling Fixture Set G4068 must be operated by authorized personnel trained in the use of the equipment.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove associated engine equipment as outlined in paragraph 3-263.

c. Install adapter 9024906 on oxidizer dome. (See figure 3-80.) Torque bolts to 600 in-lb minimum.

d. Attach fixture 9024912 to adapter.

e. Remove bolts (1, figure 3-79) and washers (2). Remove plugs (3) and slightly loosen bolts (4).

f. Disconnect strut (7).

fA. Install 2 guide pins T-5029611 in outer dome boltholes directly opposite from each other.

CAUTION

The assembly weighs approximately 2,800 pounds.

- The thrust chamber injector must not be set on the injector baffles. Damage to the baffles or clogging of orifice may result.

g. Carefully hoist oxidizer dome (6) and injector (9) until strut (7) can be removed; then raise assembly, remove seals (10, 11), and place assembly on a clean, prepared surface with support against injector face or flange. Material used must not damage injector surface.

h. Remove bolts (4) and seals (5); lift oxidizer dome from injector and remove gasket (8).

i. Remove guide pins and handling equipment.

NOTE

Handling the injector in a flat position requires adapter 9024909 and fixture 9024912. Adapter bolts must be torqued to 500 in-lb minimum.

j. Lubricate (Method A) oxidizer dome inlet closure fasteners with lubricant grease RB0140-012 (Rocketdyne).

3-286. INSTALLING OXIDIZER DOME AND THRUST CHAMBER INJECTOR. (See figure 3-79.) Lubricants used in this procedure must be applied using specified lubricating procedures (methods) outlined in section I.

WARNING

Component Handling Fixture Set G4068 must be operated by authorized personnel trained in the use of the equipment.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install adapter 9024906 on oxidizer dome. (See figure 3-80.) Torque bolts to 600 in-lb minimum.

c. Attach fixture 9024912 to adapter.

CAUTION

The oxidizer dome weighs approximately 1,600 pounds.

d. Install gasket (8, figure 3-79) on injector (9) and carefully lower oxidizer dome on injector. Make sure that dome and injector indexing holes are alined. The index holes are located between the boltholes on centerline of the oxidizer dome inlets.

e. Lubricate (Method A) bolts (4) with lubricant grease RB0140-012 (Rocketdyne). Lubricate (Method R) seals (5) with fluorinated oil Krytox 143AZ (Du Pont) or lubricant grease RB0140-012 (Rocketdyne). Install seals and bolts in inner row of holes in dome, and torque bolts (4), in sequence indicated by numbers stamped in oxidizer dome, to one-third of final torque. Final torque is 685 ±35 ft-lb.

f. Install seal (11) in thrust chamber.

CAUTION

The assembly weighs approximately 2,600 pounds.

g. Lift assembly, lubricate (Method K) seal (10) with FS1281 grease (Dow Corning Corp), and install seal on injector.

h. Aline assembly with index pins on thrust chamber and, as assembly is lowered, install strut (7) and temporarily secure strut at interface panel. Support most of assembly weight with crane until alinement pins are installed.

i. Obtain numbers of 2 boltholes used for alinement from Rigid-Duct Spacer Dimensions form in Engine Log Book.

j. Using 2 alinement pins T-5039454, back off expansion nuts of pins; then back off bolts (4).

k. Using a suitable flat washer under the expansion units, install alinement pins in applicable holes until pins bottom out. Release weight of assembly and torque expansion nuts to 350 ±35 in-lb.

l. Install strut (7) attaching hardware. Lubricate (Method Z) pins with gear grease (MIL-G-23827). Torque nuts to 35 ±5 in-lb. Safetywire nuts to heads of pins.

m. Remove handling equipment.

n. Lubricate (Method A) bolts (1) and lubricate (Method F) flat sides of washers (2) with lubricant grease RB0140-012 (Rocketdyne). Install bolts and washers in dome flange holes as indicated:

(1) Bolts 201599-5; holes numbered 11 and 41.

(2) Bolts 201599-3; holes numbered 21, 31, 37, and 58.

(3) Bolts 201599; remaining flange holes except those with pins installed.

o. Tighten sufficient bolts (1, 4) to maintain assembly in position. Remove alinement pins and install applicable bolt and washer combination.

p. Cross-torque bolts (4) to one-third final torque, in sequence indicated by numbers stamped in oxidizer dome. Repeat torque sequence in one-third increments following numerical sequence of numbers stamped in dome until bolts (1) are torqued to 425 ±25 ft-lb and bolts (4) are torqued to 685 ±35 ft-lb. Repeat torque sequence, as required, until all bolts have reached specified torque; then, following same torque sequence, back off first bolt (1) one-half turn and torque it to 335 ±15 ft-lb. Repeat for each bolt (1). Safetywire bolts (1).

q. Lubricate (Method A) plugs (3) with lubricant grease RB0140-012 (Rocketdyne). Install plugs and torque to 105 ±5 ft-lb. Safetywire plugs.

r. Install gimbal bearing as outlined in paragraph 3-255.

s. Install associated engine equipment as outlined in paragraph 3-264.

3-287. OXIDIZER DOME

3-288. This procedure removes and installs the oxidizer dome when the gimbal bearing is not installed. Replacement of the oxidizer dome does not affect engine calibration. Equipment required consists of adapter 9024906 and fixture 9024912 from Component Handling Fixture Set G4068, and alinement pins T-5039454. (See figure 3-80 for handling equipment.)

3-289. REMOVING OXIDIZER DOME. (See figure 3-79.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove associated engine equipment as outlined in paragraph 3-263.

c. Install adapter 9024906 on oxidizer dome. (See figure 3-80.) Torque bolts to 600 in-lb minimum.

d. Attach fixture 9024912 to adapter.

e. Remove bolts (1, figure 3-79), washers (2), plug (3), bolts (4), and seals (5).

f. Disconnect strut (7).

CAUTION

The oxidizer dome weighs approximately 1,600 pounds.

g. Carefully hoist oxidizer dome (6) until strut (7) can be removed; then raise assembly, and place on a clean, prepared surface.

h. Remove gasket (8).

i. Remove handling equipment.

j. Lubricate (Method A) oxidizer dome inlet closure and oxidizer dome to injector joint closure fasteners with lubricant grease RB0140-012 (Rocketdyne).

3-290. INSTALLING OXIDIZER DOME. (See figure 3-79.) Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install adapter 9024906 on oxidizer dome. (See figure 3-80.) Torque bolts to 600 in-lb minimum.

c. Attach fixture 9024912 to adapter.

d. Install gasket (8, figure 3-79) on injector.

CAUTION

The oxidizer dome weighs approximately 1,600 pounds.

e. Lift oxidizer dome and aline with index pins on thrust chamber. As assembly is lowered, install strut (7) and temporarily secure strut at interface panel. Support most of assembly weight with crane until alinement pins are installed.

f. Obtain numbers of 2 boltholes used for alinement from Rigid-Duct Spacer Dimensions form in Engine Log Book.

g. Using 2 alinement pins T-5039454, back off expansion nuts of pins and, using a suitable flat washer under the expansion nuts, install alinement pins in applicable holes until pins bottom out. Release weight of assembly and torque expansion nuts to 350 ±35 in-lb.

h. Install strut (7) attaching hardware. Lubricate (Method Z) pins with gear grease (MIL-G-23827). Torque nuts to 35 ±5 in-lb. Safetywire nuts to head of pins.

i. Remove handling equipment.

j. Lubricate (Method A) bolts (4) with lubricant grease RB0140-012 (Rocketdyne). Lubricate (Method R) seals (5) with fluorinated oil Krytox 143AZ (Du Pont) or lubricant grease RB0140-012 (Rocketdyne). Install seals and bolts in inner row of holes.

k. Lubricate (Method A) bolts (1) and lubricate (Method F) flat sides of washers (2) with lubricant grease RB0140-012 (Rocketdyne). Install bolts and washers in dome flange holes as indicated:

(1) Bolts 201599-5; holes numbered 11 and 41.

(2) Bolts 201599-3; holes numbered 21, 31, 37, and 58.

(3) Bolts 201599; remaining flange holes except those with pins installed.

l. Tighten sufficient bolts (1, 4) to maintain assembly in position. Remove alinement pins and install applicable bolt and washer combination.

m. Cross-torque bolts (4) to one-third final torque, in sequence indicated by numbers stamped in oxidizer dome. Repeat torque sequence in one-third increments following numerical sequence of numbers stamped in dome until bolts (1) are torqued to 425 +25 ft-lb and bolts (4) are torqued to 685 +35 ft-lb. Repeat torque sequence, as required, until all bolts have reached specified torque; then, following same torque sequence, back off first bolt (1) one-half turn and torque it to 335 ±15 ft-lb. Repeat for each bolt (1). Safetywire bolts (1).

n. Lubricate (Method A) plugs (3) with lubricant grease RB0140-012 (Rocketdyne). Install plugs and torque to 105 ±5 ft-lb. Safetywire plugs.

o. Install gimbal bearing as outlined in paragraph 3-255.

p. Install associated engine equipment as outlined in paragraph 3-264.

3-291. THRUST CHAMBER INJECTOR.

3-292. This procedure removes and installs the thrust chamber injector as an assembly when the oxidizer dome is not installed. Replacement of the injector affects engine calibration. Equipment required consists of adapter 9024909 and fixture 9024912 from Component Handling Fixture Set G4068 and alinement pins T-5039454. (See figure 3-80 for handling equipment.)

3-293. REMOVING THRUST CHAMBER INJECTOR. (See figure 3-79.)

WARNING

Component Handling Fixture Set G4068 must be operated by authorized personnel trained in the use of the equipment.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install adapter 9024909 on injector. (See figure 3-80.) Torque bolts to 500 in-lb minimum.

c. Attach fixture 9024912 to adapter.

CAUTION

The injector weighs approximately 1,200 pounds.

- The thrust chamber injector must not be set on the injector baffles. Damage to the baffles or clogging of orifices may result.

d. Carefully hoist assembly, remove seals (10, 11, figure 3-79), and place assembly on a clean, prepared surface with support against injector face or flange. Support material must not damage injector surfaces.

e. Remove handling equipment.

3-294. INSTALLING THRUST CHAMBER INJECTOR. (See figure 3-79.)

WARNING

Component Handling Fixture Set G4068 must be operated by authorized personnel trained in the use of the equipment.

NOTE

The injector may be installed in conjunction with procedures outlined in paragraph 3-275 or 3-283.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install adapter 9024909 on injector (9, figure 3-79). (See figure 3-80.) Torque bolts to 500 in-lb minimum.

c. Attach fixture 9024912 to adapter.

d. Install seal (11, figure 3-79) in thrust chamber.

CAUTION

The injector weighs approximately 1,200 pounds.

e. Lift injector assembly and using Method K outlined in section I, lubricate seal (10) with FS1281 grease (Dow Corning Corp), and install seal on injector.

f. Aline assembly with index pins on thrust chamber as assembly is lowered. Support most of assembly weight with crane until alinement pins are installed.

g. Obtain numbers of 2 boltholes used for alinement from Rigid-Duct Spacer Dimensions form in Engine Log Book.

h. Using 2 alinement pins T-5039454, back off expansion nuts of pins.

i. Using a suitable flat washer under the expansion nuts, install alinement pins in applicable holes until pins bottom out. Release weight of assembly and torque expansion nuts to 350 ±35 in-lb. Remove alinement pins and handling equipment.

3-295. NO. 1 FUEL INLET ELBOW. (See figure 3-81.)

3-296. Equipment required consists of adapter 9024436 and fixture 9024923-11 from Component Handling Fixture Set G4068. (See figure 3-82 for handling equipment.)

WARNING

Component Handling Fixture Set G4068 must be operated by authorized personnel trained in the use of the equipment.

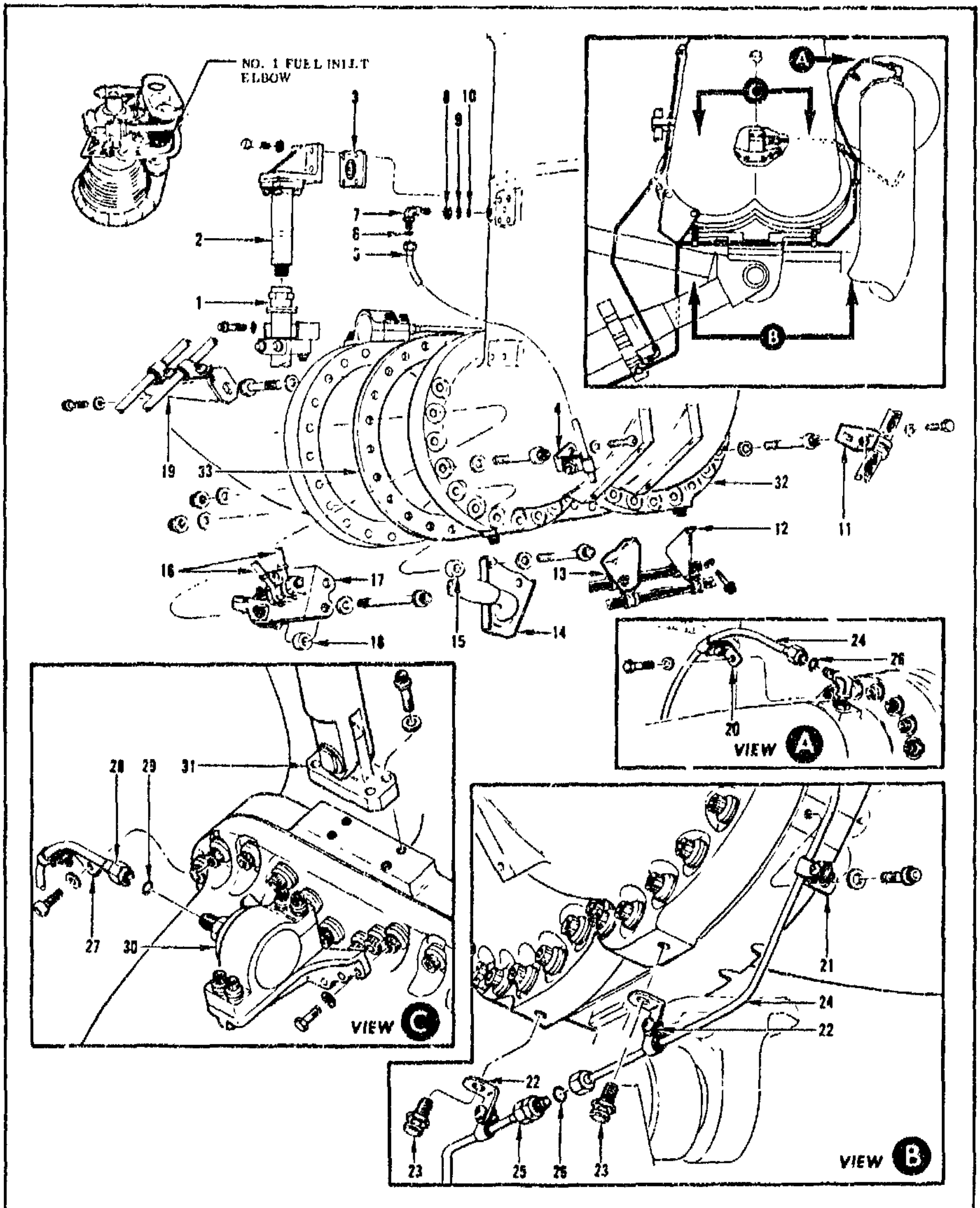


Figure 3-81. No. 1 Fuel Inlet Elbow (Sheet 1 of 2)

1	Plug	9	Ring	17	Support	25	Tube[a]
2	Transducer	10	Gasket	18	Spacer	26	Seal[a]
3	Orifice plate	11	Bracket	19	Bracket	27	Bracket[a]
4	Bracket	12	Support	20	Bracket[a]	28	Tube[a]
5	Tube	13	Support	21	Bracket[a]	29	Seal[a]
6	Seal	14	Panel	22	Bracket[a]	30	Support[a]
7	Elbow	15	Spacer	23	Bolt	31	Block
8	Nut	16	Rod	24	Tube[a]	32	Elbow
						33	Seal

(a) Engines incorporating MD150 or MD151 change

Figure 3-81. No. 1 Fuel Inlet Elbow (Sheet 2 of 2)

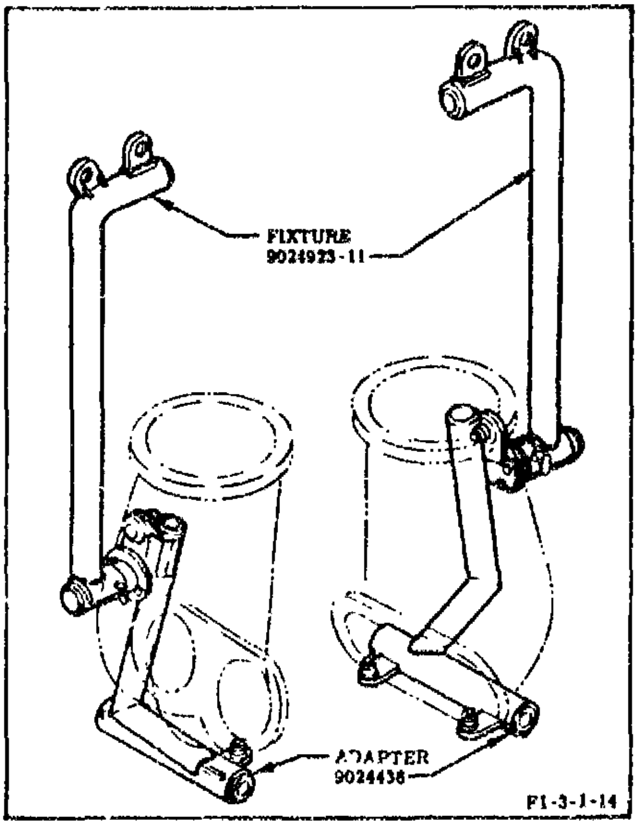


Figure 3-82. Handling Fuel Inlet Elbows

3-297. REMOVING NO. 1 FUEL INLET ELBOW. (See figure 3-81.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove the following thermal insulation bracketry, and retain attaching hardware: (Refer to R-3896-6 for part locations.)

(1) (Deleted)

(2) Support bow 145499

(3) Frame 145498

c. If installed, remove boot from between elbow and interface panel.

d. Disconnect plug (1) as outlined in paragraph 3-16.

e. Remove transducer (2) by disconnecting adapter and removing orifice plate (3).

f. Disconnect bracket (4) from bolthead, and remove tube (5) and seals (6). If elbow will be replaced, remove elbow (7), nut (8), ring (9), and gasket (10).

g. Disconnect bracket (11) and supports (12, 13) from elbow.

h. Remove 2 flange bolts and remove panel (14) and spacers (15).

i. Remove rods (16). Do not disturb turnbuckle positions.

j. Remove 2 flange bolts and remove support (17) and spacers (18).

k. Disconnect bracket (19).

NOTE

Steps l through o apply to engines incorporating MD150 or MD151 change.

l. Disconnect brackets (20, 21, 22). Reinstall bolts (23) and torque to 260-350 in-lb.

m. Disconnect tube (24) from tube (25) and elbow at duct. Remove tube (24) and seals (26).

n. Disconnect bracket (27), tube (28), and remove seal (29).

o. Remove support (30).

CAUTION

The interface panel must be supported if the struts and attachment at the No. 2 fuel inlet elbow are disconnected.

p. Disconnect block (31) from elbow flange.

q. If same elbow is to be reinstalled, mark across elbow and turbopump flanges 3 places approximately 90 degrees apart, with one mark located at lower flange area.

r. Remove elbow flange bolts except for sufficient bolts to hold elbow in place.

s. Install adapter 9024436 on elbow. (See figure 3-82.)

t. Attach fixture 9024923-11 to adapter.

CAUTION

Allowing seal (33, figure 3-81) to fall during elbow removal may damage engine equipment.

u. Support elbow (32), remove remaining flange bolts and seal (33), then remove elbow (32).

CAUTION

The fuel inlet elbow weighs approximately 86 pounds.

v. Remove fixture, then adapter.

3-298. INSTALLING NO. 1 FUEL INLET ELBOW. (See figure 3-81.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne). Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install adapter 9024436 on elbow and attach fixture 9024923-11 on adapter. (See figure 3-82.)

CAUTION

The fuel inlet elbow weighs approximately 86 pounds.

c. Hoist elbow (32, figure 3-81) into position and aline with turbopump inlet.

d. Install seal (33) and secure elbow and seal to turbopump. Do not install fasteners in flange holes at locations for panel (14) and support (17). If same elbow is reinstalled, aline marks on flanges before tightening flange fasteners. If elbow is a replacement, aline interface of elbow using procedure outlined in paragraph 3-307. Make sure washers are installed with chamfered side against boltheads; then tighten sufficient flange fasteners to maintain elbow in alined position. Remove fixture and adapter.

e. Install support (17) and spacers (18); panel (14) and spacers (15). Cross-torque all flange fasteners to 470 ±10 in-lb using torque method outlined in section I. Safetywire bolts not secured with nuts.

f. Attach block (31) to elbow. Cross-torque bolts to 800 ±30 in-lb. Safetywire bolts.

NOTE

Steps g through k apply to engines incorporating MD150 or MD151 change.

g. Install support (30). Torque bolts to 18-22 in-lb. Safetywire bolts.

h. Lubricate (Method G) tube (28). Install tube (28) with seals (29). Attach bracket (27); then torque coupling nuts to 160 ±10 in-lb. Torque fastener for bracket (27) to 18-22 in-lb. Safetywire coupling nuts.

i. Lubricate (Method G) tube (24). Remove bolts (23) and install tube (24) with seals (26). Aline brackets (20, 21, 22) and torque tube coupling nuts to 160 ±10 in-lb. Hold union attached to tube (25) during torquing. Safetywire coupling nuts.

j. Secure brackets (22), using bolts (23). Torque bolts to 260-320 in-lb.

k. Secure brackets (20, 21). Torque fastener for bracket (20) to 17-27 in-lb. Torque fastener for bracket (21) to 30-40 in-lb.

l. Attach bracket (19). Torque bolt to 30 ±5 in-lb. Safetywire bolt.

m. Install rods (16). Torque nuts to 150 ±10 in-lb.

n. Install supports (12, 13). Torque bolts to 70 ±5 in-lb. Safetywire bolts.

o. Install bracket (11). Torque bolt to 20 ±5 in-lb. Safetywire bolt.

p. If elbow (7), nut (8), ring (9), and gasket (10) were removed, lubricate (Method J) gasket and ring. Lubricate (Method A) elbow. Install elbow, and aline elbow for tube (5). Torque nut to 75-100 in-lb. Safetywire nut.

q. Lubricate (Method G) tube (5). Install tube (5) with seals (6). Aline bracket (4) and torque tube coupling nuts to 160 ±10 in-lb. Torque bracket to 15-25 in-lb. Safetywire coupling nuts and bolt.

r. Install orifice plate (3) and adapter of transducer (2). Cross-torque bolts to 45 ±5 in-lb. Safetywire bolts and install an aluminum seal on lockwire.

s. Install plug (1) as outlined in paragraph 3-17.

t. If applicable, install boot between fuel inlet elbow and interface panel. Torque fasteners to 20 ±2 in-lb.

u. Reinstall and aline thermal insulation components listed in paragraph 3-297, using procedures as outlined in R-3896-6.

v. Refer to section IV for post-maintenance test requirements.

3-299. NO. 2 FUEL INLET ELBOW (ENGINES INCORPORATING MD96 CHANGE).

3-300. Equipment required consists of adapter 9024436 and fixture 9024923-11 from Component Handling Fixture Set G4068. (See figure 3-82 for handling equipment.)

3-301. REMOVING NO. 2 FUEL INLET ELBOW (ENGINES INCORPORATING MD96 CHANGE). (See figure 3-83.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove the following thermal insulation bracketry and retain attaching hardware. (Refer to R-3896-6 for part locations.)

(1) (Deleted)

(2) Support bow 145499.

(3) Frame 145497.

c. If installed, remove boot from between elbow and interface panel.

d. Disconnect receptacles J18 and J20 of harness (1) from interface panel.

e. Disconnect support (2) and bracket (3), and remove spacer (4). Leave support and bracket attached to harness.

f. Disconnect harness clamping at support (5). Leave clamping attached to harness; then remove support (5).

g. Remove cap (6) and pad (7).

gA. Remove 4 thermal insulation support caps (7A), 4 pads (7B), and stiffener (7C).

h. Remove hose (8) and seals (9, 10).

i. Disconnect hose (11) and remove seal (12).

j. Disconnect bracket (13) from bolthead and remove tube (14) and seals (15). If elbow will be replaced, remove union (16) and gasket (17).

k. Remove support (18).

CAUTION

The interface panel must be supported if the struts and attachment at the No. 1 fuel inlet elbow are disconnected.

l. Disconnect block (19) from elbow flange.

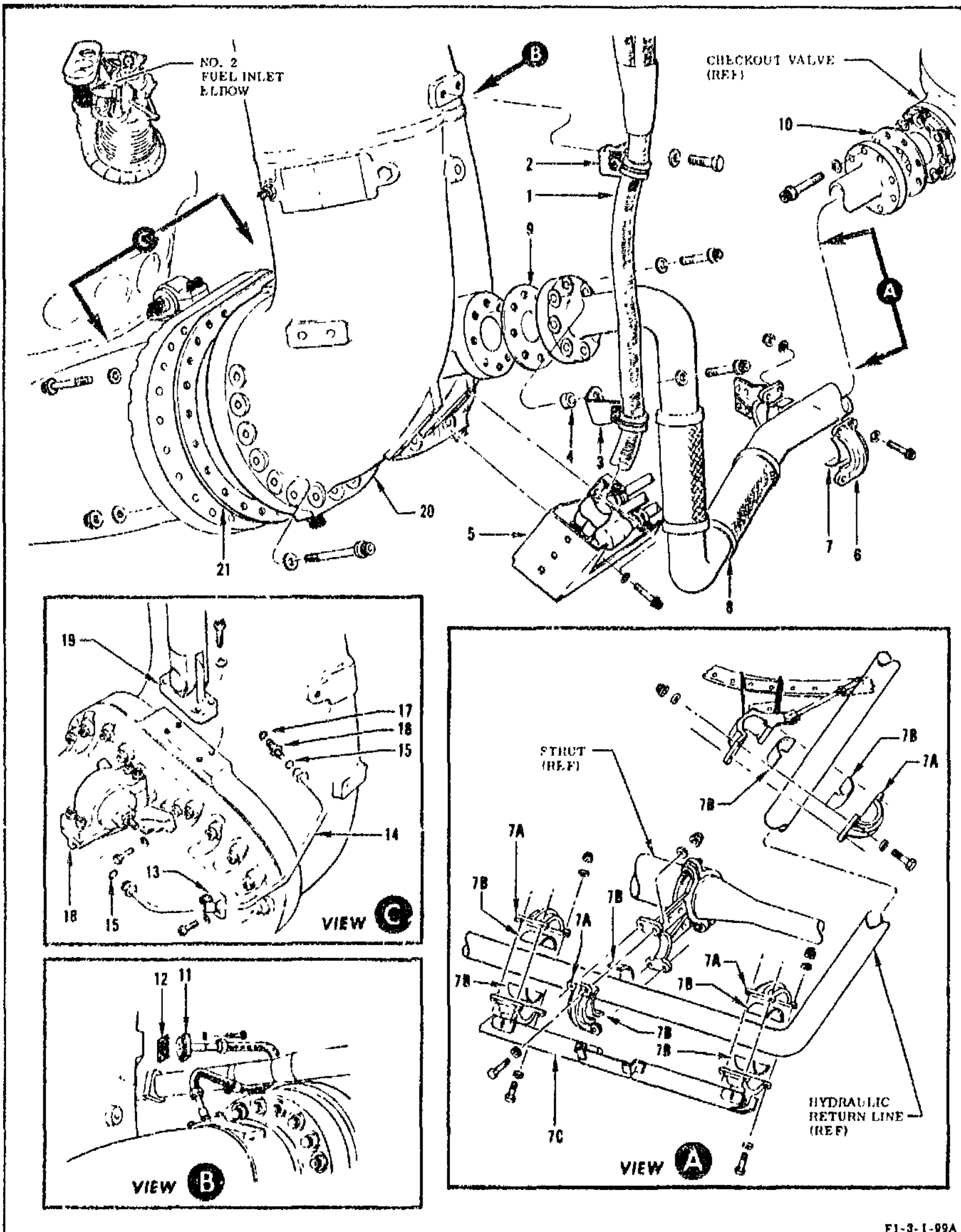


Figure 3-83. No. 2 Fuel Inlet Elbow (Engines Incorporating MD96 Change) (Sheet 1 of 2)

1	Harness	7	Pad	10	Seal	16	Union
2	Support	7A	Cap	11	Hose	17	Gasket
3	Bracket	7B	Pad	12	Seal	18	Support
4	Spacer	7C	Stiffener	13	Bracket	19	Block
5	Support	8	Hose	14	Tube	20	Elbow
6	Cap	9	Seal	15	Seal	21	Seal

Figure 3-83. No. 2 Fuel Inlet Elbow (Engines Incorporating MD96 Change) (Sheet 2 of 2)

m. If same elbow is to be reinstalled, mark across elbow and turbopump flanges 3 places approximately 90 degrees apart with one mark located at lower flange area.

n. Remove elbow flange bolts except for sufficient bolts to hold elbow in place.

o. Install adapter 9024436 on elbow (see figure 3-82.)

p. Attach fixture to adapter.

CAUTION

Allowing seal (21, figure 3-83) to fall during elbow removal may damage engine equipment.

q. Support elbow, remove remaining flange bolts and seal (21); then remove elbow (20).

CAUTION

The fuel inlet elbow weighs approximately 86 pounds.

r. Remove fixture, then adapter.

3-302. INSTALLING NO. 2 FUEL INLET ELBOW (ENGINES INCORPORATING MD96 CHANGE). (See figure 3-83.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne). Specified lubricating procedures (methods) are outlined in section I.

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install adapter 9024436 on elbow and attach fixture 9024923-11 to adapter. (See figure 3-82.)

CAUTION

The fuel inlet elbow weighs approximately 86 pounds.

c. Hoist elbow (20, figure 3-83) into position and aline with turbopump inlet.

d. Install seal (21) and secure elbow and seal to turbopump. Make sure washers are installed with chamfered side against boltheads. If same elbow is reinstalled, aline marks on flanges before tightening flange fasteners. If elbow is a replacement, aline interface of elbow, using procedure outlined in paragraph 3-307. Tighten sufficient flange fasteners to maintain elbow in alined position.

e. Remove fixture and adapter, and cross-torque flange fasteners to 470 ±10 in-lb using torque method outlined in section I. Safetywire bolts not secured with nuts.

f. Attach block (19) to elbow flange. Cross-torque bolts to 800 ±30 in-lb. Safetywire bolts.

g. Install support (18). Torque bolts to 18-22 in-lb. Safetywire bolts.

h. If gasket (17) and union (16) were removed, lubricate (Method J) gasket (17). Lubricate (Method A)union (16). Install gasket and union, and torque union to 55-80 in-lb.

i. Lubricate (Method G) tube (14), and install tube with seals (15). Aline bracket (13), apply countertorque to unions, and torque tube coupling nuts to 160 ±10 in-lb. Safetywire tube coupling nuts and unions.

j. Attach bracket (13). Torque screw to 18-22 in-lb.

k. Install hose (11) and seal (12). Cross-torque bolts to 25 ±2 in-lb. Safetywire bolts.

NOTE

If hose (11) was removed, it must be routed between the turbopump strut and the wire group that parallels the strut when reinstalled. Hose bend radii for installation is 1.50 inches minimum. Braid bulge must not extend beyond the hex flat dimension of braid retaining collar.

l. Install hose (8) and seals (9, 10). Cross-torque bolts at valve end flange to 185 ±5 in-lb. Do not tighten bolts at elbow flange.

m. Install support (5). Torque bolts to 45 ±5 in-lb. Safetywire bolts.

n. Install spacer (4) and bracket (3) at elbow flange of hose (8) and cross-torque bolts to 180 ±10 in-lb. Safetywire bolts at both flanges.

o. Install pad (7) and cap (6). Torque nuts to 30 ±2 in-lb.

oA. Reinstall thermal insulation stiffener (7C), pads (7B), and caps (7A). Make sure pads are installed between caps and hose. Torque nuts to 27 ±3 in-lb.

p. Position receptacles J18 and J20 of harness (1) in interface panel, and install support (2). Torque bolt to 45 ±5 in-lb. Safetywire bolt.

q. Secure receptacles to interface panel. Cross-torque nuts to 70 ±5 in-lb.

r. Attach harness clamping to support (5).

s. If applicable, install boot between fuel inlet elbow and interface panel. Torque fasteners to 20 ±2 in-lb.

t. Reinstall and aline thermal insulation components listed in paragraph 3-301, using procedures outlined in R-3896-6.

u. Refer to section IV for post-maintenance test requirements.

3-303. NO. 2 FUEL INLET ELBOW (ENGINES NOT INCORPORATING MD96 CHANGE).

3-304. Equipment required consists of adapter 9024436 and fixture 9024923-11 from Component Handling Fixture Set G4068. (See figure 3-82 for handling equipment.)

3-305. REMOVING NO. 2 FUEL INLET ELBOW (ENGINES NOT INCORPORATING MD96 CHANGE). (See figure 3-84.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Remove the following thermal insulation bracketry and retain attaching hardware: (Refer to R-3896-6 for part location.)

(1) Stiffener 145408.

(2) Support bow 145499.

(3) Frame 145497.

c. If installed, remove boot from between elbow and interface panel.

d. Disconnect receptacles of harnesses (1, 2) from interface panel.

e. Disconnect support (3). Leave clamping attached to harness.

f. Disconnect connector P184 from transducer (4) using procedure outlined in paragraph 3-14.

g. Remove transducer (4) and seal (5).

h. Disconnect bracket (6), and remove spacer (7). Leave clamping attached to harness.

i. Disconnect struts (8) from auxiliary junction box.

j. Disconnect support (9), and remove spacer (10).

k. Disconnect connectors of harnesses (11, 12) from auxiliary junction box as outlined in paragraph 3-14, and disconnect receptacle of harness (11) from support (13). Secure harnesses clear of elbow.

l. Disconnect clamping for harnesses (1, 2) from support (13). Attach clamping to installed position on harnesses for reinstallation; then remove support (13), and secure harnesses and support clear of elbow.

m. Remove cap (14) and pad (15).

n. Remove hose (16) and seals (17, 18).

o. Disconnect hose (19), and remove seal (20).

p. Disconnect bracket (21) from flange bolthead; then remove tube (22) and seals (23). If elbow will be replaced, remove union (24) and gasket (25).

q. Remove support (26).

CAUTION

The interface panel must be supported if the struts and attachment at the No. 1 fuel inlet elbow are disconnected.

r. Disconnect block (27) from elbow flange.

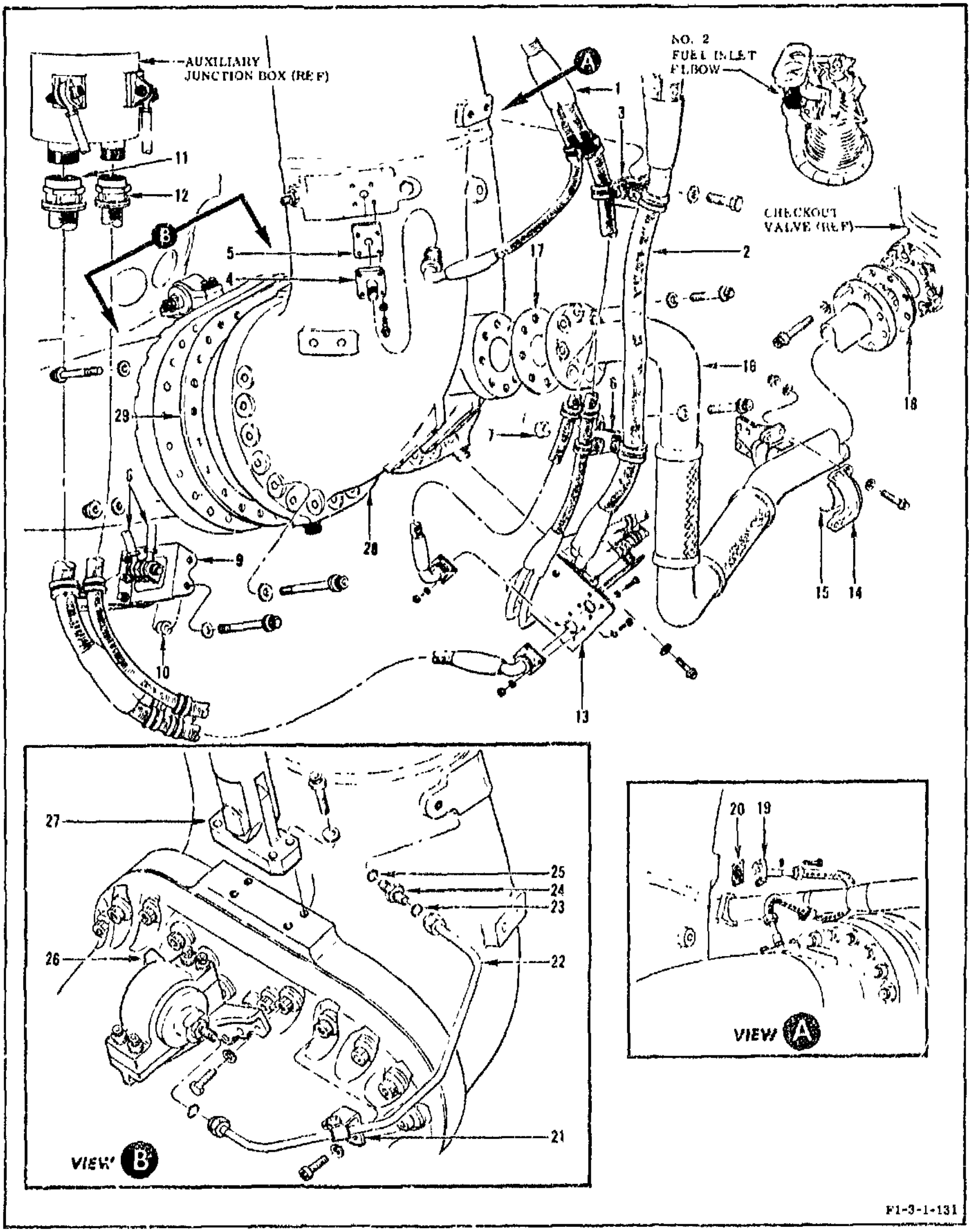


Figure 3-84. No. 2 Fuel Inlet Elbow (Engines Not Incorporating MD96 Change) (Sheet 1 of 2)

1	Harness	8	Strut	15	Pad	22	Tube
2	Harness	9	Support	16	Hose	23	Seal
3	Support	10	Spacer	17	Seal	24	Union
4	Transducer	11	Harness	18	Seal	25	Gasket
5	Seal	12	Harness	19	Hose	26	Support
6	Bracket	13	Support	20	Seal	27	Block
7	Spacer	14	Cap	21	Bracket	28	Elbow
						29	Seal

Figure 3-84. No. 2 Fuel Inlet Elbow (Engines Not Incorporating MD96 Change) (Sheet 2 of 2)

s. If same elbow is to be reinstalled, mark across elbow and turbopump flanges 3 places approximately 90 degrees apart with one mark located at lower flange area.

t. Remove elbow flange bolts except for sufficient bolts to hold elbow in place.

u. Install adapter 9024436 on elbow. (See figure 3-82.)

v. Attach fixture to adapter.

CAUTION

Allowing seal (29, figure 3-84) to fall during elbow removal may damage engine equipment.

w. Support elbow (28), remove remaining flange bolts and seal (29), then remove elbow.

CAUTION

The fuel inlet elbow weighs approximately 86 pounds.

3-306. INSTALLING NO. 2 FUEL INLET ELBOW (ENGINES NOT INCORPORATING MD96 CHANGE). (See figure 3-84.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Install adapter 9024436 on elbow, and attach fixture 9024923-11 to adapter. (See figure 3-82.)

CAUTION

The fuel inlet elbow weighs approximately 86 pounds.

c. Hoist elbow (28, figure 3-84) into position, and aline with turbopump inlet.

d. Install seal (29), and secure elbow and seal to turbopump. Make sure washers are installed with chamfered side against boltheads. If same elbow is reinstalled, aline marks on flanges before tightening flange fasteners. If elbow is a replacement, aline interface of elbow using procedure outlined in paragraph 3-307 Tighten sufficient flange fasteners to maintain elbow in alined position.

e. Remove fixture and adapter.

f. Install support (9) and spacer (10), and engage struts (8) in clevises of junction box. Torque fasteners for struts to 150 ±10 in-lb. Install remaining elbow flange fasteners and torque fasteners to 470 ±10 in-lb. Safetywire flange fasteners not secured with nuts.

g. Attach block (27) to elbow flange. Cross-torque bolts to 800 ±30 in-lb.

h. Install support (26). Torque bolts to 18-22 in-lb. Safetywire bolts.

i. If gasket (25) and union (24) were removed, lubricate union with lubricant grease RB0140-012 (Rocketdyne) using Method A outlined in section I. Install gasket (25) and union, and torque union to 55-80 in-lb.

j. Lubricate tube (22) with lubricant grease RB0140-012 (Rocketdyne) using Method G outlined in section I. Install seals (23) and tube (22). Apply countertorque to unions and torque tube coupling nuts to 160 ±10 in-lb Safetywire coupling nuts and unions.

k. Attach bracket (21). Torque screw to 18-22 in-lb.

l. Install seal (20) and connect hose (19). Cross-torque bolts to 25 ±2 in-lb. Safetywire bolts.

m. Install hose (16) and seals (17, 18). Cross-torque bolts at checkout valve end of hose to 185 ±5 in-lb. Safetywire bolts. Do not torque bolts at elbow flange.

n. Install support (13), and install harnesses (1, 2). Attach harness clamping, as required, and torque attaching bolts for support (13) to 45 ±5 in-lb. Safetywire bolts.

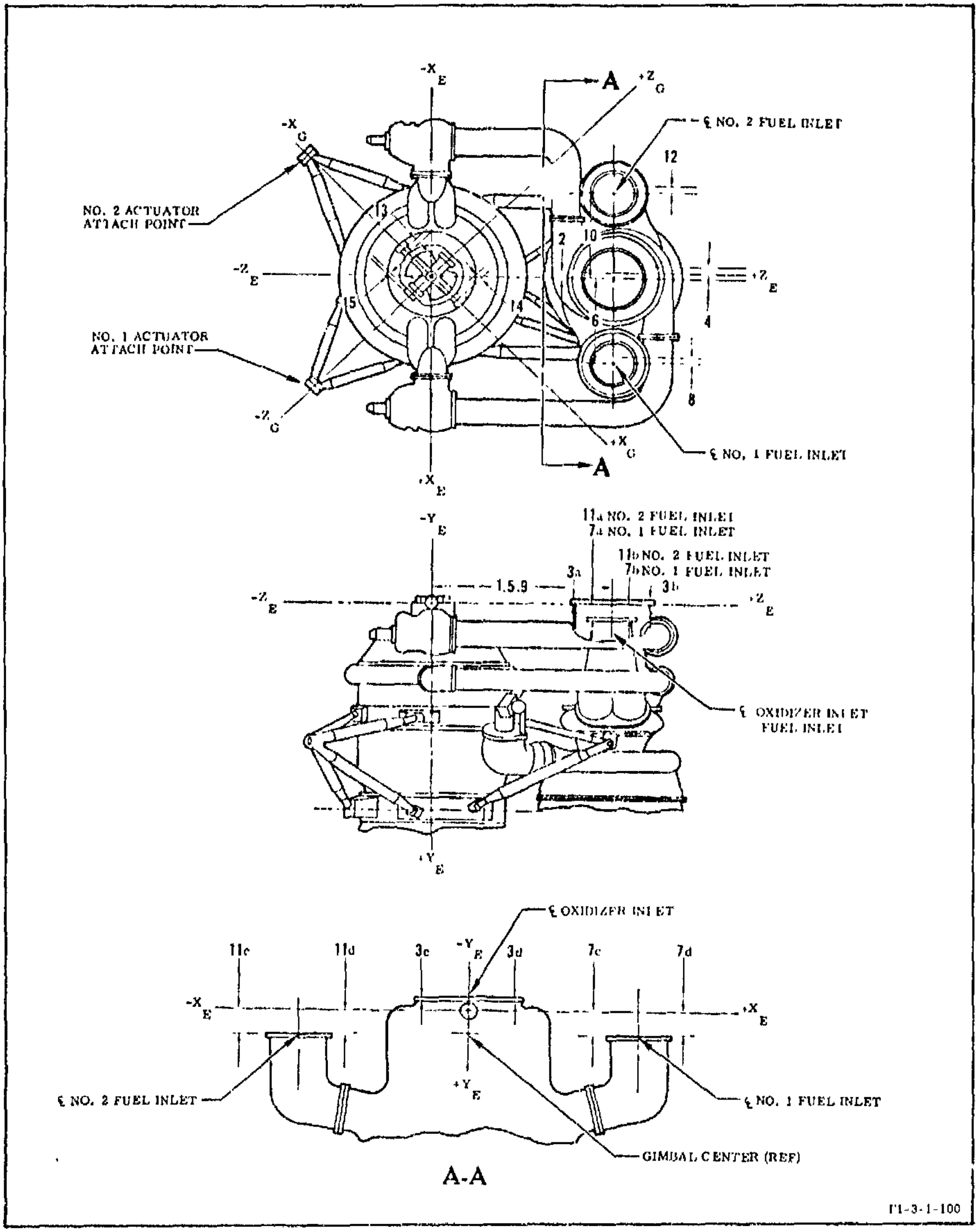


Figure 3-85. Alinement of Fuel Inlet Elbows

o. Install spacer (7) and bracket (6). Cross-torque flange bolts to 180 ±10 in-lb. Safetywire bolts.

oA. Install pad (15) and cap (14). Torque nuts to 30 ±2 in-lb.

p. Attach receptacle of harness (11) to support (13).

q. Attach connectors for harnesses (11, 12) to junction box, using procedure outlined in paragraph 3-15.

r. Install seal (5) and transducer (4). Make sure transducer is positioned to match keyway for connector. Cross-torque bolts to 45 ±5 in-lb. Safetywire bolts.

s. Install receptacles for harnesses (1, 2) in interface panel. Cross-torque fasteners to 70 ±5 in-lb.

t. Install support (3). Torque bolt to 45 ±5 in-lb. Safetywire bolt.

u. Attach connector of harness (1) to transducer (4), using procedure outlined in paragraph 3-15.

v. If applicable, install boot between fuel inlet elbow and interface panel. Torque fasteners to 20 ±2 in-lb. Safetywire fasteners.

w. Reinstall and aline thermal insulation components listed in paragraph 3-305, using procedures outlined in R-3896-6.

x. Refer to section IV for post-maintenance test requirements.

3-307. CHECKING ALINEMENT OF FUEL INLET ELBOWS.

3-308. The No. 1 and No. 2 fuel inlet elbow inlets and the oxidizer inlet alinements are checked relative to the engine interface surfaces with the gimbal in the basic aline position. Measuring equipment used to perform this procedure must be accurate within 0.001 inch. (See figure 3-85 for axis and dimensional locations.) A typical engine interface location data recording form and an index of definitions of terms and symbols are included in the Engine Log Book. All results of the following steps must be recorded in the Engine Log Book; all dimensions must be recorded to the nearest 0.001 inch.

a. Measure and record distances from plane $X_E Y_E$ along a line parallel to axis Z_E to center of the following component inlet interface surfaces. Allowable dimensions are for Z (engine) coordinate as follows:

(1) Oxidizer (1), 50 ±0.150 inches.

(2) No. 1 fuel inlet elbow (5), 50 ±0.140 inches.

(3) No. 2 fuel inlet elbow (9), 50 ±0.140 inches.

b. Measure and record distances from plane $Y_E Z_E$ along a line parallel to axis X_E to center of the following component inlet interface surfaces. Allowable dimensions are for X (engine) coordinates as follows:

(1) Oxidizer inlet (2), 0.000 ±0.160 inch.

(2) No. 1 fuel inlet elbow (6), +25.860 ±0.360 inches.

(3) No. 2 fuel inlet elbow (10), -25.860 ±0.360 inches.

c. Measure distances 3a, 3b, and 3d from plane $X_E Z_E$ along a line parallel to axis Y_E to 4 locations (90-degree increments) on oxidizer inlet interface surface. Record each distance.

d. Using distances recorded for 3a and 3b and equation $^{\theta}Z_E = 185.824\ (3a - 3b)$, calculate angle $^{\theta}Z_E$. Angle must not exceed ±11 minutes. Record result. This is flange component angle along Z (engine) axis.

e. Using distances recorded for 3c and 3d and equation $^{\theta}Z_E = 185.824\ (3c - 3d)$, calculate angle $^{\theta}X_E$. Angle must not exceed ±8 minutes. Record result. This is flange component angle along X (engine) axis.

f. Using distances recorded for 3a, 3b, 3c, and 3d and equation $Y_E = 1/4\ (3a + 3b + 3c + 3d)$, calculate mean Y_E distance. Mean distance must not exceed -0.81 ±0.150 inch. Record result. This is Y (engine) coordinate.

g. Measure distances 7a, 7b, 7c, and 7d from $X_E Z_E$ plane along a line parallel to axis Y_E to 4 locations (90-degree increments) on No. 1 fuel inlet elbow inlet interface surface. Record each distance.

h. Using distances recorded for 7a and 7b and equation $^{\theta}Z_E$ = 259.453 (7a - 7b), calculate angle $^{\theta}Z_E$. Angle must not exceed ±11 minutes. Record result. This is flange component angle along Z (engine) axis.

i. Using distances recorded for 7c and 7d and equation $^{\theta}X_E$ = 254.453 (7c - 7d), calculate angle $^{\theta}X_E$. Angle must not exceed ±26 minutes. Record result. This is flange component angle along X (engine) axis.

j. Using distances recorded for 7a, 7b, 7c, and 7d and equation Y_E = 1/4 (7a + 7b + 7c + 7d), calculate mean Y_E distance. Mean distance must not exceed +5.16 ±0.180 inches. This is Y (engine) coordinate.

k. Measure distances 11a, 11b, 11c and 11d from plane X_EZ_E along a line parallel to axis Y_E to 4 locations (90-degree increments) on the No. 2 fuel inlet elbow inlet interface surface. Record each distance.

l. Using distances recorded for 11a and 11b and equation $^{\theta}Z_E$ = 259.453 (11a - 11b), calculate angle $^{\theta}Z_E$. Angle must not exceed ±11 minutes. Record result. This is flange component angle along Z (engine) axis.

m. Using distances recorded for 11c and 11d and equation $^{\theta}X_E$ = 259.453 (11c - 11d), calculate angle $^{\theta}X_E$. Angle must not exceed ±26 minutes. Record result. This is flange component angle along X (engine) axis.

n. Using distances recorded for 11a, 11b, 11c and 11d and equation Y_E = 1/4 (11a - 11b + 11c +11d), calculate mean Y_E distance. Mean distance must not exceed +5.160 ±0.180 inches. Record result. This is Y (engine) coordinate.

o. Measure distance along a line parallel to axis Y_E from center of oxidizer inlet to centerline of oxidizer inlet bolthole farthest from plane X_EY_E. Record distance and direction of measurement (± with respect to axis Z_E).

p. Using distance recorded in step o and equation τ = 371.648 (4), calculate angle τ. Angle must not exceed ±84 minutes. Record results. This is bolt circle torsional displacement from Z (engine) axis.

q. Measure distance along a line parallel to axis X_E from center of No. 1 fuel inlet elbow to centerline of inlet elbow bolthole farthest from plane X_EY_E. Record distance and direction of measurement (± with respect to axis Z_E).

r. Using distance recorded in step q and equation τ = 518.906 (8), calculate angle τ. Angle must not exceed ±49 minutes. Record result. This is bolt circle torsional displacement from Z (engine) axis.

s. Measure distance along a line parallel to axis X_E from center of No. 2 fuel inlet elbow to centerline of inlet elbow bolthole farthest from plane X_EY_E. Record distance and direction of measurement (± with respect to axis Z_E).

t. Using distance recorded in step s and equation τ = 518.906 (12), calculate angle τ. Angle must not exceed ±49 minutes. Record result. This is bolt circle torsional displacement from Z (engine) axis.

3-309. TURBOPUMP.

3-310. Procedures for removing and installing the turbopump will be provided at a later date.

3-310A. TURBOPUMP HEATER THERMOSTAT.

3-310B. REMOVING TURBOPUMP HEATER THERMOSTAT. (See figure 3-85A.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Make sure electrical power source is turned off.

WARNING

Disconnecting electrical connectors without turning off the power source can cause electrical arcing between connectors, resulting in serious injury or death to personnel and damage to equipment.

c. Remove harness support clamp and carefully disconnect electrical plug P175 (1) from turbopump heater thermostat (2), as outlined in paragraph 3-14.

d. Note location of keyway, then remove screws securing turbopump heater thermostat, and remove thermostat.

3-310C. INSTALLING TURBOPUMP HEATER THERMOSTAT. (See figure 3-85A.)

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Make sure electrical power source is turned off.

WARNING

Connecting electrical connectors without turning off the power source can cause electrical arcing between connectors, resulting in serious injury or death to personnel and damage to equipment.

c. Install turbopump heater thermostat (2). Keyway must have same location as noted in removal procedure. Torque screws to 8-10 in-lb. Safetywire screws.

d. Connect electrical plug P175 (1) to turbopump heater thermostat, as outlined in paragraph 3-15.

e. Install harness support clamp. Torque nut to 8-10 in-lb.

f. Refer to section IV for post-maintenance test requirements for turbopump heater thermostat.

3-311. <u>FUEL IMPELLER BALANCE CAVITY SUPPLY TUBE.</u> (See figure 3-86.)

3-312. REMOVING FUEL IMPELLER BALANCE CAVITY SUPPLY TUBE.

a. Observe safety, and contamination and damage prevention procedures outlined in section I.

b. Remove clamps that secure static-firing instrumentation transducer tube and clamps that secure balance cavity supply tube to brackets.

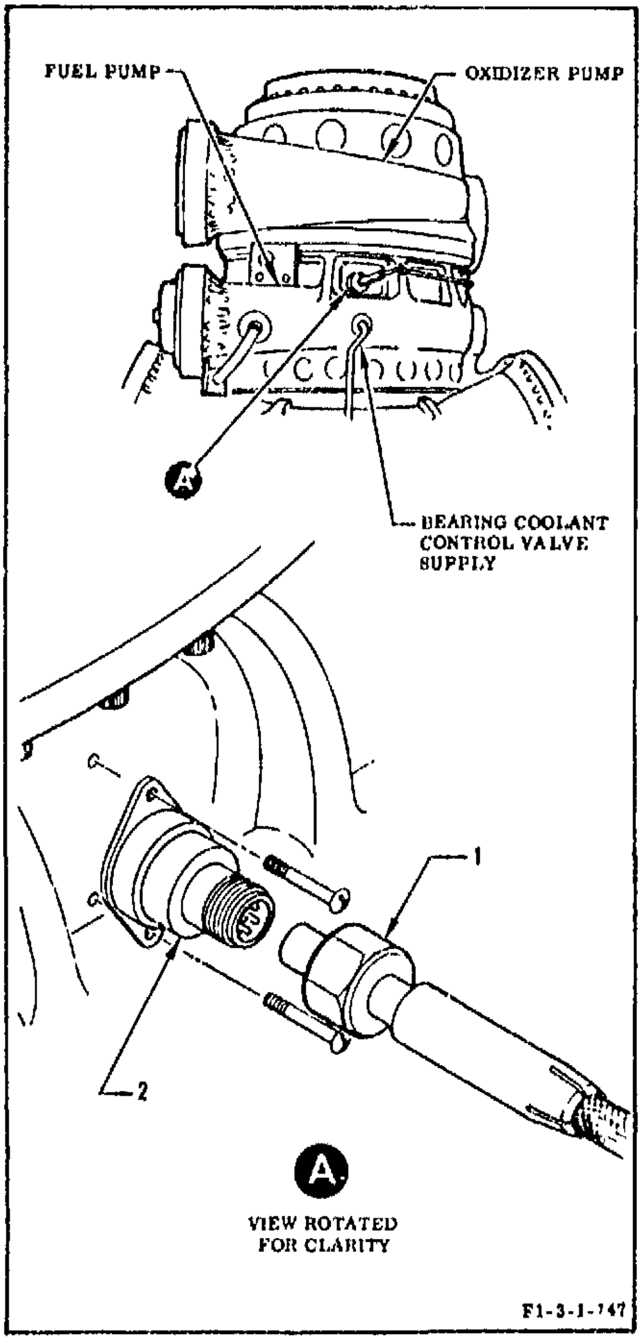
c. Disconnect balance cavity supply tube and attaching hardware at 4-bolt flange at fuel pump outlet volute by removing 4 bolts, 4 washers, and one orifice plate. Retain orifice plate.

d. Carefully disconnect tube at 2-bolt flange at fuel volute by removing 2 bolts and one packing, making sure that packing is completely removed from turbopump. Install closures.

CAUTION

Packing damage can cause contamination of the turbopump.

e. Inspect to make sure that removed packing is intact. If any portion of packing is missing, contact Rocketdyne representative for disposition. If packing or any portion of packing is missing, make sure it did not drop from volute area before turbopump disassembly is initiated.



1	Plug P175	2	Turbopump heater thermostat

Figure 3-85A. Turbopump Heater Thermostat

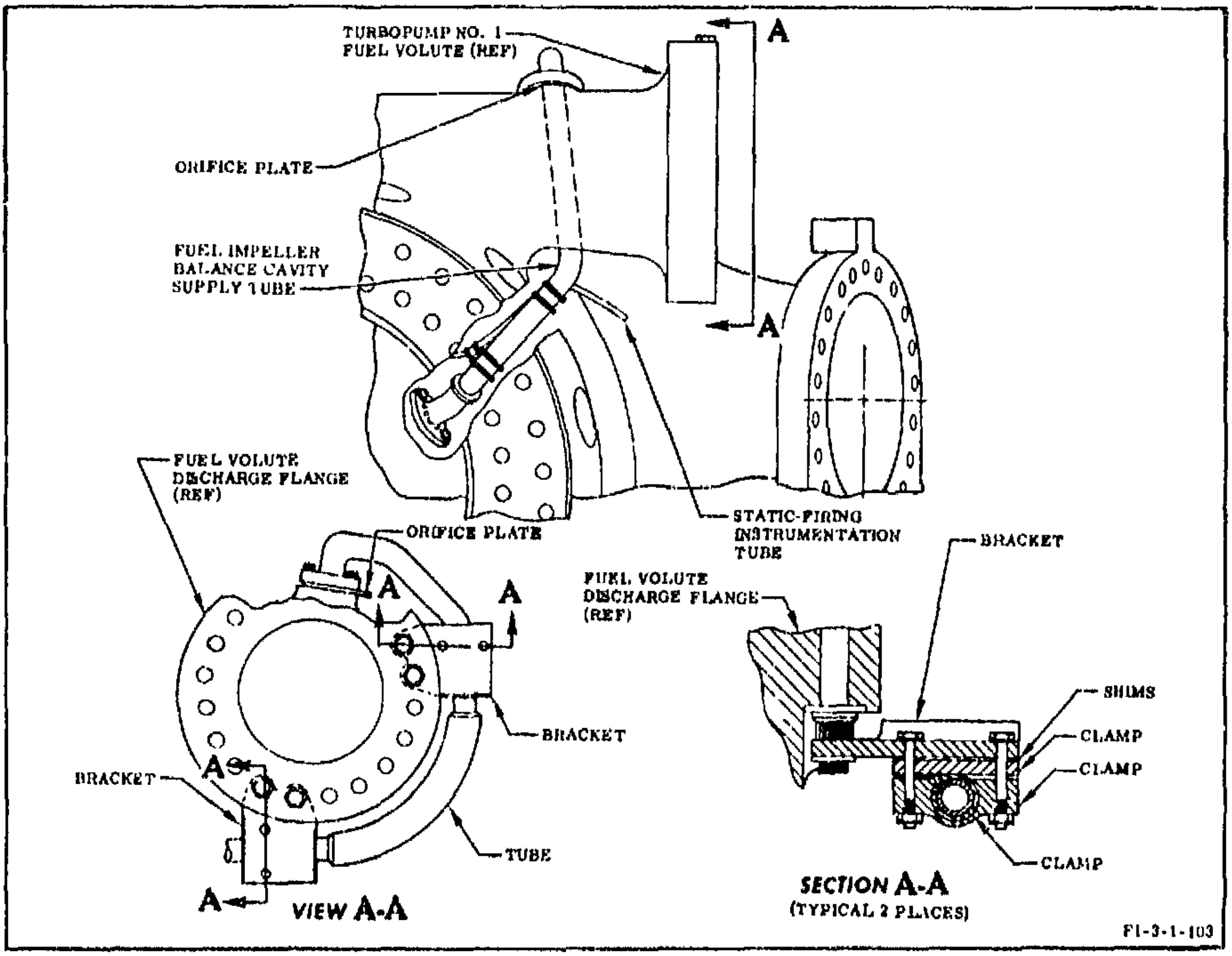


Figure 3-86. Fuel Impeller Balance Cavity Supply Tube

3-313. INSTALLING FUEL IMPELLER BALANCE CAVITY SUPPLY TUBE.

a. Observe safety, and contamination and damage prevention procedures outlined in section I.

b. Carefully install new balance cavity supply tube as follows:

(1) Using lubricant grease RB0140-012 (Rocketdyne), install packing in volute end of tube. Apply lubricant using Method J outlined in section I.

(2) Lightly lubricate (Method Z) fuel volute port with lubricant grease RB0140-012 (Rocketdyne) where tube is to be attached.

CAUTION

If the tube is not installed perfectly straight into the volute, damage to the packing and contamination of the turbopump can result.

(3) Carefully install 2-bolt flange end of tube into fuel pump volute, keeping tube perpendicular to attaching flange on volute.

(4) Install 2 bolts in tube and fuel volute flange. Using tool T-5039499, tighten bolts equally until bottom of boltheads are approximately 1/16 inch above tube flange.

(5) Inspect as large an area of packing as possible using an appropriate mirror and light, to determine that packing is properly installed and that no bulges exist. If packing has any bulges, packing must be removed, since further tightening of bolts will cut packing. If packing is bulged, contact Roc tdyne representative for disposition. If no bulges exist, proceed to step c.

c. Connect 4-bolt flange end of tube to fuel volute discharge using 4 bolts, 4 washers, and one orifice plate with orifice plate positioned so that identification is visible. Install bolts loosely so that tube can be rotated slightly, if required.

d. Install bracket clamps and shims. Use shims to position flexible part of tube so that tube is approximately parallel with fuel volute discharge flange. Do not tighten nuts.

e. Tighten 2 bolts evenly at 2-bolt flange. Cross-torque bolts to 170-270 in-lb.

f. Cross-torque bolts at 4-bolt flange to 45-65 in-lb.

g. Make sure that shim buildup at each bracket does not deflect tube. Adjust shims, if required.

h. (Deleted)

i. Cross-torque nuts for clamps to 60 18 in-lb. Observe tube for deflection during torquing. If tube is deflected, adjust shims to eliminate deflection.

j Safetywire bolts at 4-bolt flange and install an aluminum seal on lockwire.

k. Record and verify orifice installation in Engine Log Book.

l. Refer to section IV for post-maintenance test requirements.

3-314. FUEL IMPELLER BALANCE CAVITY RETURN HOSE.

3-315. REMOVING FUEL IMPELLER BALANCE CAVITY RETURN HOSE. (See figure 3-87.)

a. Observe safety, and contamination and damage prevention procedures outlined in section I.

b. Disconnect balance cavity return hose and attaching hardware at 4-bolt flange at fuel inl y removing 4 bolts, 4 washers, and one orifice plate. Retain orifice plate.

c. Carefully disconnect hose at 2-bolt flange at fuel volute by removing 2 bolts and one packing, making sure that packing is comple ely removed from turbopump. Install closures.

CAUTION

Packing damage can cause contamination of the turbopump.

d. Inspect to make sure that removed packing is intact. If any portion of packing is missing, contact Rocketdyne representative for disposition. If packing or any portion of packing is missing, make sure it did not drop from volute area before turbopump disassembly is initiated.

3-316. INSTALLING FUEL IMPELLER BALANCE CAVITY RETURN HOSE. (See figure 3-87.)

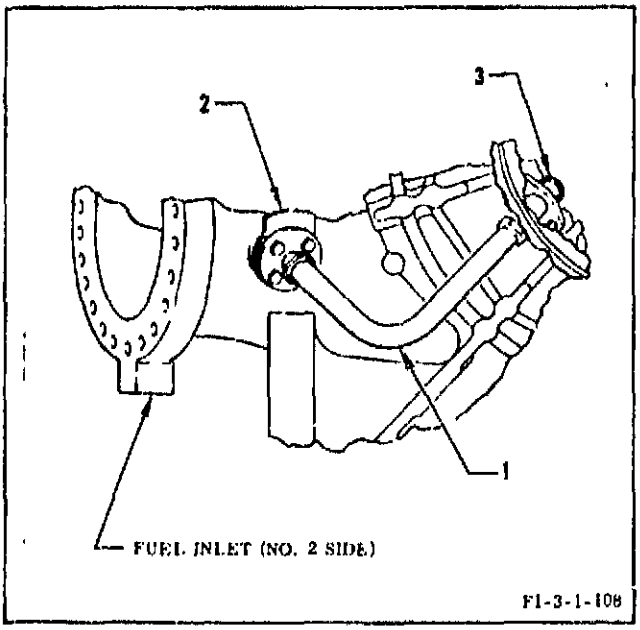
a. Observe safety, and contamination and damage prevention procedures outlined in section I.

CAUTION

Bending or twisting of the balance cavity return hose can result in damage to the Teflon lining.

b. Carefully install balance cavity return hose (1) as follows:

(1) Using lubricant grease RB0140-012 (Rocketdyne), install packing (3) in volute end of hose. Apply lubricant using Method J outlined in section I.



1 Balance cavity return hose
2 4-bolt flange end
3 Packing

Figure 3-87. Fuel Impeller Balance Cavity Return Hose

(2) Lightly lubricate (Method Z) fuel volute port with lubricant grease RB0140-012 (Rocketdyne) where hose is to be attached, and install packing in groove on end of hose.

CAUTION

If the hose is not installed perfectly straight into the volute, damage to the packing and contamination of the turbopump can result.

(3) Carefully install 2-bolt flange end of hose into fuel pump volute, keeping line perpendicular to attaching flange on volute.

(4) Install 2 bolts in hose and fuel volute flange. Using tool T-5039499, tighten bolts equally until bottom of boltheads are approximately 1/16 inch above hose flange.

(5) Inspect as large an area of packing as possible using appropriate mirror and light, to determine that packing is properly installed and that no bulges exist. If packing has any bulges, packing must be removed, since further tightening of bolts will cut packing. If packing is bulged, contact Rocketdyne representative for disposition. If no bulges exist, proceed to substep 6.

(6) Tighten 2 bolts evenly and torque to 170-270 in-lb.

c. Lubricate 4 bolts with lubricant grease RB0140-012 (Rocketdyne). Apply lubricant using Method A outlined in section I. Connect 4-bolt flange end (2) of hose to fuel inlet using 4 bolts, 4 washers, and one orifice plate with orifice plate positioned so that identification plate is visible.

d. Torque 4 bolts to 50-70 in-lb. Safetywire bolts and install an aluminum seal on lockwire.

e. Record and verify orifice installation in orifice records of Engine Log Book.

f. Refer to section IV for post-maintenance test requirements.

3-316A. FUEL DRAIN MANIFOLD.

3-316B. REMOVING FUEL DRAIN MANIFOLD. (See figure 3-88.) Specified lubricating procedures (methods) are outlined in section I

a. Observe safety, and contamination and damage prevention requirements outlined in section I.

b. Disconnect line (1) and remove seal (2). Leave bracket (3) attached to flex hose clamp.

c. On engines not incorporating MD145 change, disconnect tube (4), hose (7), and line (9). Remove seals (5, 8, 10). On engines incorporating MD145 change, disconnect hose (7) and remove seal (8).

d. Disconnect tubes (12, 13, 14). On engines not incorporating MD145 change, disconnect tube (15).

e. Remove bolts attaching manifold (17) to tooling rings, remove bushing (16), and carefully remove manifold. Tubing may be deflected or tube clamping loosened to remove manifold. Use care to prevent bending or damaging tubing.

f. Remove parts indexed (18 through 27 and 31, 32) from manifold. On engines not incorporating MD145 change, remove reducer (28) and gasket (29). On engines incorporating MD145 change, remove plug (30) and gasket (29).

g. Lubricate (Method A) closure fasteners with lubricant grease RB0140-012 (Rocketdyne).

3-316C. INSTALLING FUEL DRAIN MANIFOLD. (See figure 3-88.) The lubricant used in this procedure is lubricant grease RB0140-012 (Rocketdyne). Specified lubricating procedures (methods) are outlined in section I.

NOTE

Steps a through g install parts prior to installing manifold.

a. Install seal (32) and plate (31). Torque bolts to 45 ±2 in-lb. Safetywire bolts.

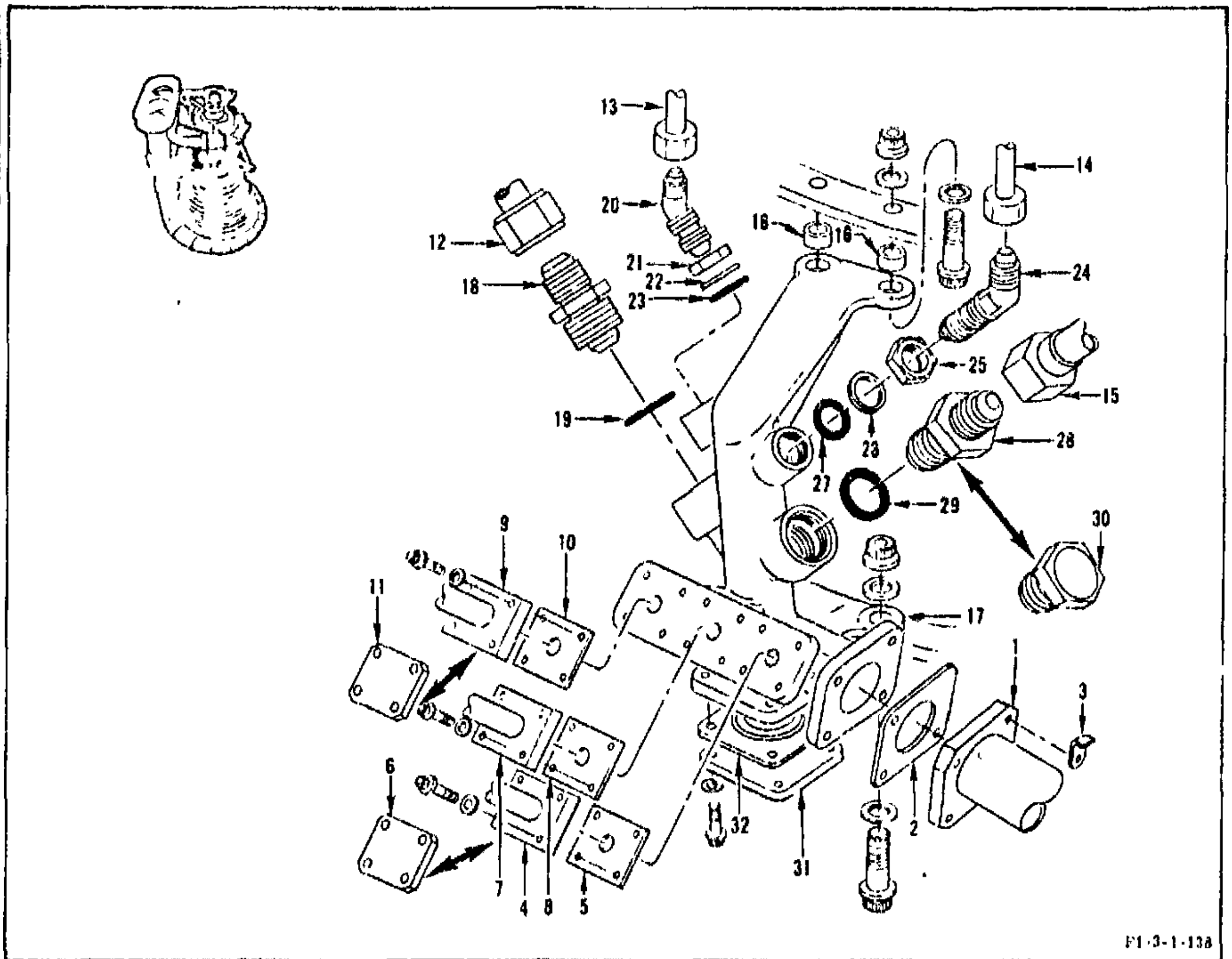
b. On engines incorporating MD145 change, lubricate (Method J) gasket (29) and lubricate (Method A) plug 30). Install gasket and plug and torque plug to 300-500 in-lb.

c. On engines not incorporating MD145 change, lubricate (Method J) gasket (29) and lubricate (Method A) reducer (28). Install gasket and reducer and torque reducer to 420-600 in-lb.

d. Lubricate (Method J) gaskets (23, 27) and rings (22, 26) and lubricate (Method A) elbows (20, 24). Install gaskets, rings, nuts (21, 25), and elbows. Do not torque nuts at this time.

e. Lubricate (Method J) gasket (19) and lubricate (Method A) reducer (18). Install gasket and reducer and torque reducer to 420-600 in-lb.

f. On engines incorporating MD145 change, install seals (5, 10) and plates (6, 11). Torque bolts to 45 ±2 in-lb. Safetywire bolts.



1	Line	9	Line[a]	17	Manifold	25	Nut
2	Seal	10	Seal	18	Reducer	26	Ring
3	Bracket	11	Plate[b]	19	Gasket	27	Gasket
4	Tube[a]	12	Tube	20	Elbow	28	Reducer[a]
5	Seal	13	Tube	21	Nut	29	Gasket
6	Plate[b]	14	Tube	22	Ring	30	Plug[b]
7	Hose	15	Tube[a]	23	Gasket	31	Plate
8	Seal	16	Bushing	24	Elbow	32	Seal

(a) Engines not incorporating MD145 change
(b) Engines incorporating MD145 change

Figure 3-88. Fuel Drain Manifold

g. Carefully install manifold (17) between tooling rings. Use care to prevent damage to fittings and tubes.

h. Install bushings (16) and secure manifold to tooling rings. Torque nuts to 375 ±25 in-lb.

i. Position elbows (20, 24) for tubes (13, 14). Torque nuts (21, 25) to 200-250 in-lb. Safety-wire nuts.

j. Lubricate (Method G) fittings of tubes (12, 13, 14) and on engines not incorporating MD145 change, tube (15). Connect tube and torque coupling nuts to valves as follows:

(1) Tube (12) (engines not incorporating MD145 change), 270-345 in-lb

(2) Tube (13, 14), 450-525 in-lb

(3) Tube (15) (engines not incorporating MD145 change), 450-525 in-lb

k. On engines not incorporating MD145 change, install seals (5, 10) and connect tube (4) and line (9). Torque bolts to 45 ±2 in-lb. Safetywire bolts.

l. Install seal (8) and hose (7). Torque bolts to 45 ±2 in-lb. Safetywire bolts.

m. Install seal (2) and line (1). Attach bracket (3), and torque bolts to 45 ±2 in-lb. Safetywire bolts.

n. Refer to section IV for post-maintenance test requirements.

3-317. ENGINE VARIABLE ORIFICES.

3-318. The orifice diameters are determined for each engine by engineering and calibration tests. The orifice identification, part number actual measured size, and engine serial number are stamped on each orifice plate or on a metal tag with the tag attached adjacent to the orifice. The orifice name, part number, size, and location identification code are recorded in each Engine Log Book. When it becomes necessary to replace an orifice, the replacement orifice must be machined to the diameter specified in the Engine Log Book and identified as specified in section I. The orifice is identified with the actual measured size, which may differ from the Engine Log Book Record by the machining tolerance of the orifice. Orifice diameters are not to be increased or decreased in size without prior approval of Rocketdyne Engineering.

3-319. THRUST CHAMBER BODY.

3-320. Removal and reinstallation of the thrust chamber body does not affect engine calibration. Removal and replacement, however, requires engine calibration. If a thrust chamber body is removed, reinstalled, or replaced, notify manufacturer's representative for requirements and procedures.

3-321. THRUST CHAMBER NOZZLE EXTENSION.

3-322. Procedures for removing and installing the thrust chamber nozzle extension are outlined in R-3896-11.

3-323. OXIDIZER AND NITROGEN OVERBOARD DRAIN LINES.

3-324. Procedures for removing and installing the oxidizer and nitrogen overboard drain lines are outlined in R-3896-11.

3-325. FUEL OVERBOARD DRAIN LINES.

3-326. Procedures for removing and installing the fuel overboard drain lines are outlined in R-3896-11.

3-327. HYPERGOL CARTRIDGE.

3-328. Procedures for removing and installing the hypergol cartridge are outlined in R-3896-11.

3-329. IGNITERS.

3-330. Procedures for removing and installing the igniters are outlined in R-3896-11.

3-331. IGNITER HARNESS.

3-332. Procedures for removing and installing the igniter harness are outlined in R-3896-11.

3-333. INTERFACE PANEL ACCESS DOOR.

3-334. Procedures for removing and installing the interface panel access door are outlined in R-3896-11.

3-335. THRUST CHAMBER THROAT SECURITY CLOSURE.

3-336. Procedures for removing and installing the thrust chamber throat security closure are outlined in R-3896-11.

3-337. ENGINE ENVIRONMENTAL COVER.

3-338. Procedures for removing and installing the engine environmental cover are outlined in R-3896-11.

3-339. FUEL INLET ELBOW TO INTERFACE PANEL INSULATION BOOT.

3-340. Procedures for removing and installing the fuel inlet elbow to interface panel insulation boot are outlined in R-3896-11.

3-341. TURBOPUMP OXIDIZER INLET.

3-342. Procedures for removing and installing the turbopump oxidizer inlet are outlined in R-3896-3, Volume II.

SECTION IV

POST-MAINTENANCE TEST REQUIREMENTS

4-1. SCOPE. This section contains post-maintenance test requirements that will verify the integrity of engine systems affected by the removal and installation of individual engine components and lines.

4-2. DEFINING COMPONENT POST-MAINTENANCE TEST REQUIREMENTS.

4-3. The component post-maintenance test requirements are based upon, and listed in the same sequence as, the removal and installation procedures in section III, and are applicable for uninstalled and installed engines. The test requirements include a brief description of each test and a listing of the items of the system to be tested. The required system tests referred to in this section correspond to the same test title that appears in the detailed leak- and function-test procedures in R-3896-11. The requirements do not include methods, sequences, or limits since they are determined from scheduled leak- and function-test procedures outlined in R-3896-11. The R-3896-3, Volume II is referenced when a specific nonscheduled component test, such as continuity testing of electrical harnesses, is required. Details for determining the post-maintenance test requirements for single components or groups of components are outlined in paragraphs 4-4 through 4-7. Details for determining test requirements after partial removal of components and lines are outlined in paragraph 4-8.

4-4. DETERMINING POST-MAINTENANCE TEST REQUIREMENTS FOR A SINGLE COMPONENT.

4-5. Each single component removed and installed in section III that requires post-maintenance testing has a corresponding paragraph for post-maintenance test requirements in this section. The specific items to be tested in each system are listed. In some instances the removal and installation of one component makes it necessary to remove and install other components; therefore, the test requirements for the other components are included in the test requirement paragraph for the primary component. For example, the post-maintenance test requirements for the No. 1 and No. 2 fuel high-pressure ducts include post-maintenance test requirements for the fuel high-pressure duct spacers and seal plates. When this situation exists, the user is informed in the introductory information provided in each component post-maintenance test requirement paragraph. Because single-component test requirements are based on the procedures in section III, deviations from those procedures make it necessary for the user to determine any changes in the post-maintenance test requirements.

4-6. DETERMINING POST-MAINTENANCE TEST REQUIREMENTS FOR GROUPS OF COMPONENTS.

4-7. If two or more individual components are removed from the engine, post-maintenance testing may be delayed until all components are installed.

4-8. DETERMINING POST-MAINTENANCE TEST REQUIREMENTS FOR MISCELLANEOUS REMOVAL AND INSTALLATION TASKS.

4-9. Miscellaneous removal and installation tasks are defined in this section as those tasks that affect engine system integrity but are not supported by individual paragraphs for post-maintenance test requirements. These tasks consist of partially removing components or disconnecting various parts of engine systems, and then restoring these items to the required configuration. These tasks can vary to such an extend that separate paragraphs for post-maintenance test requirements are not practical. The user must determine the specific items to be tested by applying the system test requirements for the item to the corresponding component post-maintenance test requirement paragraph in this section or, in cases where there is no corresponding component paragraph, to the applicable system test procedure.

4-10. COMPONENT POST-MAINTENANCE TEST REQUIREMENTS.

4-11. ENGINE CONTROL HARNESSES AND CABLES. The engine control harnesses and cables post-maintenance test requirements consist of the electrical function tests required for the components listed in this section.

4-12. FLIGHT INSTRUMENTATION HARNESSES AND CABLES. The flight instrumentation harnesses and cables post-maintenance test requirements consist of the electrical function tests required for the components listed in this section.

4-13. QUICK-DISCONNECTS AND ADAPTERS.

a. No. 1 and No. 2 fuel high-pressure duct drain quick-disconnects, No. 1 and No. 2 fuel inlet elbow drain quick-disconnects, engine control valve supply tube drain quick-disconnect, checkout valve engine return hose drain quick-disconnect, and gas generator ball valve fuel drain quick-disconnect:

Test Required	Item Tested
Fuel feed system leak test.	Quick-disconnect body to mounting flange or adapter joint, as required.

b. No. 1 and No. 2 fuel inlet manifold drain quick-disconnects, No. 1 and No. 2 fuel valve purge quick-disconnects, hypergol manifold drain quick-disconnect, hypergol manifold purge quick-disconnect, and ignition monitor valve drain quick-disconnect:

Thrust chamber pneumatic leak test.	Quick-disconnect body to mounting flange or adapter joint, as required.

c. Actuator return line drain quick-disconnect:

Test Required	Item Tested
Hydraulic control system leak and function test.	Quick-disconnect body to actuator return line cover joint.

d. Preservative inlet quick-disconnect:

Pneumatic leak test (perform during turbopump preservation).	Quick-disconnect body to bearing coolant control valve joint.

4-14. FLIGHT INSTRUMENTATION PRESSURE TRANSDUCERS. When a flight instrumentation pressure transducer is replaced in the field, an initial voltage checkout is required. The new transducer output voltage readings and the barometric pressure at the test area must be recorded in the Engine Log Book in place of the values that were listed for the replace transducer. The new voltage and barometric pressure values become a reference for use in subsequent voltage checkout tests of the new transducer.

a. Oxidizer pump bearing pressure transducer LB1a:

Test Required	Item Tested
(1) Flight instrumentation system function test.	Transducer bridge calibration output voltage.
(2) LOX pump seal purge leak and function test.	Transducer body to mounting flange joint.

b. Gas generator chamber pressure transducer GG1d and turbine outlet pressure transducer TG5c:

(1) Flight instrumentation system function test.	Transducer bridge calibration output voltage.
(2) Exhaust system leak test.	Transducer body to mounting flange joint.

Pages 4-2A and 4-2B Blank deleted.

c. Thrust chamber combustion chamber pressure transducer CG1e:

Test Required	Item Tested
(1) Flight instrumentation system function test.	Transducer bridge calibration output voltage.
(2) Thrust chamber pneumatic leak test.	Transducer body to flange or adapter joint, as required.

d. No. 1 fuel pump inlet pressure transducer KF6a-1 and No. 2 fuel pump outlet pressure transducer PF2a-2:

(1) Flight instrumentation system function test.	Transducer bridge calibration output voltage.
(2) Fuel feed system leak test.	Transducer body to mounting flange or adapter joint, as required.

e. No. 2 oxidizer pump outlet pressure transducer PO2a-2:

(1) Flight instrumentation system function test.	Transducer bridge calibration output voltage.
(2) LOX feed system leak test.	Transducer body to instrumentation tube joint.

f. Common hydraulic return pressure transducer NH5c:

(1) Flight instrumentation system function test.	Transducer bridge calibration output voltage.
(2) Hydraulic system leak and function test.	Transducer body to mounting flange joint.

4-15. TURBINE INLET MANIFOLD TEMPERATURE TRANSDUCER (TG4a) (ENGINES INCORPORATING MD149 CHANGE BUT NOT INCORPORATING MD176 CHANGE).

Test Required	Item Tested
a. Flight instrumentation system function test.	Sensing element resistance at ambient conditions.
b. Exhaust system leak test.	Transducer body to turbine manifold mounting flange joint.

4-16. ENVIRONMENTAL TEMPERATURE TRANSDUCER (CGT1).

Test Required	Item Tested
Flight instrumentation system function test.	Sensing element resistance at ambient conditions.

4-17. OXIDIZER PUMP BEARING TEMPERATURE TRANSDUCER NO. 1 (LS1).

Test Required	Item Tested
Flight instrumentation system function test.	Sensing element resistance at ambient conditions.

4-18. TURBOPUMP HEATER THERMOSTAT.

Test Required	Item Tested
Flight instrumentation system function test.	Thermostat pickup and dropout temperatures.

4-19. PRIMARY JUNCTION BOX. The primary junction box post-maintenance test requirements consist of performing the flight instrumentation function test to check voltage output of each flow, speed, and pressure transducer; resistance values of each temperature transducer and valve potentiometer.

4-20. OXIDIZER FLOWMETER.

Test Required	Item Tested
a. Flight instrumentation system function test.	Coil output voltage.
b. Heat exchanger LOX system leak test.	(1) Heat exchanger check valve to oxidizer flowmeter joint.
	(2) Oxidizer flowmeter to heat exchanger oxidizer supply hose joint.

4-21. HEAT EXCHANGER CHECK VALVE.

Test Required	Item Tested
a. Heat exchanger LOX system leak test.	Heat exchanger check valve to oxidizer flowmeter joint.
b. Thrust chamber pneumatic leak test.	Heat exchanger check valve to oxidizer dome joint.

4-22. WRAP-AROUND DUCTS AND HOSES.

There is no post-maintenance test requirement for the wrap-around ducts and hoses prior to engine installation into the stage. After engine installation into the stage, stage procedures must be used for joint verification.

4-23. HEAT EXCHANGER AND TURBOPUMP TURBINE.

Test Required	Item Tested
a. Exhaust system leak test.	(1) Turbine outlet pressure hose to instrumentation tap TG5c joint.
	(2) Turbine outlet to heat exchanger joint.
b. Heat exchanger helium system leak test (required only if ducts and/or hoses were disconnected).	(1) Helium supply duct (heat exchanger end) to heat exchanger joint.
	(2) Helium return duct (heat exchanger end) to heat exchanger joint.
	(3) Helium supply duct (heat exchanger end) to helium bypass hose joint.
	(4) Helium return duct (heat exchanger end) to helium bypass hose joint.
c. Heat exchanger LOX system leak test (required only if ducts and/or hoses were disconnected).	(1) Oxidizer supply hose to heat exchanger joint.
	(2) GOX duct (heat exchanger end) to heat exchanger joint.
	(3) Oxidizer supply hose to oxidizer bypass hose joint.
	(4) GOX duct (heat exchanger end) to oxidizer bypass hose joint.

4-24. HEAT EXCHANGER AND HEAT EXCHANGER DUCTS AND HOSES.

Test Required	Item Tested
a. Exhaust system leak test.	(1) Turbine outlet pressure hose to instrumentation tap TG5c joint.
	(2) Turbine outlet to heat exchanger joint.
	(3) Heat exchanger outlet to turbine exhaust manifold joint.
b. Heat exchanger helium system leak test.	(1) Helium supply duct (heat exchanger end) to heat exchanger joint.
	(2) Helium return duct (heat exchanger end) to heat exchanger joint.

Test Required	Item Tested
	(3) Helium supply duct (heat exchanger end) to helium bypass hose joint.
	(4) Helium return duct (heat exchanger end) to helium bypass hose joint.
c. Heat exchanger LOX system leak test.	(1) Oxidizer supply hose to heat exchanger joint.
	(2) GOX duct (heat exchanger end) to heat exchanger joint.
	(3) Oxidizer supply hose to oxidizer bypass hose joint.
	(4) GOX duct (heat exchanger end) to oxidizer bypass hose joint.

4-25. IGNITER FUEL SUPPLY TUBE.

a. Prepare joints of igniter fuel supply tube for leak test as outlined in paragraph 4-33.

Test Required	Item Tested
Fuel feed system leak test.	(1) Igniter fuel supply tube to No. 1 fuel high-pressure duct joint.
	(2) Igniter fuel supply tube to igniter fuel valve joint.

b. Secure joints of igniter fuel supply tube as outlined in paragraph 4-34.

4-26. ENGINE SUPPLY TUBE.

a. Prepare engine supply tube for leak test as outlined in paragraph 4-33.

Test Required	Item Tested
Fuel feed system leak test.	(1) Engine supply tube to No. 2 fuel high-pressure duct joint.
	(2) Engine supply tube to engine hydraulic supply check valve joint.

b. Secure joints of engine supply tube as outlined in paragraph 4-34.

4-27. FUEL HIGH-PRESSURE DUCT SPACERS AND SEAL PLATES. The fuel high-pressure duct spacers and seal plates post-maintenance test requirement consists of leak-testing the fuel duct joints. This test is included in the No. 1 and No. 2 fuel high-pressure duct post-maintenance test requirements outlined in paragraphs 4-31 and 4-32.

4-28. FUEL VALVE TO FUEL MANIFOLD ORIFICE PLATE. The fuel valve to fuel manifold orifice plate post-maintenance test requirement consists of leak-testing the fuel valve joint between the fuel valve and the fuel manifold inlet. This test is included in the No. 1 and No. 2 fuel valve post-installation test requirements outlined in paragraphs 4-37 and 4-38.

4-29. OXIDIZER HIGH-PRESSURE DUCT SPACERS AND PRESSURE-ACTUATED SEALS. The oxidizer high-pressure duct spacer and pressure-actuated seal post-maintenance test requirement consists of leak-testing the oxidizer duct joint. This test is included in the No. 1 and No. 2 oxidizer high-pressure duct post-maintenance test requirements outlined in paragraphs 4-35 and 4-36.

4-30. OXIDIZER VALVE TO OXIDIZER DOME PRESSURE-ACTUATED SEAL. The oxidizer valve to oxidizer dome pressure-actuated seal post-maintenance test requirement consists of leak-testing the oxidizer valve joint between the oxidizer valve and the oxidizer dome. This test is included in the No. 1 and No. 2 oxidizer valve post-maintenance test requirements outlined in paragraphs 4-39 and 4-40.

4-31. NO. 1 FUEL HIGH-PRESSURE DUCT.

a. Prepare joints of igniter fuel supply tube for leak test as outlined in paragraph 4-33.

Test Required	Item Tested
Fuel feed system leak test.	(1) No. 1 fuel high-pressure duct to fuel pump outlet joint.
	(2) No. 1 fuel high-pressure duct to No. 1 fuel valve joint.
	(3) No. 1 fuel high-pressure duct to igniter fuel supply tube joint.
	(4) Igniter fuel supply tube to igniter fuel valve joint.
	(5) No. 1 fuel high-pressure duct to No. 1 fuel high-pressure duct drain quick-disconnect joint.
	(6) No. 1 fuel high-pressure duct to gimbal supply plate joint.

b. Secure joints of igniter fuel supply tube as outlined in paragraph 4-34.

Thrust chamber pneumatic leak test (required only if fuel valve to thrust chamber fuel inlet manifold joint was disturbed).	No. 1 fuel valve to fuel inlet manifold joint.

4-32. NO. 2 FUEL HIGH-PRESSURE DUCT.

a. Prepare joints of engine supply tube for leak test as outlined in paragraph 4-33.

Test Required	Item Tested
Fuel feed system leak test.	(1) No. 2 fuel high-pressure duct to fuel pump outlet joint.
	(2) No. 2 fuel high-pressure duct to No. 2 fuel valve joint.
	(3) No. 2 fuel high-pressure duct to engine supply tube joint.
	(4) Engine supply tube to engine hydraulic supply check valve joint.
	(5) No. 2 fuel high-pressure duct to No. 2 fuel bleed hose joint.
	(6) No. 2 fuel high-pressure duct to gas generator fuel duct joint.
	(7) No. 2 fuel high-pressure duct to No. 2 fuel pump outlet pressure transducer PF2a joint.
	(8) No. 2 fuel high-pressure duct to No. 2 fuel high-pressure duct drain quick-disconnect joint.

b. Secure joints of engine supply tube as outlined in paragraph 3-34.

Thrust chamber pneumatic leak test (required only if fuel valve to thrust chamber fuel inlet manifold joint was disturbed).	No. 2 fuel valve to fuel inlet manifold joint.

4-33. PREPARING IGNITER FUEL SUPPLY AND ENGINE SUPPLY TUBE JOINTS FOR LEAK TESTING. This procedure is performed only when specified in other procedures in this section. The flanged joints of the igniter fuel supply and engine supply tubes contain eccentric spacers. This procedure provides a method for separating the metal-to-metal surfaces of the spacers and tube flanges to verify the integrity of the O-rings used in the joints.

CAUTION

Extreme care must be taken to prevent loosening flange bolts more than one turn each. Additional loosening of bolts may allow installed O-rings to leave their grooves and cause O-ring damage when bolts are torqued.

a. Remove lockwire and loosen bolts at each flange of the applicable tube a maximum of one turn each.

b. Separate joint surfaces by hand and insert 0.004-inch thick feeler gage stock at a corner, on both sides of eccentric spacer at each tube joint as shown in figure 4-1.

NOTE

Feeler gage stock must be moved toward the tube centerline until its edge contacts the flange bolt.

c. With feeler gage stock retained in position, cross-torque all flange bolts to torque value indicated for applicable tube.

(1) Igniter fuel supply tube: 60 ±5 in-lb.

(2) Engine supply tube: 85 ±5 in-lb.

d. Perform applicable leak test.

4-34. SECURING IGNITER FUEL SUPPLY AND ENGINE SUPPLY TUBES. This procedure is performed only when specified in other procedures in this section. The procedure provides a method for securing the flanged joints of the igniter fuel supply and engine supply tubes after the applicable post-maintenance leak test.

CAUTION

Extreme care must be taken to prevent loosening flange bolts more than one turn each. Additional loosening of bolts may allow installed O-rings to leave their grooves and cause O-ring damage when bolts are torqued.

a. Loosen all flange bolts of applicable tube a maximum of one turn each. Remove all feeler gage stock from tube and boss joints.

b. Cross-torque all flange bolts to torque values indicated for applicable tube.

(1) Igniter fuel supply tube: 60 ±5 in-lb.

(2) Engine supply tube: 85 ±5 in-lb.

c. Safetywire bolts.

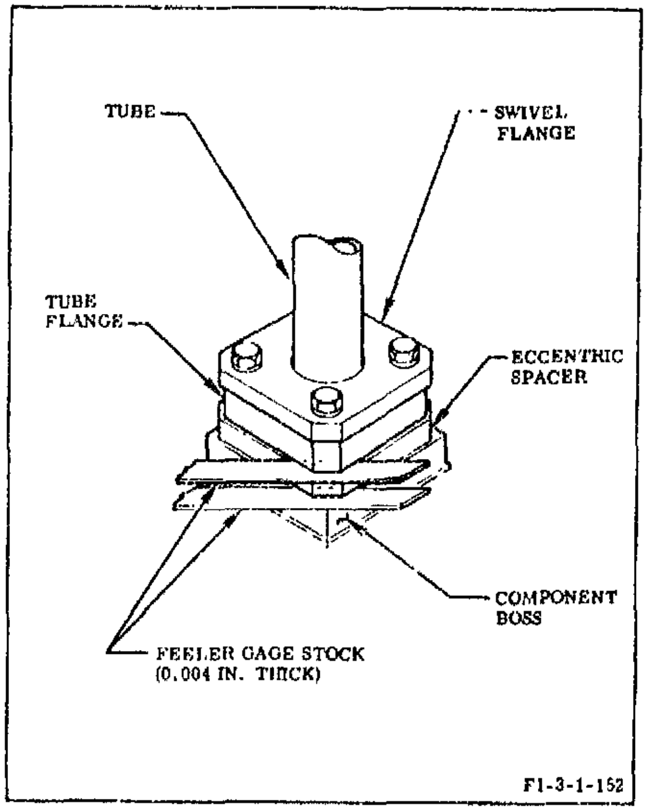


Figure 4-1. Preparing Igniter Fuel Supply and Engine Supply Tube Joints for Leak Testing

4-35. NO. 1 OXIDIZER HIGH-PRESSURE DUCT.

Test Required	Item Tested
a. LOX feed system leak test.	(1) No. 1 oxidizer high-pressure duct to No. 1 oxidizer pump outlet joint.
	(2) No. 1 oxidizer high-pressure duct to No. 1 oxidizer valve joint.

Test Required	Item Tested
	(3) No. 2 oxidizer pump outlet pressure transducer PO2a-2 to instrumentation tube joint.
b. Flight instrumentation system function test.	No. 2 oxidizer pump outlet pressure transducer PO2a-2 bridge calibration output voltage.
c. Thrust chamber pneumatic leak test (required only if oxidizer valve to oxidizer dome joint was disturbed).	No. 1 oxidizer valve to oxidizer dome joint.

4-36. NO. 2 OXIDIZER HIGH-PRESSURE DUCT.

Test Required	Item Tested
a. LOX feed system leak test.	(1) No. 2 oxidizer high-pressure duct to No. 2 oxidizer pump outlet joint.
	(2) No. 2 oxidizer high-pressure duct to No. 2 oxidizer valve joint.
	(3) No. 2 oxidizer high-pressure duct to gas generator oxidizer duct (duct end) joint.
	(4) No. 2 oxidizer pump outlet pressure transducer PO2a-2 instrumentation tube to No. 2 oxidizer high-pressure duct joint.
b. Thrust chamber pneumatic leak test (required only if oxidizer valve to oxidizer dome joint was disturbed).	No. 2 oxidizer valve to oxidizer dome joint.

4-37. NO. 1 FUEL VALVE.

Test Required	Item Tested
a. Hydraulic control system leak and function test.	(1) Fuel valve to propellant valves close tube joint.
	(2) Fuel valve to No. 1 open control tube joint.
	(3) Transducer potentiometer resistance with valve in close and open position.
b. Valve timing function test.	Opening and closing times.
c. Fuel feed system leak test	Fuel valve to No. 1 fuel high-pressure duct joint.
d. Thrust chamber pneumatic leak test.	(1) Fuel valve to fuel inlet manifold joint.
	(2) Fuel valve to No. 1 fuel valve drain quick-disconnect joint.

4-38. NO. 2 FUEL VALVE.

Test Required	Item Tested
a. Hydraulic control system leak and function test.	(1) Fuel valve to propellant valves close tube joint.
	(2) Fuel valve to No. 2 fuel valve open control tube joint.
	(3) Transducer potentiometer resistance with valve in close and open position.
b. Valve timing function test.	Opening and closing times.
c. Fuel feed system leak test.	Fuel valve to No. 2 fuel high-pressure duct joint.

Test Required	Item Tested
d. Thrust chamber pneumatic leak test.	(1) Fuel valve to fuel inlet manifold joint.
	(2) Fuel valve to No. 2 fuel valve drain quick-disconnect joint.

4-39. NO. 1 OXIDIZER VALVE.

Test Required	Item Tested
a. Hydraulic control system leak and function test.	(1) Oxidizer valve to propellant valves close tube joint.
	(2) Oxidizer valve to propellant valves open tube joint.
	(3) Oxidizer valve to sequence valve to sequence valve line joint.
	(4) Oxidizer valve to gas generator open tube joint.
	(5) Transducer potentiometer resistance with valve in close and open position.
b. Valve timing function test.	Opening and closing times.
c. LOX feed system leak test.	Oxidizer valve to No. 1 oxidizer high-pressure duct joint.
d. Thrust chamber pneumatic leak test.	Oxidizer valve to oxidizer dome joint.
e. LOX dome and gas generator LOX injector purge leak test.	Oxidizer dome purge check valve to No. 1 oxidizer valve dome purge tube joint.

4-40. NO. 2 OXIDIZER VALVE.

Test Required	Item Tested
a. Hydraulic control system leak and function test.	(1) Oxidizer valve to propellant valves close tube joint.
	(2) Oxidizer valve to propellant valves open tube joint.
	(3) Oxidizer valve to sequence valve to sequence valve line joint.
	(4) Transducer potentiometer resistance with oxidizer valve in close and open position.
b. Valve timing function test.	Opening and closing times.
c. LOX feed system leak test.	Oxidizer valve to No. 2 oxidizer high-pressure duct joint.
d. Thrust chamber pneumatic leak test.	Oxidizer valve to oxidizer dome joint.
e. LOX dome and gas generator LOX injector purge leak test.	Oxidizer dome purge check valve to No. 2 oxidizer valve dome purge tube joint.

4-41. FUEL VALVE POSITION TRANSDUCER.

Test Required	Item Tested
a. Hydraulic control system leak and function test.	(1) Transducer to fuel valve joint.
	(2) Transducer potentiometer resistance with valve in open and close position.
b. Valve timing function test.	Opening and closing times.

4-42. OXIDIZER VALVE POSITION TRANSDUCER.

Test Required	Item Tested
a. Hydraulic control system leak and function test.	Transducer resistance with valve in close and open position.
b. Valve timing function test.	Opening and closing times.

4-43. OXIDIZER DOME PURGE CHECK VALVE.

Test Required	Item Tested
a. Thrust chamber pneumatic leak test.	Oxidizer dome purge check valve to oxidizer valve joint.
b. LOX dome and gas generator LOX injector purge leak test.	Oxidizer dome purge check valve to oxidizer valve dome purge line joint.

4-44. SEQUENCE VALVE.

Test Required	Item Tested
Hydraulic control system leak and function test.	a. Oxidizer valve cylinder to sequence valve cylinder head joint.
	b. Cylinder head to cap joint.
	c. Tube connections at PRESS IN and PRESS OUT ports on sequence valve cylinder head.

4-45. BEARING COOLANT CONTROL VALVE.

Test Required	Item Tested
a. Turbopump bearing coolant system leak test.	(1) Bearing coolant control valve to No. 1 and No. 2 bearings lube feed tube joint.
	(2) No. 1 and No. 2 bearings lube feed tube to turbine bearing support lube feed hose joint (engines not incorporating MD145 change).
	(3) Bearing coolant control valve to oxidizer pump bearing pressure transducer LB1a joint.
b. Fuel feed system leak test.	(1) Fuel volute lube feed tube to bearing coolant control valve joint.
	(2) Fuel volute lube feed tube turbopump joint.
c. Flight instrumentation system function test.	Oxidizer pump bearing pressure transducer LB1a bridge calibration voltage output.

4-46. BEARING COOLANT CONTROL VALVE FILTERS.

Test Required	Item Tested
Fuel feed system leak test.	Bearing coolant control valve body to caps (2 places).

4-47. HYPERGOL MANIFOLD.

Test Required	Item Tested
a. Hypergol installed switch function test.	Switch actuation and deactuation.
b. Hypergol manifold leak and function test.	Hypergol manifold joints.
c. Hydraulic control system leak and function test.	(1) Ignition monitor valve to propellant valves open tube joint.
	(2) Ignition monitor valve to No. 1 fuel valve open tube joint.

Test Required	Item Tested
	(3) Ignition monitor valve to No. 2 fuel valve open tube joint.
	(4) Ignition monitor valve to ignition monitor valve return line joint.
d. Ignition monitor valve shuttle pressure test.	Poppet movement.
e. Ignition monitor valve interflow test.	Poppet leakage.
f. Fuel feed system leak test.	Igniter fuel supply tube joints as outlined in paragraph 4-25.
g. Thrust chamber pneumatic leak test.	(1) Hypergol manifold to hypergol manifold outlet hose joint.
	(2) Ignition monitor valve to ignition monitor valve sense tube joint.
	(3) Ignition monitor valve sense tube to ignition monitor valve CONTROL port quick-disconnect joint.

4-48. HYPERGOL MANIFOLD CARTRDIGE CONTAINER.

Test Required	Item Tested
Thrust chamber pneumatic leak test.	a. Hypergol manifold to hypergol manifold cutlet hose joint.
	b. Hypergol manifold to cartridge container joint.

4-49. HYPERGOL INSTALLED SWITCH.

Test Required	Item Tested
Hypergol installed switch function test.	Switch actuation and deactuation.

4-49A. IGNITION MONITOR VALVE CAP.

Test Required	Item Tested
a. Ignition monitor valve diaphragm leak test.	(1) Diaphragm from ATMOS REF port.
	(2) Cap to body joint.
	(3) Coupling to tube and tube to coupling joint.
b. Thrust chamber pneumatic leak test.	Tube to thrust chamber fuel manifold joint.
c. Ignition monitor valve shuttle pressure function test.	Ignition monitor valve control port pressure required for valve actuation.

4-50. ENGINE CONTROL VALVE.

Test Required	Item Tested
a. Hydraulic control system leak and function test.	(1) Engine control valve start and stop solenoid current drain.
	(2) Engine control valve ground hydraulic supply hose to GSE hydraulic supply check valve joint.
	(3) Engine control valve to propellant valves open tube joint.
	(4) Engine control valve to propellant valves close tube joint.
	(5) Engine control valve to system return line joint.
	(6) Engine control valve to redundant shutdown valve supply hose joint.
	(7) Redundant shutdown valve supply hose to redundant shutdown valve.
	(8) Engine control valve to cover plate joint.

Test Required	Item Tested
b. Valve timing function test.	Oxidizer and fuel valves opening and closing times.
c. Hydraulic control system leak and function test.	(1) Redundant shutdown valve override hose to engine control valve joint. (2) Redundant shutdown valve override hose to redundant shutdown valve joint.
d. Fuel feed system leak test.	Engine supply tube joints as outlined in paragraph 4-26.

4-51. ENGINE AND GSE HYDRAULIC SUPPLY CHECK VALVES.

Test Required	Item Tested
a. Hydraulic control system leak and function test.	(1) Engine control valve to GSE hydraulic supply check valve joint. (2) Check valve to engine control valve ground hydraulic supply hose joint. (3) Engine control valve to engine supply check valve joint.
b. Fuel feed system leak test.	Engine supply tube joints as outlined in paragraph 4-26.

4-52. ENGINE CONTROL VALVE FILTERS.

Test Required	Item Tested
Hydraulic control system leak and function test.	Cover to engine control valve manifold joint.

4-53. ENGINE CONTROL VALVE COVER PLATE AND RETURN PLUG.

Test Required	Item Tested
Hydraulic control system leak and function test.	Cover plate to body joint.

4-54. ENGINE CONTROL VALVE STOP AND GUIDE.

Test Required	Item Tested
Hydraulic control system leak and function test.	a. Redundant shutdown valve override hose to engine control valve joint. b. Stop to guide joint. c. Guide to body joint.

4-54A. FOUR-WAY SOLENOID VALVE.

Test Required	Item Tested
a. Hydraulic control system leak and function test.	(1) On uninstalled engines, engine control valve start and stop solenoid current drain. (2) Engine control valve to system return line joint. (3) System return line to actuator return line joint. (4) Four-way solenoid valve to manifold joint. (5) Redundant shutdown valve hose to four-way solenoid valve joints.
b. Valve timing function test.	Oxidizer and fuel valves opening and closing times.

4-55. REDUNDANT SHUTDOWN VALVE.

Test Required	Item Tested
Hydraulic control system leak and function test.	a. Solenoid current drain. b. Redundant shutdown valve to redundant shutdown valve supply hose joint. c. Redundant shutdown valve to redundant shutdown valve override hose joint.

4-56. THRUST OK PRESSURE SWITCHES.

Test Required	Item Tested
a. Thrust chamber pneumatic leak test.	Thrust OK pressure switches to thrust chamber fuel inlet manifold joint.
b. Thrust OK pressure switch function test.	Switch actuation and deactuation.

4-57. INERT PREFILL CHECK VALVE.

Test Required	Item Tested
Thrust chamber pneumatic leak test.	a. Thrust chamber fuel inlet manifold to inert prefill check valve joint.
	b. Inert prefill check valve to cover plate joint, if installed.

4-58. CHECKOUT VALVE.

Test Required	Item Tested
a. Checkout valve function test.	Actuator operation.
b. Hydraulic control system leak and function test.	(1) Checkout valve to actuator return line joint.
	(2) Checkout valve to checkout valve ground return hose joint.
c. Fuel feed system leak test.	Checkout valve to checkout valve engine return hose joint.

4-59. CHECKOUT VALVE ACTUATOR.

Test Required	Item Tested
Checkout valve function test.	Actuator operation.

4-60. GAS GENERATOR FUEL DUCT.

Test Required	Item Tested
Fuel feed system leak test.	a. Gas generator fuel feed duct to No. 2 fuel high-pressure duct joint.
	b. Gas generator fuel feed duct to gas generator ball valve joint.

4-61. GAS GENERATOR OXIDIZER DUCT (DUCT END).

Test Required	Item Tested
LOX feed system leak test.	a. No. 2 oxidizer high-pressure duct to gas generator oxidizer duct (duct end) joint.
	b. Gas generator oxidizer duct (duct end) to gas generator oxidizer duct (valve end) joint.

4-62. GAS GENERATOR OXIDIZER DUCT (VALVE END).

Test Required	Item Tested
LOX feed system leak test.	a. Gas generator ball valve to gas generator oxidizer duct (valve end) joint.
	b. Gas generator oxidizer duct (valve end) to gas generator oxidizer duct (duct end) joint.

4-63. GAS GENERATOR BALL VALVE.

Test Required	Item Tested
a. Hydraulic control system leak and function test.	(1) Gas generator ball valve to gas generator close tube joint.
	(2) Gas generator ball valve to gas generator open tube joint.
b. Valve timing function test.	Gas generator ball valve opening and closing times.
c. Fuel feed system leak test.	(1) Gas generator ball valve to gas generator fuel duct joint.
	(2) Gas generator ball valve to gas generator ball valve drain quick-disconnect joint.
d. LOX feed system leak test.	Gas generator ball valve and gas generator oxidizer duct (valve end) joint.
e. Exhaust system leak test.	(1) Gas generator ball valve to gas generator injector joint.
	(2) Gas generator ball valve to housing tee joint.
	(3) Housing tee to gas generator injector joint.
f. LOX dome and gas generator LOX injector purge leak and function test.	(1) Gas generator oxidizer purge tube and purge check valve.
	(2) Purge check valve and gas generator ball valve.

4-64. GAS GENERATOR.

Test Required	Item Tested
a. Hydraulic control system leak and function test.	(1) Gas generator ball valve to gas generator close tube joint.
	(2) Gas generator ball valve to gas generator open tube joint.
b. Valve timing function test.	Gas generator ball valve opening and closing times.

Test Required	Item Tested
c. Fuel feed system leak test.	(1) Gas generator ball valve to gas generator feed duct joint.
	(2) Gas generator ball valve to gas generator ball valve drain quick-disconnect joint.
d. LOX feed system leak test.	Gas generator ball valve to gas generator oxidizer duct (valve end) joint.
e. Exhaust system leak test.	Gas generator combustor to turbine manifold joint.
f. LOX dome and gas generator LOX injector purge leak test.	(1) Gas generator oxidizer purge tube to purge check valve joint.
	(2) Purge check valve to gas generator ball valve joint.

4-65. GAS GENERATOR BALL VALVE POSITION SWITCH.

Test Required	Item Tested
Valve timing function test.	Gas generator ball valve opening and closing times.

4-66. GAS GENERATOR OXIDIZER PURGE CHECK VALVE.

Test Required	Item Tested
LOX dome and gas generator LOX injector purge leak test.	a. Gas generator oxidizer purge tube and purge check valve joint.
	b. Purge check valve and gas generator ball valve joint.

4-67. ELECTRICAL CABLE SUPPORT POST. There is no post-maintenance test requirement for the electrical cable support post.

4-68. INTERFACE PANEL TO OXIDIZER INSULATION SEAL. There is no post-maintenance test requirement for the interface panel to oxidizer insulation seal.

4-69. INTERFACE PANEL. There is no post-maintenance test requirement for the interface panel.

4-70. GIMBAL BEARING. There is no post-maintenance test requirement for the gimbal bearing.

4-71. ASSOCIATED ENGINE EQUIPMENT. The associated engine equipment consists of those items that must be removed to accomplish any oxidizer dome removal either singularly or in combination with the gimbal bearing and/or the thrust chamber injector. The post-maintenance test requirements for these items of hardware are included in the gimbal bearing, oxidizer dome, and thrust chamber injector post-maintenance test requirements outlined in paragraph 4-72.

4-72. GIMBAL BEARING, OXIDIZER DOME, AND THRUST CHAMBER INJECTOR.

Test Required	Item Tested
Thrust chamber pneumatic leak test.	a. No. 1 oxidizer valve to oxidizer dome joint.
	b. No. 2 oxidizer valve to oxidizer dome joint.
	c. Heat exchanger check valve to oxidizer dome joint.
	d. Thrust chamber combustion chamber pressure transducer CG1e to adapter joint.
	e. Adapter to injector joint.
	f. Oxidizer dome to injector joint.
	g. Injector to thrust chamber body joint.
	h. Hypergol manifold outlet hose to oxidizer dome joint.

4-73. GIMBAL BEARING AND OXIDIZER DOME. The gimbal bearing and oxidizer dome post-maintenance test requirements are the same as those outlined for the gimbal bearing, oxidizer dome, and thrust chamber injector (paragraph 4-72).

4-74. OXIDIZER DOME AND THRUST CHAMBER INJECTOR. The oxidizer dome and thrust chamber injector post-maintenance test requirements are the same as those outlined for the gimbal bearing, oxidizer dome, and thrust chamber injector (paragraph 4-72).

4-75. OXIDIZER DOME. The oxidizer dome post-maintenance test requirements are the same as those outlined for the gimbal bearing, oxidizer dome, and thrust chamber injector (paragraph 4-72).

4-76. THRUST CHAMBER INJECTOR. The thrust chamber injector post-maintenance test requirements are the same as those outlined for the gimbal bearing, oxidizer dome, and thrust chamber injector (paragraph 4-72).

4-77. NO. 1 FUEL INLET ELBOW.

Test Required	Item Tested
Fuel feed system leak test.	a. Fuel inlet elbow to No. 1 fuel pump inlet joint.
	b. No. 1 fuel pump inlet No. 1 pressure transducer KF6a-1 to fuel pump inlet elbow joint.

4-78. NO. 2 FUEL INLET ELBOW.

Test Required	Item Tested
Fuel feed system leak test.	a. Fuel inlet elbow to fuel pump inlet joint.
	b. Fuel pump inlet elbow to checkout valve engine return hose joint.
	c. Checkout valve engine return hose to checkout valve joint.
	d. Fuel pump inlet elbow to No. 2 fuel bleed hose joint.

4-79. TURBOPUMP. The turbopump post-maintenance test requires that a complete engine system leak and functional checkout be performed and the engine be static-tested.

4-80. FUEL IMPELLER BALANCE CAVITY SUPPLY TUBE.

Test Required	Item Tested
Fuel feed system leak test.	Tube to turbopump joints.

4-81. FUEL IMPELLER BALANCE CAVITY RETURN HOSE.

Test Required	Item Tested
Fuel feed system leak test.	Tube to turbopump joints.

4-82. FUEL DRAIN MANIFOLD.

Test Required	Item Tested
Turbopump bearing coolant system leak test.	Manifold to overboard drain line joint.

4-83. TURBOPUMP OXIDIZER INLET.

Test Required	Item Tested
LOX feed system leak test.	Oxidizer inlet to oxidizer volute joint.

All data on pages 4-17 through 4-58 deleted.

MANUAL DATA SUPPLEMENTS

Manual Data Supplements are issued from time to time to communicate important and urgent information concerning the equipment covered in this volume. These supplements bear an identifying number and should be filed in this Appendix.

Manual Data Supplements directly affect the data in this volume and will be incorporated into this volume during a future updating effort.

A Manual Data Supplement Record is issued periodically to indicate the status of supplements issued for this volume. The status of each supplement is indicated in the "Supplement Status" column. For active supplements, no status is entered. For incorporated supplements, "Incorporated" is entered.

Upon receipt of a Manual Data Supplement, make an appropriate reference to the supplement in the margin next to the data supplemented and enter the number, date, and subject matter of the supplement on the Manual Data Supplement Record.

MANUAL DATA SUPPLEMENT RECORD

This Manual Data Supplement Record indicates the status of supplements issued for Technical Manual R-3896-3, Volume I. Supplements that have been incorporated into this volume shall be removed from the Appendix and destroyed.

Supplement Number	Dated	Description	Supplement Status
R-3896-3 Vol I-1	2 May 1966	Lists established hardware cleanness requirements for component removal and installation.	Incorporated
R-3896-3 Vol I-2	10 June 1966	Provides procedures for correct handling, removing, and installing of pressure-actuated (Naflex) seals.	Incorporated
R-3896-3 Vol I-3	17 June 1966	Provides revised misalinement limits to be used while fit-checking rigid lines and oxidizer and fuel valves.	Incorporated
R-3896-3 Vol I-4	3 August 1966	Expands maintenance level of engine-installed hypergol manifold assembly to include removal and reinstallation or replacement of hypergol cartridge container.	Incorporated
R-3896-3 Vol I-5	22 August 1966	Adds note stating that procedure for transferring engine from air transport engine handler to roadable vertical engine dolly is applicable only if engine is in maintenance position.	Incorporated

Supplement Number	Dated	Description	Supplement Status
R-3896-3 Vol I-6	31 August 1966	Revises thrust chamber flushing procedure to include a more thorough flushing method.	Incorporated in R-3896-7
R-3896-3 Vol I-7	31 August 1966	Provides installation procedures for oxidizer and fuel drain lines on thrust chamber nozzle extension.	Incorporated in R-3896-7
R-3896-3 Vol I-8	15 September 1966	Provides handling procedures for new and reusable seal plates containing molded rubber seals.	Incorporated
R-3896-3 Vol I-9	13 October 1966	Changes hydraulic control and purge line alinement procedure, oxidizer pump inlet test plate 9020163-21 removal procedure, and turbine exhaust gas igniter harness installation requirements.	Incorporated in R-3896-3 and R-3896-7
R-3896-3 Vol I-10	15 December 1966	Adds part number of washers and specifies use of new nuts at turbopump-to-oxidizer-outlet flanged joint.	Incorporated
R-3896-3 Vol I-11	21 December 1966	Deletes removal and installation procedures for engine control valve solenoid valves.	Incorporated
R-3896-3 Vol I-12	5 January 1967	Provides procedure for draining and cleaning position indicator shaft bore in fuel valve prior to position indicator installation.	Incorporated
R-3896-3 Vol I-13	1 February 1967	Authorizes use of MIL-T-27602 and Federal Specification O-T-634, Type I, trichloroethylene for flushing thrust chamber oxidizer dome and gas generator injector oxidizer cavity.	Incorporated in R-3896-7
R-3896-3 Vol I-14	16 January 1967	Identifies covers and closures to be used on engine lines, checkout valve manifold, and engine control valve when engine control valve is removed.	Incorporated
R-3896-3 Vol I-15	23 January 1967	Adds an engine environmental temperature parameter to flight instrumentation parameters	Incorporated in R-3896-7
R-3896-3 Vol I-16	8 February 1967	Provides leak- and function-test procedures for redundant shutdown system.	Incorporated in R-3896-7

Supplement Number	Dated	Description	Supplement Status
R-3896-3 Vol I-17	11 February 1967	Provides a procedure for shipping thrust chamber nozzle extension installed on shipping container RK392-40013-11.	Incorporated in R-3896-9
R-3896-3 Vol I-18	8 March 1967	Adds steps to engine loading and unloading procedures to clarify installation of lift adapters on Air Transport Engine Handler G4044 prior to lifting the engine and handler.	Incorporated in R-3896-9
R-3896-3 Vol I-19	6 April 1967	Adds leakage monitoring port seals, plugs, lubrication, and plug torque requirements.	Incorporated in R-3896-7
R-3896-3 Vol I-20	6 April 1967	Provides additional damage limits and disposition information for electrical connectors installed on engine harnesses.	Incorporated
R-3896-3 Vol I-21	3 April 1967	Adds steps to turbopump preservation procedure to purge turbopump prior to connecting preservative oil system.	Incorporated in R-3896-7
R-3896-3 Vol I-22	20 April 1967	Revises preface page to add change in use of lubricants.	Incorporated
R-3896-3 Vol I-23	12 May 1967	Clarifies torquing sequence of bolts that secure sequence-valve-to-gas-generator open line during installation of gas generator.	Incorporated
R-3896-3 Vol I-24	24 May 1967	Revises redundant shutdown valve actuation procedure and replaces a caution with a warning.	Incorporated in R-3896-7
R-3896-3 Vol I-25	12 June 1967	Clarifies requirement to leak-test oxidizer dome flush port plugs anytime plugs are removed and reinstalled, adds information for removal of rust from plated and non-plate steel surfaces, and revises Manual Data Supplement Record to record disposition of Supplement No. R-3896-3 Vol I-18.	Incorporated

Supplement Number	Dated	Description	Supplement Status
R-3896-3 Vol I-26	16 June 1967	Adds a caution to engine handling procedures calling attention to the possibility that damage to engine heat exchanger can occur when engine is in either vertical or horizontal position if Engine Rotating Sling G4050 is not properly repositioned before sling is disconnected from engine.	Incorporated
R-3896-3 Vol I-27	21 June 1967	Provides additional disposition information for electrical connectors installed on engine harnesses, and replaces fuel valve position indicator removal and installation procedure.	Incorporated
R-3896-3 Vol I-28	23 June 1967	Adds additional requirements for installing and alining engine pressurization lines, and specifies torque limits for connection of self-locking coupling nuts to fittings on engine control valve.	Incorporated
R-3896-3 Vol I-29	10 July 1967	Clarifies use of load condition numbered strip positions for operating Engine Rotating Sling G4050.	Incorporated
R-3896-3 Vol I-30	13 September 1967	Deletes a checkout requirement from the purge system leak test and adds a checkout requirement to the turbopump LOX intermediate seal flow test.	Incorporated in R-3896-7
R-3896-3 Vol I-31	22 September 1967	Adds a caution when torquing electrical connectors.	Incorporated
R-3896-3 Vol I-32	25 September 1967	Adds requirement for using potentiometer indications when verifying No. 1 and No. 2 fuel valve position.	Incorporated in R-3896-7
R-3896-3 Vol I-33	31 October 1967	Adds corrosion removal and control procedures for gas generator fuel feed line gimbal section and oxidizer feed line bellows of oxidizer feed line gimbal section.	Incorporated

Supplement Number	Dated	Description	Supplement Status
R-3896-3 Vol I-34	8 November 1967	Revises removal and installation procedures for turbopump balance cavity high-pressure tube assembly, and adds procedures for removal and installation of turbopump balance line hose assembly (pressure return).	Incorporated
R-3896-3 Vol I-35	11 December 1967	Increases allowable axial spacing between thrust chamber throat plug spacer and shaft collar when installing thrust chamber throat plug on engines incorporating MD31 change.	Incorporated
R-3896-3 Vol I-36	16 January 1968	Deletes area damage limits for anodic-coated parts.	Incorporated
R-3896-3 Vol I-37	8 February 1968	Changes a hypergol manifold test.	Incorporated
R-3896-3 Vol I-38	5 March 1968	Reduces hose self-locking nut minimum torque value from 50 to 35 inch-pounds.	Incorporated
R-3896-3 Vol I-39	13 March 1968	Changes torque values of fasteners that secure gas generator chamber pressure transducer P119 and combustion chamber pressure transducer P123 to their respective adapters, and changes torque value of gas generator fuel inlet drain quick-disconnect.	Incorporated
R-3896-3 Vol I-40	5 April 1968	Adds lubrication requirements and torque values for gas generator fuel inlet drain quick-disconnect on engines incorporating MD168 change.	Incorporated
R-3896-3 Vol I-41	2 May 1968	Revises format in order to clarify inspection test requirements for cleaned parts.	Incorporated
R-3896-3 Vol I-42	31 August 1968	Provides limitations for using flexible instrumentation hoses.	Incorporated
R-3896-3 Vol I-43	15 October 1968	Deletes inspection requirements in regard to reforming copper rings on turbine inlet temperature transducer, and adds a requirement that transducer must be returned to Rocketdyne representative for disposition.	Incorporated

Supplement Number	Dated	Description	Supplement Status
R-3896-3 Vol I-44	30 October 1968	Provides towing instructions for Roadable Vertical Engine Dolly G4051.	Incorporated
R-3896-3 Vol I-45	6 November 1968	Superseded by Supplement No. R-3896-3 Vol I-46.	
R-3896-3 Vol I-46	30 December 1968	Adds selected flight engine configuration component preinstallation test requirements, and changes thrust OK pressure switch pickup pressure tolerance.	Incorporated
R-3896-3 Vol I-47	14 January 1969	Clarifies engine variable orifice requirements, and changes seal monitoring port requirement for heat exchanger check valve to LOX flowmeter.	Incorporated
R-3896-3 Vol I-48	15 January 1969	Provides additional requirements for removing and installing turbine inlet manifold temperature transducers.	Incorporated
R-3896-3 Vol I-49	28 January 1969	Changes line joint alinement requirements for gas generator system close line, adds joints alinement requirements for gas generator system open line, and deletes lubricating requirements for igniter injector end line seal.	Incorporated
R-3896-3 Vol I-50	3 February 1969	Adds acceptance criteria and disposition regarding electrical connectors that are found to be loose, and seal monitoring port requirement for heat exchanger LOX flowmeter to heat exchanger LOX inlet line.	Incorporated
R-3896-3 Vol I-51	7 February 1969	Changes torque values of helium and GOX wrap-around lines, and changes part number of nuts that secure cocoon purge wrap-around line.	Incorporated
R-3896-3 Vol I-52	18 March 1969	Changes torque value of ignition monitor valve bypass line to manifold.	Incorporated
R-3896-3 Vol I-53	21 March 1969	Add orificing requirements for changing bearing coolant control valve.	Incorporated
R-3896-3 Vol I-54	24 March 1969	Changes usability requirements and adds inspection criteria for K-seals.	Incorporated

Supplement Number	Dated	Description	Supplement Status
R-3896-3 Vol I-55	27 March 1969	Adds engine purge requirement and procedure for LOX pump seal during engine rotation. (Data for fabrication of drain tube assemblies is incorporated in R-3896-3, Volume II.)	Incorporated
R-3896-3 Vol I-56	26 May 1969	Adds seal monitoring port reverse-leak test and torque value change for joint fasteners of helium and GOX wrap-around ducts.	Incorporated
R-3896-3 Vol I-57	30 June 1969	Changes lubricating material for electrical and instrumentation connectors.	Incorporated
R-3896-3 Vol I-58	3 July 1969	Provides clarification for reuse of seal plates.	Incorporated
R-3896-3 Vol I-59	17 July 1969	Provides revised installation procedure for fuel impeller balance cavity supply tube.	Incorporated
R-3896-3 Vol I-60	6 August 1969	Adds clarification for use of nylon or polyethylene gloves.	Incorporated
R-3896-3 Vol I-61	15 September 1969	Adds removal, installation, and leak test procedures for sequence valve.	Incorporated
R-3896-3 Vol I-62	25 September 1969	Adds instructions for locating and installing engine identification plate and modification identification plates.	Incorporated
R-3896-3 Vol I-63	23 September 1969	Substitutes lubricant grease RB0140-012 (Rocketdyne) for lubricant KEL-F 90 (Minnesota Mining and Mfg) for all engine applications except thrust chamber oxidizer dome bolts, adds a caution concerning removal of covers and closures before engine components are installed or connected, and changes torque values on heat exchanger wrap-around lines and bearing coolant control valve supply line.	Incorporated

Supplement Number	Dated	Description	Supplement Status
R-3896-3 Vol I-64	15 October 1969	Adds procedures for drying cleaned parts to remove cleaning compounds or solvents, specifies use of either gaseous nitrogen (MIL-P-27401) or clean, dry air conforming to the cleanness and humidity requirements of MIL-P-27401, and adds a warning when liquid nitrogen is used during cleaning of all-metal hoses.	Incorporated
R-3896-3 Vol I-65	6 November 1969	Adds requirement to perform a valve timing test during engine control valve post-maintenance test.	Incorporated
R-3896-3 Vol I-66	25 November 1969	Removes standard requirements for retorquing fasteners.	Incorporated
R-3896-3 Vol I-67	12 March 1970	Expands and clarifies general torquing procedure.	Incorporated
R-3896-3 Vol I-68	17 March 1970	Increases acceptable shelf life and installed life of synthetic rubber parts.	Incorporated
R-3896-3 Vol I-69	17 March 1970	Adds procedure for removing solenoid slave pilot valve and return plug cover plate, inspections to be made, measurements to be taken, and hydraulic control system leak and test requirement.	Incorporated
R-3896-3 Vol I-70	21 April 1970	Adds procedure for alining igniter fuel supply and engine supply tubes, and modifies applicable component removal and installation procedures.	Incorporated
R-3896-3 Vol I-71	22 May 1970	Changes fitting part number and adds post-maintenance test requirements for joints of igniter fuel supply and engine supply tubes.	Incorporated
R-3896-3 Vol I-72	19 June 1970	Adds alternate material for removing rust from external engine surfaces.	Incorporated
R-3896-3 Vol I-73	16 October 1970	Provides new procedures for removing and installing the engine control valve and changes control and purge line gap dimensions.	Incorporated
R-3896-3 Vol I-74	19 October 1970	Deletes the preinstallation test requirements for certain engine components.	Incorporated

Supplement Number	Dated	Description	Supplement Status
R-3896-3 Vol I-75	5 November 1970	Provides criteria for preinstallation inspection of Naflex seals.	Incorporated
R-3896-3 Vol I-76	13 January 1971	Provides a procedure for disconnecting and connecting the heat exchanger for installation of a torque bar on the second-stage turbine wheel during turbopump maintenance.	Incorporated
R-3896-3 Vol I-77	28 January 1971	Adds a step for inspecting that pin securing gate in oxidizer dome purge check valve is installed before installing the valve, and adds a procedure for replacing packings and retainers in the override port end of the engine control valve.	Incorporated
R-3896-3 Vol I-78	14 April 1971	Adds removal and installation procedures and post-maintenance test requirements for the ignition monitor valve cap.	Superseded by R-3896-3 Vol I-82
R-3896-3 Vol I-79	21 April 1971	Relaxes torque requirement for the oxidizer duct to volute flange fasteners.	Incorporated
R-3896-3 Vol I-80	26 April 1971	Clarifies alinement requirements for control and purge line critical joints.	Incorporated
R-3896-3 Vol I-81	29 April 1971	Adds a procedure for stripping dye from surfaces that will contact liquid oxygen when parts are installed.	Incorporated
R-3896-3 Vol I-82	30 April 1971	Adds removal and installation procedures and post-maintenance test requirements for the ignition monitor valve cap.	Incorporated
R-3896-3 Vol I-83	13 July 1971	Corrects the plug and seal requirements for the heat exchanger oxidizer flowmeter seal monitoring ports.	Superseded by R-3896-3 Vol I-84 dated 28 July 1971

Supplement Number	Dated	Description	Supplement Status
R-3896-3 Vol I-84	28 July 1971	Replaces Manual Data Supplement R-3896-3 Vol I-83, dated 13 July 1971 and existing figure 3-3B, titled Seal Monitoring Port Requirements, to be compatible with the format of the seal monitoring port requirements specified in R-3896-11, OICN No. 57, which clarified seal lubrication requirements.	Incorporated
R-3896-3 Vol I-86	24 August 1971	Corrects seal part numbers for instrumentation taps HH3c, HH4, and HO5.	Incorporated
R-3896-3 Vol I-87	16 August 1971	Updates component preinstallation test requirements.	Superseded by R-3896-3 Vol I-88 dated 11 October 1971
R-3896-3 Vol I-88	11 October 1971	Replaces Manual Data Supplement R-3896-3 Vol I-87, dated 16 August 1971 to add preinstallation test requirements, removal and installation procedures, and post installation test procedures for the four-way solenoid valve; to update existing preinstallation test requirements to indicate that the requirements are only for replacement components; to change preinstallation test requirements for the engine control valve; and to correct a torque value for installing hypergol manifold cartridge container.	Incorporated
R-3896-3 Vol I-89	20 January 1972	Adds age control requirements and usability testing for specified materials.	Incorporated
R-3896-3 Vol I-90	7 March 1972	Adds an allowable alternate part for a gasket.	Incorporated
R-3896-3 Vol I-91	31 March 1972	Adds a procedure for cleaning interior of electrical connectors.	Incorporated
R-3896-3 Vol I-92	10 April 1972	Adds a torque method for installing fittings which use K-seals.	Incorporated
R-3896-3 Vol I-93	13 June 1972	Changes the pressure limits for low-pressure gases.	Incorporated

Supplement Number	Dated	Description	Supplement Status
R-3896-3 Vol I-94	30 October 1972	Adds a usability test for gasket sealant RB0120-034.	Incorporated
R-3896-3 Vol I-95	6 November 1972	Adds a procedure for cleaning tarnish from electrical connector pins, updates the material list to include the materials required to clean off the tarnish, and changes the shelf life and specification reference for white sealant RTV-102 (General Electric).	Incorporated
R-3896-3 Vol I-96	2 February 1973	Adds information about potential hazards when using polyurethane and urethane foam.	Incorporated
R-3896-3 Vol I-97	1 March 1973	Changes the passivating procedure by adding the requirement for a glass fiber applicator.	Incorporated
R-3896-3 Vol I-98	5 April 1973	Adds warnings for handling specific materials used in the manual.	Incorporated
R-3896-3 Vol I-99	16 April 1973	Deletes leak-test compound (MIL-L-25567).	Incorporated