



AEROSPACE INFORMATION REPORT

AIR1899™**REV. A**

Issued 1985-08
Revised 2001-03
Reaffirmed 2023-04

Superseding AIR1899

Aerospace Military Aircraft Hydraulic System Characteristics

RATIONALE

AIR1899A has been reaffirmed to comply with the SAE Five-Year Review policy.

TABLE OF CONTENTS

1. SCOPE	4
1.1 Purpose	4
1.2 Field of Application	4
2. APPLICABLE DOCUMENTS.....	5
2.1 SAE Publications	5
2.2 U.S. Government Publications.....	5
3. ATTACK AIRPLANES	5
3.1 Northrop Grumman A-6A.....	5
3.2 Northrop Grumman A-7E.....	12
3.3 Fairchild A-10A	18
3.4 Lockheed F-117A	24
4. FIGHTER AIRPLANES.....	29
4.1 Northrop Grumman F-5E.....	29
4.2 Northrop Grumman F-14A	34
4.3 Boeing F-15A	41
4.4 Lockheed Martin F-16A	48
4.5 Boeing F/A-18A	54
4.6 MRCA	59
5. BOMBERS	65
5.1 Boeing B-1B.....	65
5.2 Northrop Grumman B-2A.....	73

SAE Executive Standards Committee Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2023 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
http://www.sae.org

SAE WEB ADDRESS:

Full document details: SAE AIR1899A

For more information on this standard, visit
<https://www.sae.org/standards/content/AIR1899A/>

Documents

Document Sharing Hub

TABLE OF CONTENTS (Continued)

6. ANTI-SUB - FIXED WING AIRCRAFT.....	80
6.1 Lockheed Martin P-3.....	80
6.2 Lockheed Martin S-3A	85
7. TRANSPORT AIRPLANES.....	91
7.1 Lockheed Martin C-5A	91
7.2 Boeing C-17A Globemaster III	97
7.3 Lockheed Martin C-130.....	104
7.4 Lockheed Martin C-141B	110
8. HELICOPTERS.....	118
8.1 Bell 214.....	118
8.2 Sikorsky CH-53E.....	123
8.3 Sikorsky S-76	128
9. BOATS.....	133
9.1 M-161 Boat	133
10. SUMMARY.....	138
FIGURE 1 A6-A Aircraft Hydraulic System.....	10
FIGURE 2 A-6A Power System.....	11
FIGURE 3 A-7E Aircraft Hydraulic System.....	16
FIGURE 4 A-7E Power System.....	17
FIGURE 5 A-10A Aircraft Hydraulic System	22
FIGURE 6 A-10A Power System	23
FIGURE 7 F-117A Aircraft Hydraulic System	27
FIGURE 8 F-117A Power System	28
FIGURE 9 F-5E Aircraft Hydraulic System	32
FIGURE 10 F-5E Power System	33
FIGURE 11 F-14A Aircraft Hydraulic System	39
FIGURE 12 F-14A Power System	40
FIGURE 13 F-15A Aircraft Hydraulic System	45
FIGURE 14 F-15A Flight Power System	46
FIGURE 15 F-15A Utility Power System	47
FIGURE 16 F-16A Aircraft Hydraulic System	52
FIGURE 17 F-16A Power System	53
FIGURE 18 F-18A Aircraft Hydraulic System	57
FIGURE 19 F-18A Power System	58
FIGURE 20 MRCA Aircraft Hydraulic System	63
FIGURE 21 MRCA Power System	64

TABLE OF CONTENTS (Continued)

FIGURE 22	B-1B Aircraft Flight Control System	69
FIGURE 23	B-1B Aircraft Utility System	70
FIGURE 24	B-1B Power System	71
FIGURE 25	B-1B Hydraulic Reservoir	72
FIGURE 26	B-2A Aircraft Flight Controls Hydraulic System	77
FIGURE 27	B-2A Aircraft Utility System	78
FIGURE 28	B-2A Power System	79
FIGURE 29	P-3 Aircraft Hydraulic System	83
FIGURE 30	P-3 Power System	84
FIGURE 31	S-3A Aircraft Hydraulic System	89
FIGURE 32	S-3A Power System	90
FIGURE 33	C-5A Aircraft Hydraulic System	95
FIGURE 34	C-5A Power System	96
FIGURE 35	C-17A Aircraft Hydraulic System	102
FIGURE 36	C-17A Power System	103
FIGURE 37	C-130 Aircraft Hydraulic System	108
FIGURE 38	C-130 Power System	109
FIGURE 39	C-141B Aircraft Hydraulic System	114
FIGURE 40	C-141B Power System 1	115
FIGURE 41	C-141B Power System 2	116
FIGURE 42	C-141B Power System 3	117
FIGURE 43	214 Aircraft Hydraulic System	121
FIGURE 44	214 Power System	122
FIGURE 45	CH-53E Aircraft Hydraulic System	126
FIGURE 46	CH-53E Power System	127
FIGURE 47	S-76 Aircraft Hydraulic System	131
FIGURE 48	S-76 Power System	132
FIGURE 49	M-161 Boat Hydraulic System	136
FIGURE 50	M-161 Power System 1	137
TABLE 1	Summary	139

1. SCOPE:

This SAE Aerospace Information Report (AIR) has been compiled to provide information on hydraulic systems fitted to the following categories of military vehicles.

- Attack Airplanes
- Fighter Airplanes
- Bombers
- Anti-Sub, Fixed Wing Airplanes
- Transport Airplanes
- Helicopters
- Boats

1.1 Purpose:

The purpose of this document is to provide hydraulic system information to military vehicle system and component designers in order to assist them in future aircraft fluid power system designs.

The information provided in this Information Report may be used to find similar type systems, components and materials which will in turn help solve specific problems and lower costs.

1.2 Field of Application:

- Design requirements: Procurement Specifications
- System pressure: Fluid power system operating pressure
- Hydraulic fluid: Type of fluid system is designed for
- No. of hydraulic systems: No. and ID of independent hydraulic systems
- System temperature: Minimum and maximum operating temperatures
- Main hydraulic pump: Flow, pressure, displacement
- Backup pump data: System auxiliary pump or backup pump data
- Hydraulic motor data: System hydraulic motor requirements
- Accumulator data: Usage, volume and precharge requirements
- Reservoir data: Type, volume and pressure
- Relief valve data: Usage, crack and reseal pressure, rated flow
- Filtration: Usage, filtration rating
- Tubing data: Materials, sizes, wall thickness
- Fitting data: Type, size range, material
- Schematic block diagram: System architecture, services supplied
- Power circuit schematic: Detail schematic of power system
- Heat exchangers: Cooling medium
- Hand pump data: System hand pump data
- Miscellaneous: Quiescent flow, seal material, etc.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS1290 Graphic Symbols for Aircraft Hydraulic and Pneumatic Systems

2.2 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-H-5440

(now AS5440) Hydraulic Systems, Aircraft, Design and Installation Requirements for

MIL-H-5606 Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance

MIL-PRF-83282 Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Metric, Nato Code Number H-537

MIL-PRF-87257 Hydraulic Fluid, Fire Resistant, Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile

3. ATTACK AIRPLANES:

3.1 Northrop Grumman A-6A:

3.1.1 Design Requirements: MIL-H-5440B

3.1.2 System Pressure: 3000 psi (20,690 kPa)

3.1.3 Hydraulic Fluid: MIL-H-5606/MIL-PRF-83282

3.1.4 Number of Hydraulic Systems: 2

3.1.5 System Temperature: -65 to 275 °F (-54 to 135 °C)

3.1.6 Main Hydraulic Pump Data:

Engine Driven Pump: 2

Type of Pump: Variable displacement, pressure compensated, inline piston

	Flight Sys	Combined Sys
Rated Flow	14.2 gpm	14.2 gpm
Pressure	2900 psi full flow	2900 psi full flow
Displacement	0.92 in ³ /rev	0.92 in ³ /rev
Rated Speed	3750 rpm	3750 rpm
Ground Idle	2380 rpm	2380 rpm
Approach	3168 rpm	3168 rpm
Long Range Cruise	3960 rpm	3960 rpm
Torque	490 in/lb	490 in/lb
Rotation from shaft end	CCW	CCW
Eng/Pump Speed Ratio	0.34	0.34
Case Flow	0.76 gpm	0.76 gpm

3.1.7 Backup Pump Data:

Type of Pump: Variable pressure fixed displacement

	Flight Sys	Combined Sys
Type	Elec Motor Dr-Backup	Elec Motor Dr-Aux
Pressure	3000 psi	3000 psi
Flow	3 gpm @ 1000 psi 0 gpm @ 3100 psi	0.6 gpm @ 2700 psi
Speed	5650 rpm	-----
Displacement	0.128 in ³ /rev	0.023 in ³ /rev
Volts	115/200 AC 400 cps	24 V DC Continuous
Amps	8.66 A	60 A Max
hp/kW	2.41 hp	-----

3.1.8 Hydraulic Motor Data:

System	Displacement in ³ /rev	Speed rpm	Pressure psi	Flow gpm	Torque in-lb
Flap	0.115	10,000	3000	5.03	45.5
Slat	0.115	10,000	3000	5.03	45.5

3.1.9 Accumulator Data:

1 in each Hydraulic System Power Circuit

Type: Piston, gas charged

Volume: 25 in³

Precharge Pressure: 2000 psi

1 in Emergency Power Package (RAT)

Type: Piston, gas charged

Volume: 50 in³

Precharge Pressure: 500 psi

1 in Emergency Brakes

Type: Piston, gas charged

Volume: 50 in³

Precharge Pressure: 800 psi

3.1.10 Reservoir Data:

	Flight System	Combined System	Back-up System
Type:	Air/Oil	Air/Oil	Spring/Oil
Full Volume	170 in ³	688 in ³	24 in ³
Total Volume	255 in ³	1040 in ³	48 in ³
System Volume	1290 in ³	3000 in ³	
Return Press	40 psi	40 psi	40 psi

3.1.11 Relief Valve Data:

Main System Relief Valve: 2 per Aircraft		
	Flight System	Combined System
Relief Pressure	3560 psi max	3560 psi max
Min Reseat Pressure	3100 psi min	3100 psi min
Rated Flow	Unknown	Unknown

3.1.12 Filtration:

Pressure Filtration Location	Flight System	Combined System	Back-up System
Pressure	5 μ abs	5 μ abs	5 μ abs
Return	5 μ abs	5 μ abs	
Case Drain	5 μ abs	5 μ abs	
Flight Actuators	15 μ abs	15 μ abs	
Other	Chemical Dryer	Chemical Dryer	

3.1.13 Tubing Data:

High Pressure Material Specification:	18-8 6061-T6
Low Pressure Material Specification:	6061-T6 5052-0

3.1.14 Fitting Data:

Separable Type: MS Flared (37°)
Material: 304 CRES

Permanent Type None

3.1.15 Hand Pump Data:

Pressure 3000 psi
Displacement 1.8 in³/cycle 750 psi
0.45 in³/cycle 3000 psi

3.1.16 Miscellaneous:

System Quiescent Flow: Comb 1.02 gpm, Flt Norm 1.02 gpm,
Stab Aux 2.54 gpm

Seal Material: Flight Actuators
Piston - Spring Loaded Teflon
MS28775 Buna-N O-Rings
MS28778 Buna-N O-Rings

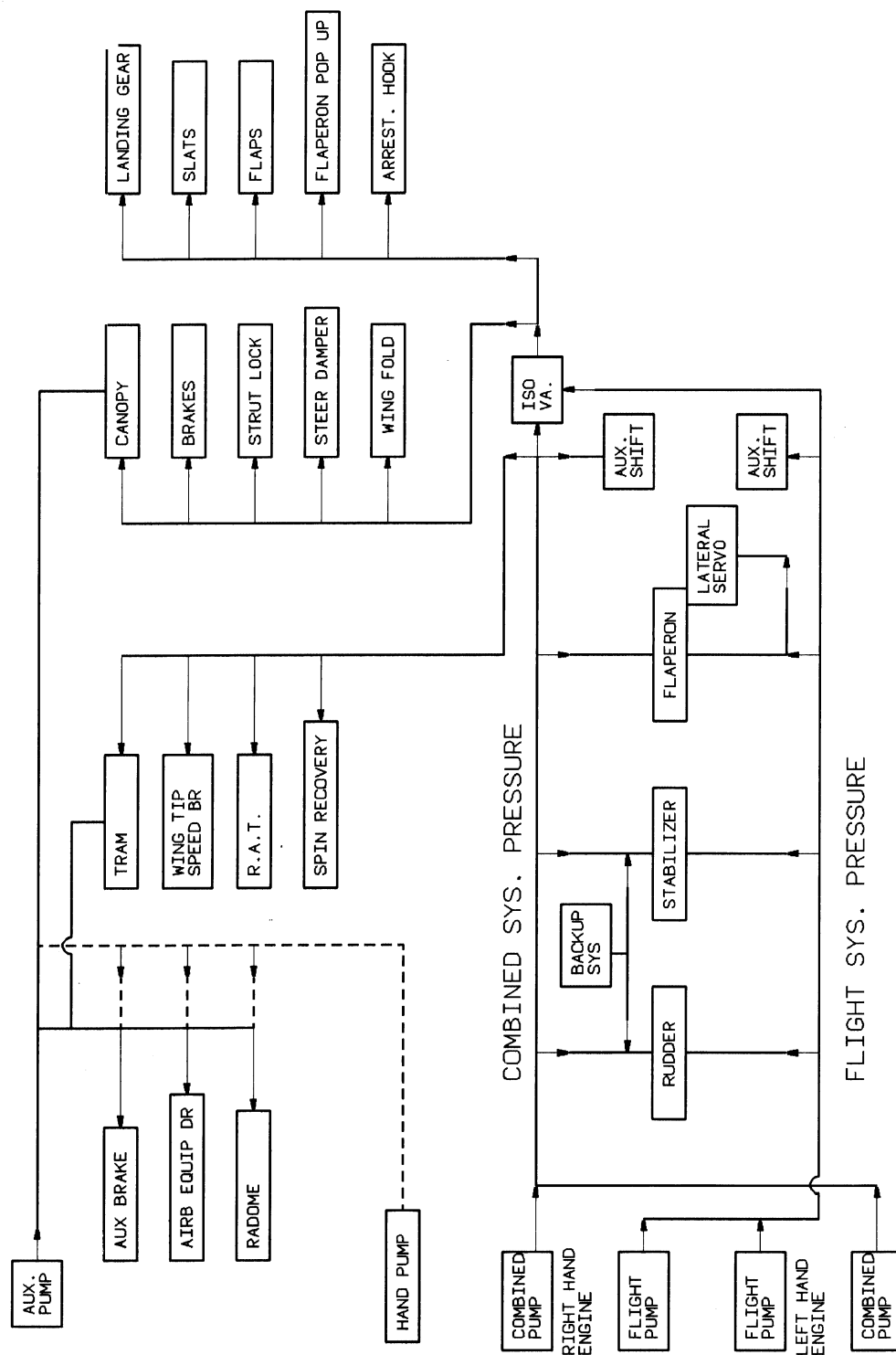


FIGURE 1 - A-6A Aircraft Hydraulic System

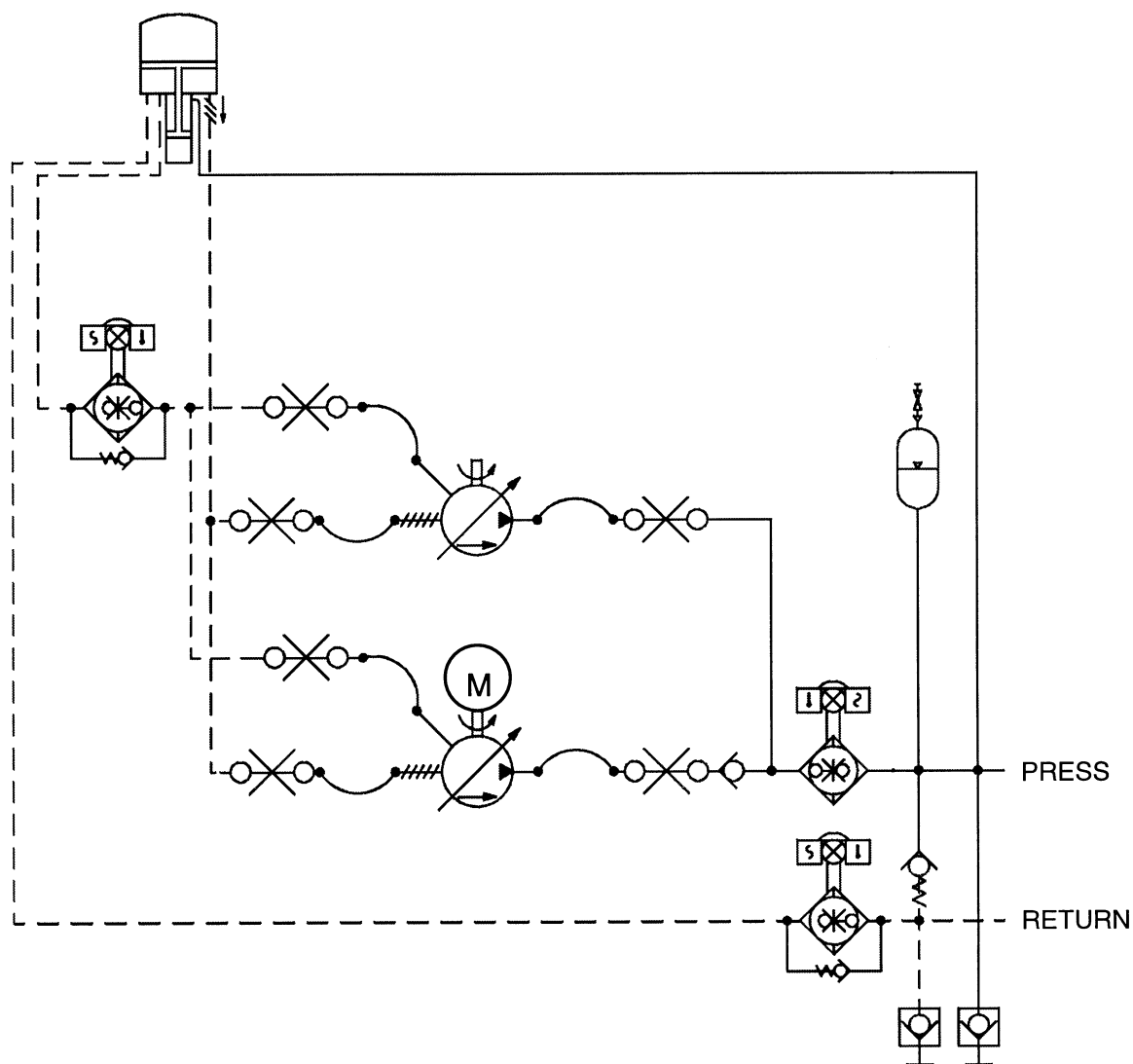


FIGURE 2 - A-6A Power System

3.2 Northrop Grumman A-7E:

3.2.1 Design Requirements: MIL-H-5440D

3.2.2 System Pressure: 3000 psig (20,690 kPa)

3.2.3 Hydraulic Fluid: MIL-H-5606/MIL-PRF-83282

3.2.4 Number of Hydraulic Systems: 3

3.2.5 System Temperature: -65 to 275 °F (-54 to 135 °C)

3.2.6 Main Hydraulic Pump Data:

Engine Driven Pump: 3

Type of Pump: Variable displacement, pressure compensated, inline piston

	System 1	System 2	System 3
Rated Flow	24.1 gpm	42.3 gpm	15.6 gpm
Displacement	1.15 in ³ /rev	1.80 in ³ /rev	0.90 in ³ /rev
Rated Speed	5890 rpm	5890 rpm	4400 rpm
Rotation from shaft end	CCW	CCW	CW
Eng/Pump Speed Ratio	0.454	0.454	0.339
Case Flow	-----	1.9 gpm	1.5 gpm

3.2.7 Backup Pump Data:

RAT Driven Pump: 1

Type of Pump: Variable disp with variable press relief valve, 3000 psig

Displacement	0.113 in ³ /rev
Rated Speed	12,650 rpm
Rotation from shaft end	CW
Case Flow	Internally Drained

3.2.8 Hydraulic Motor Data: None

3.2.9 Accumulator Data:

1 in each Hyd Sys Power Circuit

Type: Piston, gas charged

Volume: 26.2 in³Precharge Press: 1500 +/-50 psi
at 60°F

1 in Emergency Landing Gear

Type: Piston, gas charged

Volume: 142.5 in³Precharge Press: 1350 +/-50 psi
at 60°F

1 in Emer Power Package (RAT)

Type: Piston, gas charged

Volume: 73.3 in³Precharge Press: 1250 +/-50 psi
at 60°F

1 in Emergency Brakes

Type: Piston, gas charged

Volume: 73.3 in³Precharge Press: 1300 +/-50 psi
at 60°F

1 in Emergency Flaps

Type: Piston, gas charged

Volume: 155.5 in³

Precharge Press: 1200 +/-50 psi at 60°F

3.2.10 Reservoir Data:

	System 1	System 2	System 3
Type:	Bootstrap	Bootstrap	Bootstrap
Full Volume	144 in ³	917 in ³	144 ³
Total Volume	265 in ³	1280 in ³	265 in ³
System Volume	540 in ³	1592 in ³	515 in ³
Return Press	90 psi	97.5 psi	90 psi

3.2.11 Relief Valve Data:

Main System Relief Valve: 3 per Aircraft

	System 1	System 2	System 3
Relief Pressure, Max	3850 psi	3850 psi	3850 psi
Rated Flow	32 gpm	45 gpm	32 gpm

3.2.12 Filtration:

Pressure Filtration Location	System 1	System 2	System 3
Pressure	5 μ abs	5 μ abs	5 μ abs
Return	None	None	None
Case Drain	5 μ abs	5 μ abs	5 μ abs
Other	Components 45 μ abs, Rsvr Rel Valve 65 μ abs		

3.2.13 Tubing Data:

High Pressure Material Specification:	304 per CVA 1-404 321 per CVA 1-409 (Brazed Tubing)
Low Pressure Material Specification:	6061T6 per MILT-7081 321 per CVA-1-409 (Brazed Tubing)

3.2.14 Fitting Data:

Separable Type:	MS Flareless
Material:	AL, CRES
End Connections:	External Swage, Gold Braze
Permanent Type End Connections	Gold Braze

3.2.15 Hand Pump Data:

0.7 in³/cycle at 3000 psig

3.2.16 Miscellaneous:

System Quiescent Flow: PC-1, 1.2 gpm; PC-2, 2.0 gpm; PC-3, 1.1 gpm

Seal Material

Piston - Cast Iron, O-Ring with Teflon Cap
Buna N O-Ring, T-Ring

Flight Actuators - MS28775 with Teflon Cap,
M83248 Viton, Fluorosilicone (Low Pressure),
M83461 O-Rings
CVC4233 O- Rings (Static)

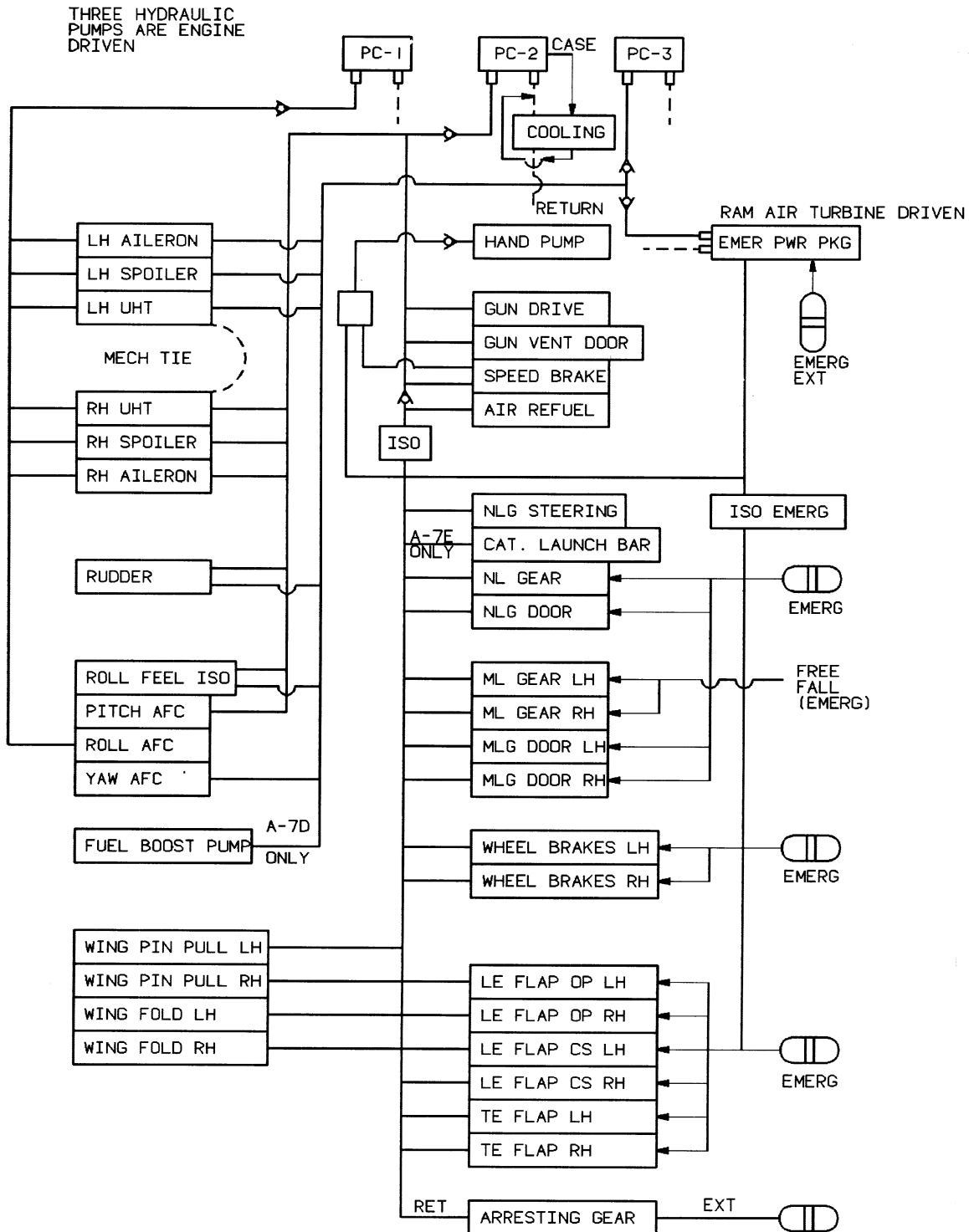
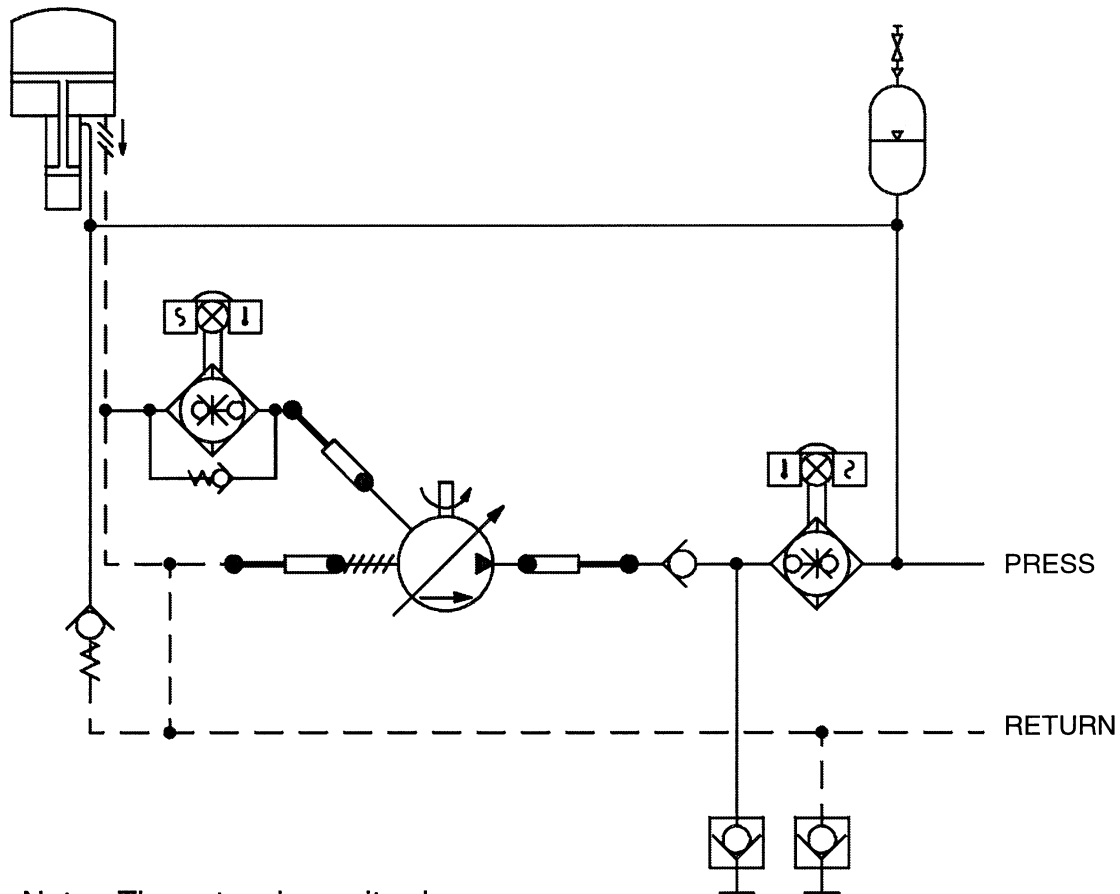


FIGURE 3 - A-7E Aircraft Hydraulic System



Note: The extension units shown were replaced by hoses during the model production run.

FIGURE 4 - A-7E Power System

3.3 Fairchild A-10A:

3.3.1 Design Requirements: MIL-H-5440F

3.3.2 System Pressure: 3000 psi (20,690 kPa)

3.3.3 Hydraulic Fluid: MIL-PRF-83282

3.3.4 Number of Hydraulic Systems: 2

3.3.5 System Temperature: -65 to 275 °F (-54 to 135 °C) Fluid, -65 to 160 °F Amb

3.3.6 Main Hydraulic Pump Data:

Engine Driven Pump: 2

Type of Pump: Variable displacement, pressure compensated, inline piston

	Left Sys	Right Sys
Rated Flow	43 gpm	43 gpm
Pressure	3100 psig $\pm$ 75 psig	3100 psig $\pm$ 75 psig
Displacement	1.9 in ³ /rev	1.9 in ³ /rev
Rated Speed		
Ground Idle	3717 rpm	3717 rpm
Cruise	5113 rpm	5113 rpm
Take-off	5709 rpm	5709 rpm
Rotation from shaft end	CCW	CCW
Eng/Pump Speed Ratio	Unknown	Unknown

3.3.7 Backup Pump Data:

APU Driven Pump:

Type of Pump: Variable displacement

	Flight Sys
Type	APU Dr-Backup
Pressure	3025 psi $\pm$ 75 psi
Flow	10 gpm
Speed	8000 rpm $\pm$ 300 rpm
Displacement	0.3 in ³ /rev

3.3.8 Hydraulic Motor Data:

System	Displacement in ³ /rev	Speed rpm	Pressure psi	Flow gpm	Torque in-lb
Gun Dr	0.97	6200	2578	26	300

3.3.9 Accumulator Data:

1 at each Boot-strap Reservoir

Type: Piston, gas charged

Volume: 10 in³

Precharge Pressure: 1600 psi

1 in Emergency Landing Gear System

Type: Piston, gas charged

Volume: 50 in³

Precharge Pressure: 1200 psi

1 in Emergency Brakes

Type: Piston, gas charged

Volume: 50 in³

Precharge Pressure: 1200 psi

3.3.10 Reservoir Data:

	Left System	Right System
Type:	Bootstrap	Bootstrap
Full Volume	550 +25 in ³ -0 in ³	550 + 25 in ³ -0 in ³
Total Volume	Unknown	Unknown
System Volume	4068 in ³	4068 in ³
Return Press	70 psi	70 psi

3.3.11 Relief Valve Data:

Main System Relief Valve: 2 per Aircraft		
	Left System	Right System
Relief Pressure	3850 psi max	3850 psi max
Min Reseat Pressure	Unknown	Unknown
Rated Flow	45 gpm	45 gpm

3.3.12 Filtration:

Pressure Filtration Location	Left System	Right System	APU System
Pressure	5 μ abs	5 μ abs	-----
Return	5 μ abs	5 μ abs	-----
Case Drain	-----	-----	5 μ abs

3.3.13 Tubing Data:

High Pressure Material Specification:	21-6-9 AMS 5561
Low Pressure Material Specification:	6061-T6 MIL-T-7081

3.3.14 Fitting Data:

Separable Type:	MS Flareless
Material:	CRES & AL
Permanent Type	Permaswage

3.3.15 Hand Pump Data:

None

3.3.16 Miscellaneous:

System Quiescent Flow: Left 0.74 Gpm, Right 2.75 Gpm

Seal Material:

Flight Actuators
Shamban S11065
S11589, S13077
MS28775, MS28774

Components

Pump - MS28775
“T” Seal
M83248/1/2

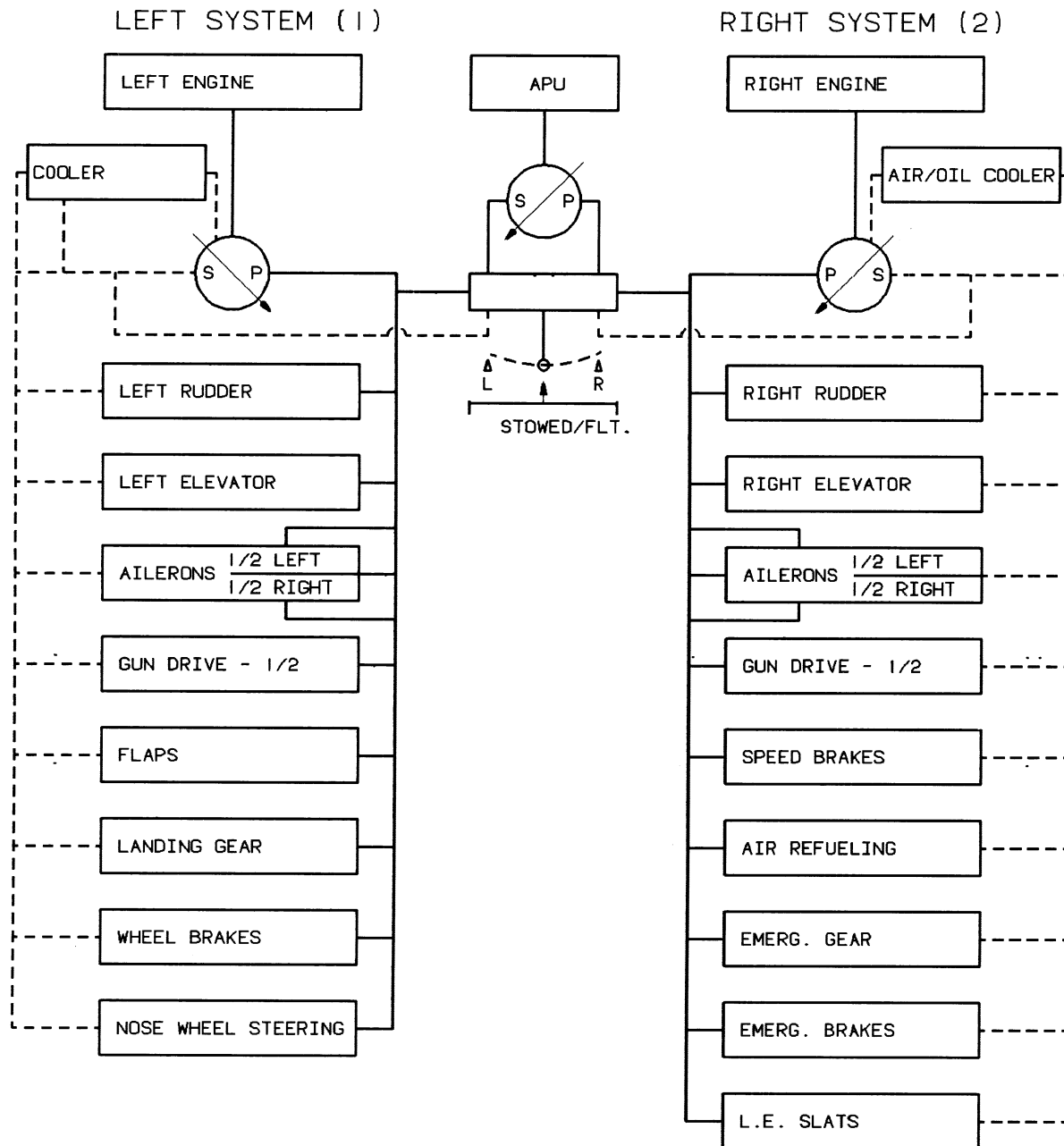


FIGURE 5 - A-10A Aircraft Hydraulic System

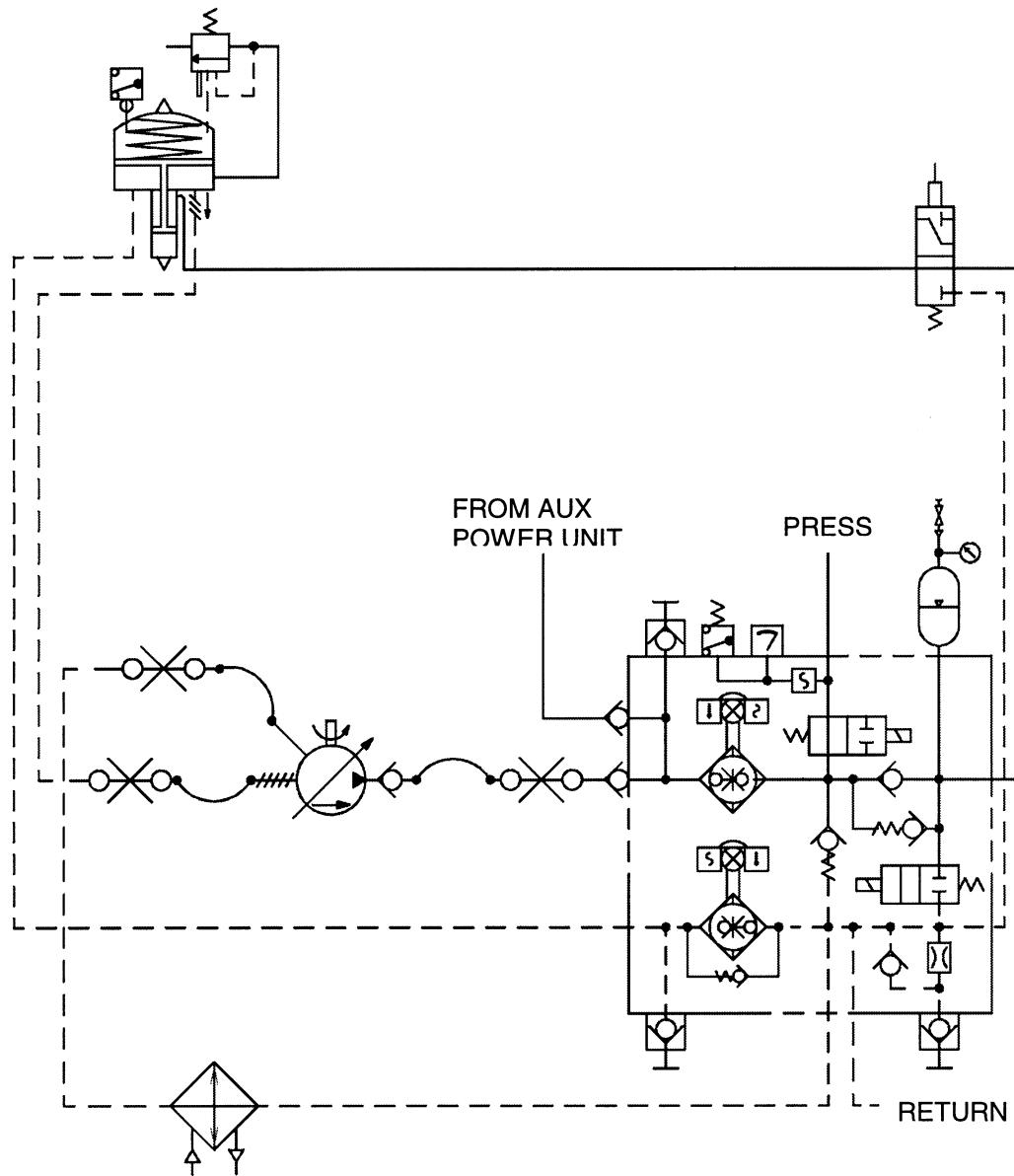


FIGURE 6 - A-10A Power System

3.4 Lockheed F-117A:

3.4.1 Design Requirements: MIL-H-5440G

3.4.2 System Pressure: 3000 psi (20,690 kPa)

3.4.3 Hydraulic Fluid: MIL-PRF-83282

3.4.4 Number of Hydraulic Systems: 2, Utility and Flight

3.4.5 System Temperature: -65 to 275 °F (-54 to 135 °C) Fluid

3.4.6 Main Hydraulic Pump Data:

Engine Driven Pump: 2

Type of Pump: Variable displacement, pressure compensated, axial piston

	Utility System	Flight System
Rated Flow	56 gpm	56 gpm
Pressure	3000 psig	3000 psig
Displacement	3.0 in ³ /rev	3.0 in ³ /rev
Rotation from shaft end	CCW	CCW
Eng/Pump Speed Ratio	.2708	.2708

3.4.7 Backup Pump Data:

EPU/APU Driven Pump

Type of Pump: Variable displacement, pressure compensated, axial piston

Pressure	3000 psig
Flow	6 gpm
Speed	6600 rpm
Displacement	0.22 in ³ /rev

3.4.8 Hydraulic Motor Data:

None

3.4.9 Accumulator Data:

2 in Brake System

Type: Piston, gas charged

Volume: 75 in³

Precharge Press: 1250 psi at 70 °F

1 in Flight Control System

Type: Double Ended Piston, gas charged

Volume: 105 in³

Precharge Press: 1000 psi at 70 °F

1 in Flight Control System

Type: Piston, gas charged

Volume: 50 in³

Precharge Press: 1500 psi at 80 °F

3.4.10 Reservoir Data:

	Utility System	Flight System
Type:	Bootstrap	Bootstrap
Full Volume	829 in ³	234 in ³
Total Volume	1420 in ³	380 in ³
System Volume	24 gal	8 gal
Return Press	50 psi	50 psi

3.4.11 Relief Valve Data:

	Utility System	Flight System
Relief Pressure	3600 psi max	3600 psi max
Reseat Pressure	3250 psi max	3250 psi max
Rated Flow	55 gpm @ 3800 psi max	35 gpm @ 3600 psi max
Relief Pressure	Brake 4100 psi ± 10% psi	Return 90 psi ± 5 psi
Reseat Pressure	3500 psi ± 200 psi	65 psi min
Rated Flow	2 gpm @ < 5125 psi	35 gpm @ 155 psi

3.4.12 Filtration:

Location	Utility System	Flight System
Pressure	5 μ abs	5 μ abs Non-bypassing
Return/Case drain	5 μ abs	5 μ abs Bypassing

3.4.13 Tubing Data:

High Pressure
3AL-2.5V Ti per AMS 4944
21-6-9 CRES per AMS 5561

Low Pressure
3AL-2.5V TI per AMS 4944
6061-T6 Aluminum per WW-T-700/6

3.4.14 Fitting Data:

Separable Type:	MS Flareless
Material:	Ti,CRES & AL
End Connections:	External Swage (Permaswage or Rynglok)
Permanent Type:	
End Connections	External Swage (Permaswage or Rynglok)

3.4.15 Hand Pump Data:

None

3.4.16 Miscellaneous:

None

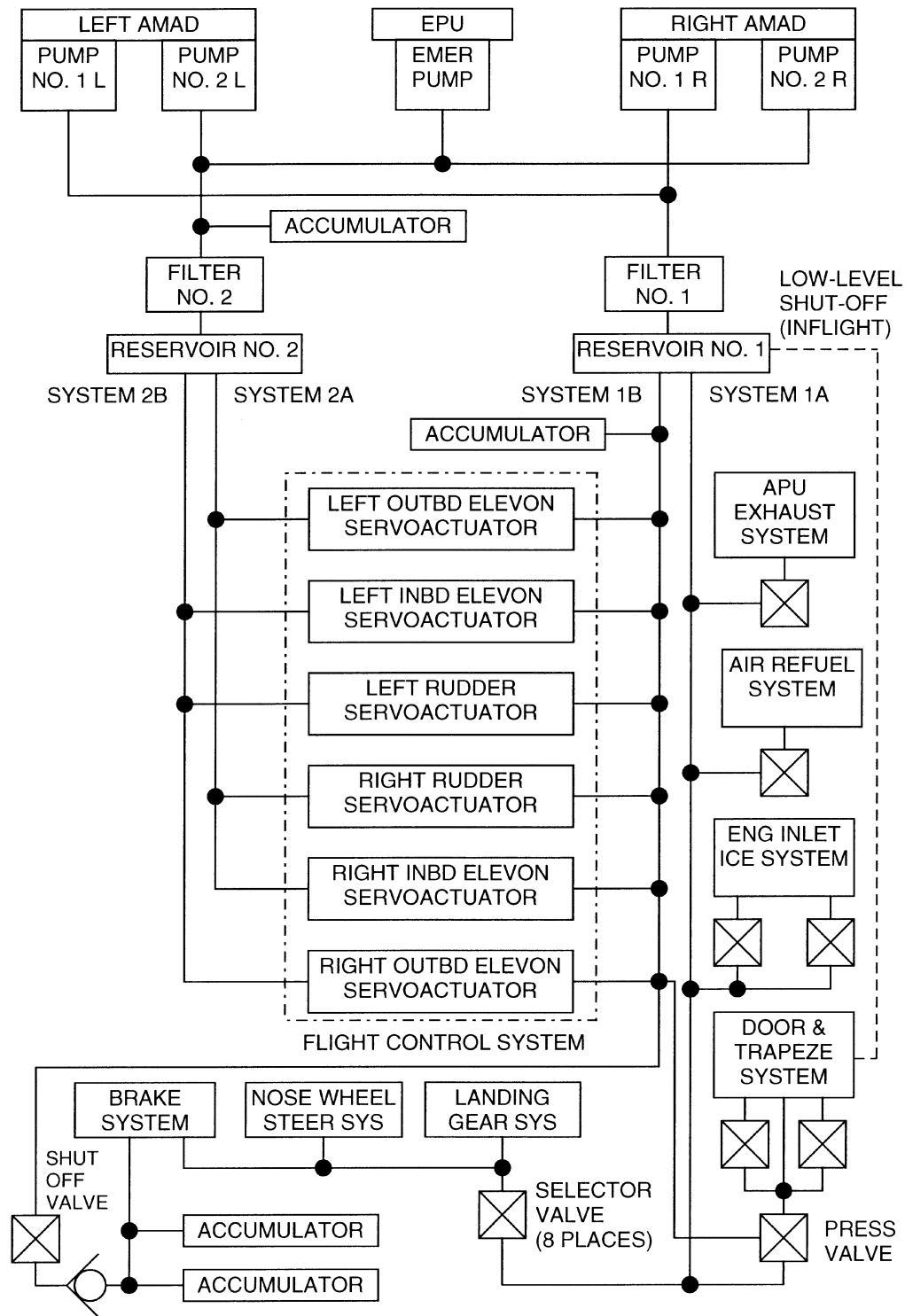


FIGURE 7 - F-117A Aircraft Hydraulic System

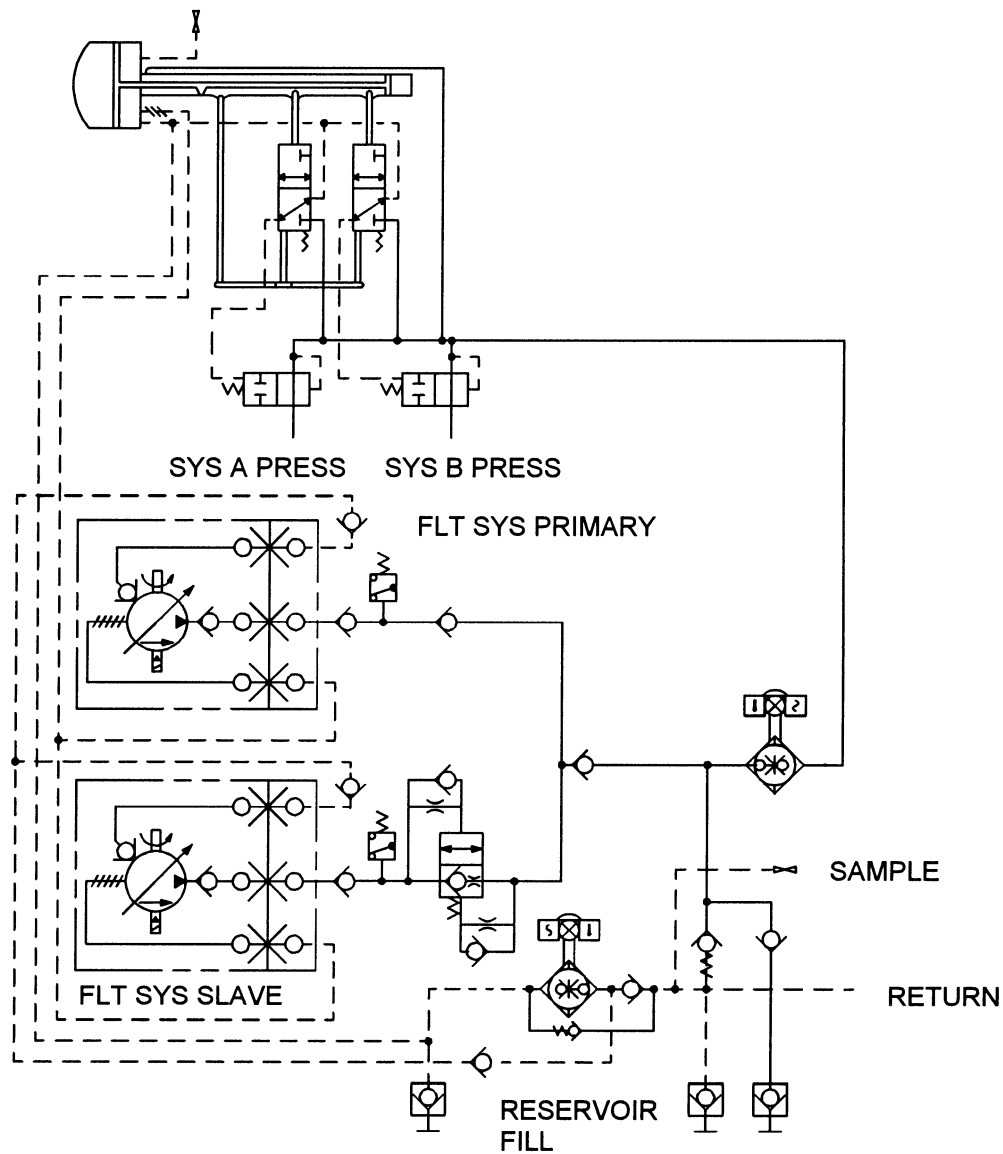


FIGURE 8 - F-117A Power System

4. FIGHTER AIRPLANES:

4.1 Northrop Grumman F-5E:

4.1.1 Design Requirements: MIL-H-5440B, also D & F

4.1.2 System Pressure: 3000 psi (20,690 kPa)

4.1.3 Hydraulic Fluid: MIL-H-5606/MIL-PRF-83282

4.1.4 Number of Hydraulic Systems: 2

4.1.5 System Temperature: -65 to 275 °F (-54 to 135 °C) Fluid, -65 to 160 °F Ambient

4.1.6 Main Hydraulic Pump Data:

Engine Driven Pump: 2

Type of Pump: Variable displacement, pressure compensated, check valve

	Utility Sys	Flight Sys
Rated Flow	8.9 gpm	8.9 gpm
Pressure	3000 psig	3000 psig
Displacement	0.6 in ³ /rev	0.6 in ³ /rev
Rated Speed	3750 rpm	3750 rpm
Ground Idle	2731 rpm	2731 rpm
Climb	3752 rpm	3752 rpm
Rotation from shaft end	CCW	CCW
Eng/Pump Speed Ratio	Low 0.463 High 0.693	Low 0.463 High 0.693

4.1.7 Backup Pump Data:

None

4.1.8 Hydraulic Motor Data:

None

4.1.9 Accumulator Data:

None

4.1.10 Reservoir Data:

	Utility System	Flight System
Type:	Air/Oil	Air/Oil
Full Volume	428 in ³	428 in ³
Refill Volume	368 in ³	368 in ³
Total Volume	477 in ³	477 in ³
System Volume	1100 in ³	525 in ³
Return Press	18 psi	18 psi

4.1.11 Relief Valve Data:

Main System Relief Valve:	2 per Aircraft	
	Utility System	Flight System
Relief Press Full Flow	3750 psi max	3750 psi
Cracking Press	3500 psi	3500 psi
Min Reseat Pressure	Unknown	Unknown
Rated Flow	Unknown	Unknown

4.1.12 Filtration:

Location	Utility System	Flight System
Press	10 μ abs	10 μ abs
Return	10 μ abs	10 μ abs

4.1.13 Tubing Data:

High Pressure
Material Specification: CRES 304 - 1/8 H

Low Pressure
Material Specification: CRES 304 - 1/8 H
5052-O

4.1.14 Fitting Data:

Separable Type: MS Flareless
Material: CRES & AL

Permanent Type Permaswage

4.1.15 Hand Pump Data:

None

4.1.16 Miscellaneous:

System Quiescent Flow: Utility 1.0 gpm, Flight 1.0 gpm

Seal Material: Flight Actuators
Filled Teflon U Cups for 1st stage seal
MS28775 O-Rings and Teflon MS Backups

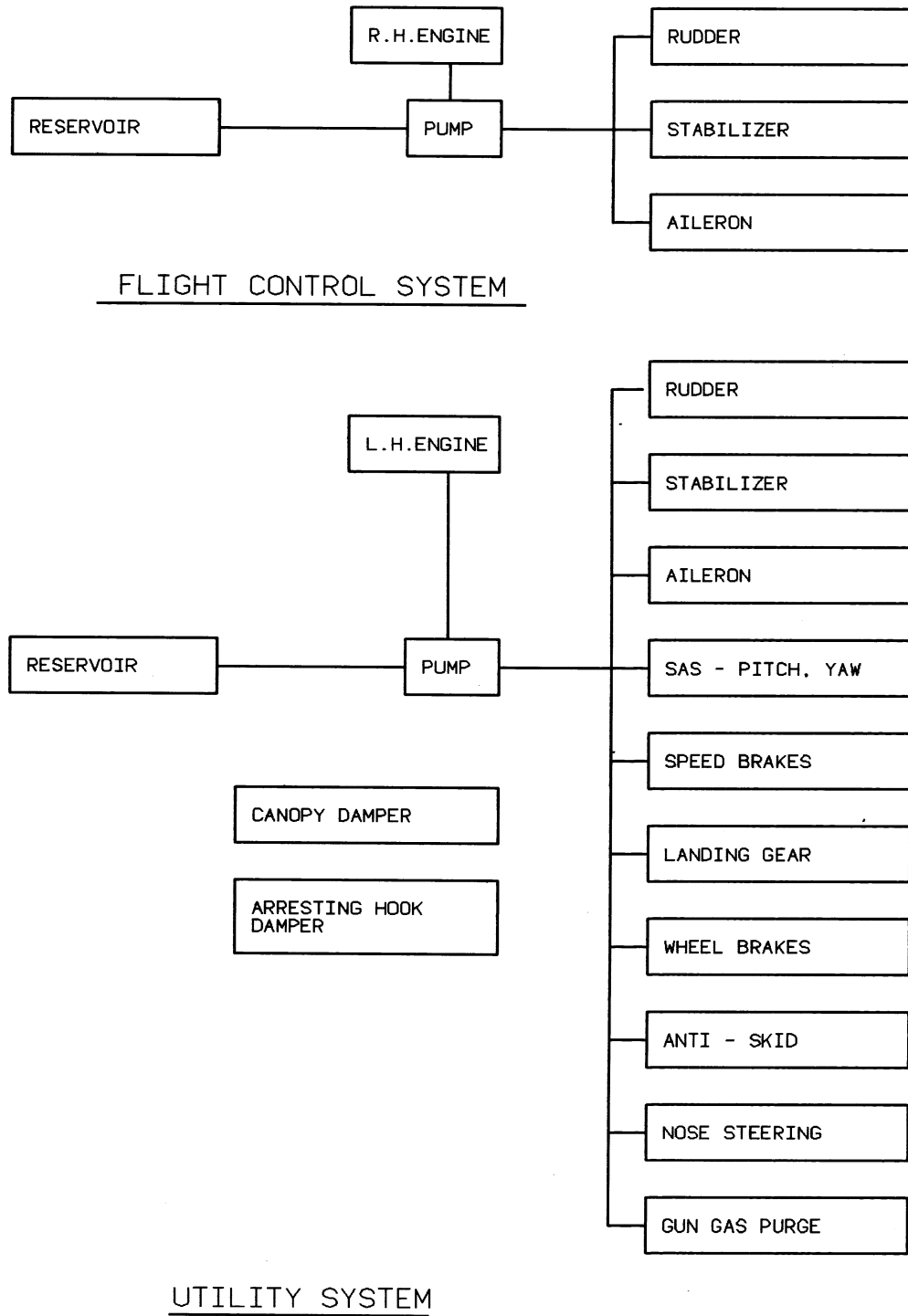


FIGURE 9 - F-5E Aircraft Hydraulic System

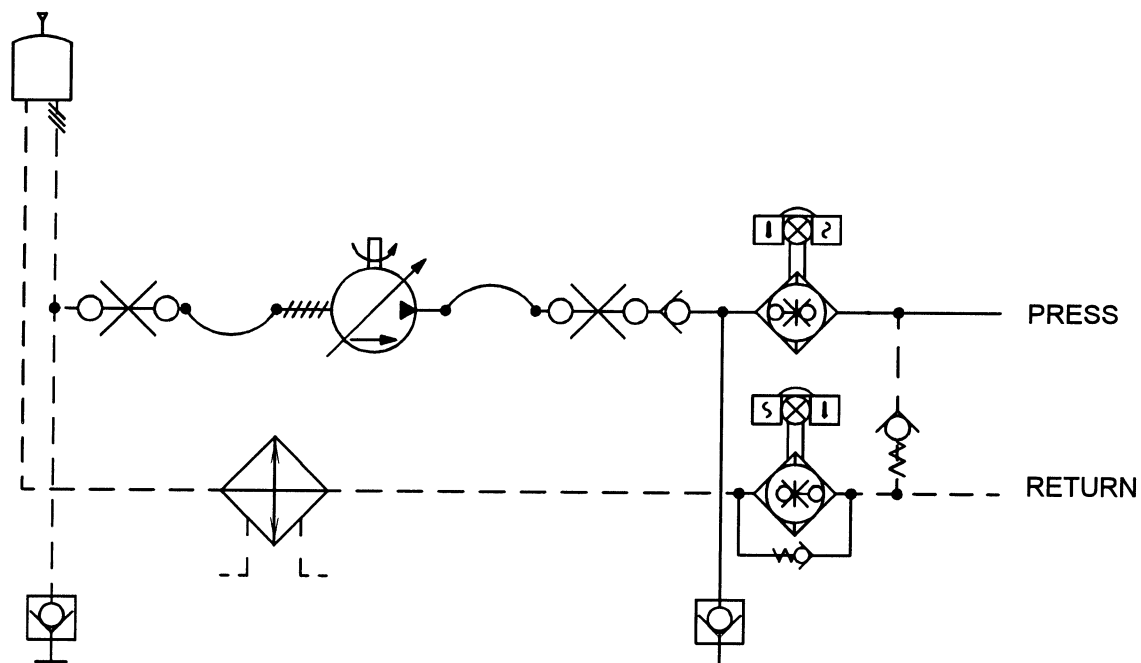


FIGURE 10 - F-5E Power System

4.2 Northrop Grumman F-14A:

4.2.1 Design Requirements: MIL-H-5440D

4.2.2 System Pressure: 3000 psi (20,690 kPa)

4.2.3 Hydraulic Fluid: MIL-H-5606/MIL-PRF-83282

4.2.4 Number of Hydraulic Systems: 2

4.2.5 System Temperature: -65 to 275 °F (-54 to 135 °C) Fluid

4.2.6 Main Hydraulic Pump Data:

Engine Driven Pump: 2

Type of Pump: Variable displacement, pressure compensated, inline piston

	Combined Sys	Flight Sys
Rated Flow	84 gpm	84 gpm
Pressure	3000 psig	3000 psig
Displacement	3.7 in ³ /rev	3.7 in ³ /rev
Rated Speed	5540 rpm	5540 rpm
Ground Idle	3867 rpm	3867 rpm
Cruise M=.7	4868 rpm	4868 rpm
Flight M=.2	3892 rpm	3892 rpm
Rotation from shaft end	CCW	CCW
Eng/Pump Speed Ratio	0.388	0.388

4.2.7 Backup Pump Data:

Type of Pump:	Flight ControlL	Spoiler Mod and Hi Lift
Pressure	AC Motor Driven	AC Motor Driven
Flow	3000 psi	3000 psi
	14.5 gpm - 500 psi (HI)	6.5 rpm - 2050 psi
	2.4 gpm - 3000 psi (HI)	
	0.5 gpm - 3000 psi	
	7.2 gpm - 500 psi (LOW)	
	1.2 gpm - 3000 psi (LOW)	
Speed	12,000 rpm (HI)	11,300 rpm
	6000 rpm (LOW)	
Displacement	0.32 in ³ /rev	0.133 in ³ /rev
Type of pump	Transfer Pump	
Pump Output	Hyd Pump/Motor, Fixed Displacement	
Rated	0-30 gpm @ 2050 psi - 2400 psi	
Motor Input	30 gpm @ 2050 psi	
Rated	0-33 gpm @ 2400 psi - 3000 psi	
Rated Flow	32.8 gpm @ 2850 psi	
Displacement	5750 rpm	
	1.27 in ³ /rev	

4.2.8 Hydraulic Motor Data:

System	Displacement in ³ /rev	Speed rpm	Pressure psi	Flow gpm
EM GEN.	0.173	12,000	3000	9.0
WNG SWP	1.15	7510	3000	40.0
HI-LIFT	0.22	9400	3000	8.95

4.2.9 Accumulator Data:

1 at Combined Sys Reservoir
Type: Piston, gas charged
Volume: 50 in³
Precharge Pressure: 1800 psi

1 at Flight Sys Reservoir
Type: Piston, gas charged
Volume: 75 in³
Precharge Pressure: 1800 psi

1 in Wheel Brake System
Type: Piston, gas charged
Volume: 50 in³
Precharge Pressure: 1900 psi

1 in Unknown Application
Type: Piston, gas charged
Volume: 200 in³
Precharge Pressure: 1200 psi

4.2.10 Reservoir Data:

	Combined System	Flight System
Type:	Bootstrap	Bootstrap
Full Volume	1340 in ³	724 in ³
Total Volume	1687 in ³	787 in ³
System Volume	Unknown	Unknown
Return Press	105 psi	105 psi

4.2.11 Relief Valve Data:

Main System Relief Valve: 2 per Aircraft		
	Combined Sys	Flight Sys
Relief Press Full Flow	3750 psi max	3750 psi
Min Reseat Pressure	3250 psi	3250 psi
Rated Flow	Unknown	Unknown

4.2.12 Filtration:

Location	Combined Sys	Flight Sys	Other
Pressure	5 μ abs	5 μ abs	-----
Return	5 μ abs	5 μ abs	-----
Case Drain	5 μ abs	5 μ abs	
Transfer Pump	-----	-----	5 μ abs

4.2.13 Tubing Data:

High Pressure Material Specification:	TI 3AL-2V
Low Pressure Material Specification:	TI 3AL-2V

4.2.14 Fitting Data:

Separable Type:	Lip Seal
Material:	17-4PH & TI 6AL-4V
Permanent Type	Cryofit

4.2.15 Hand Pump Data:

0.7 in³ Reservoir Capacity 0.063 gal

4.2.16 Miscellaneous:

System Quiescent Flow: Combined 3-6 gpm, Flight 2-3 gpm

Seal Material: Flight Actuators
 Piston - Spring Loaded Teflon
 MS28775 Buna-N O-Rings
 MS28778 Buna-N O-Rings

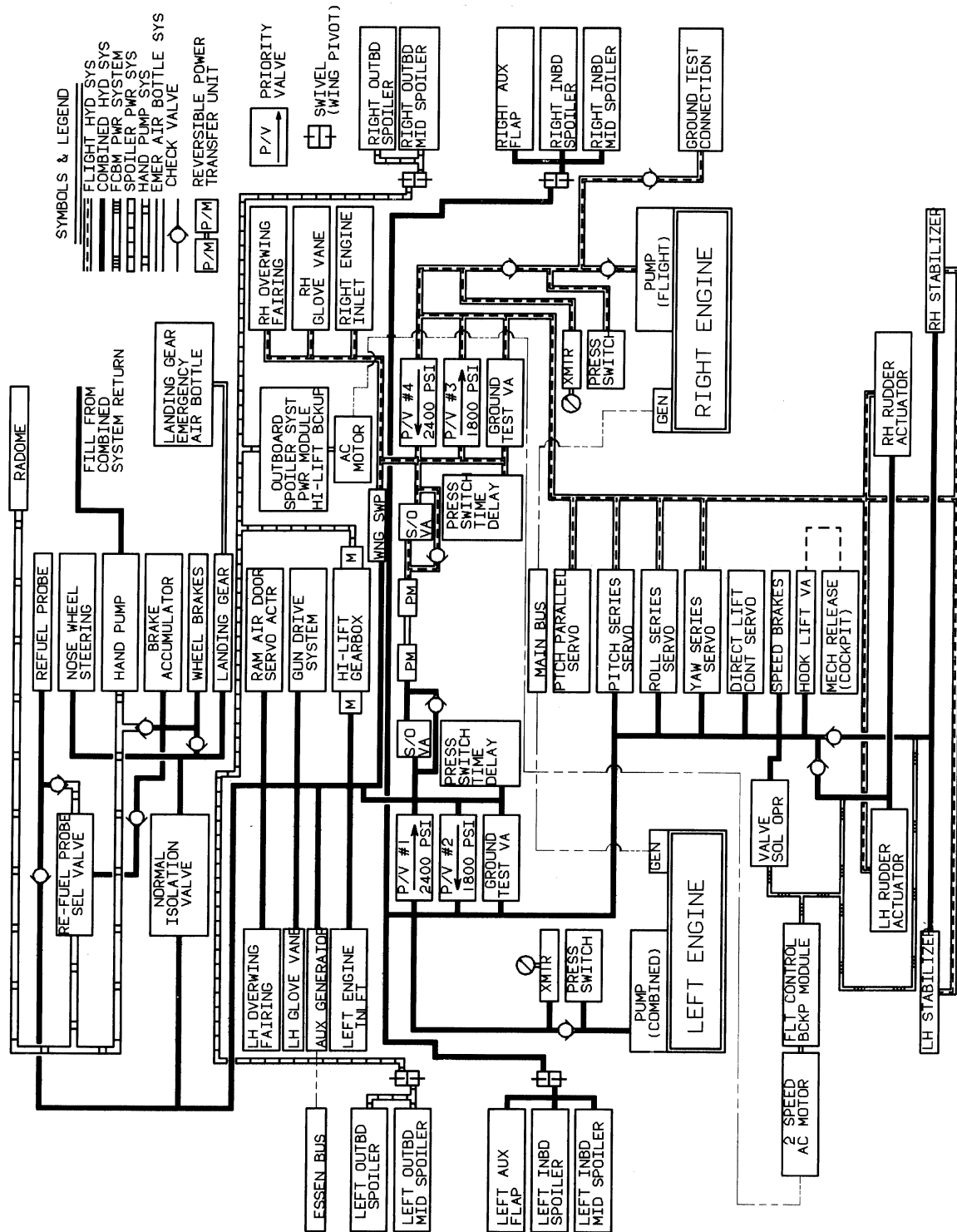


FIGURE 11 - F-14A Aircraft Hydraulic System

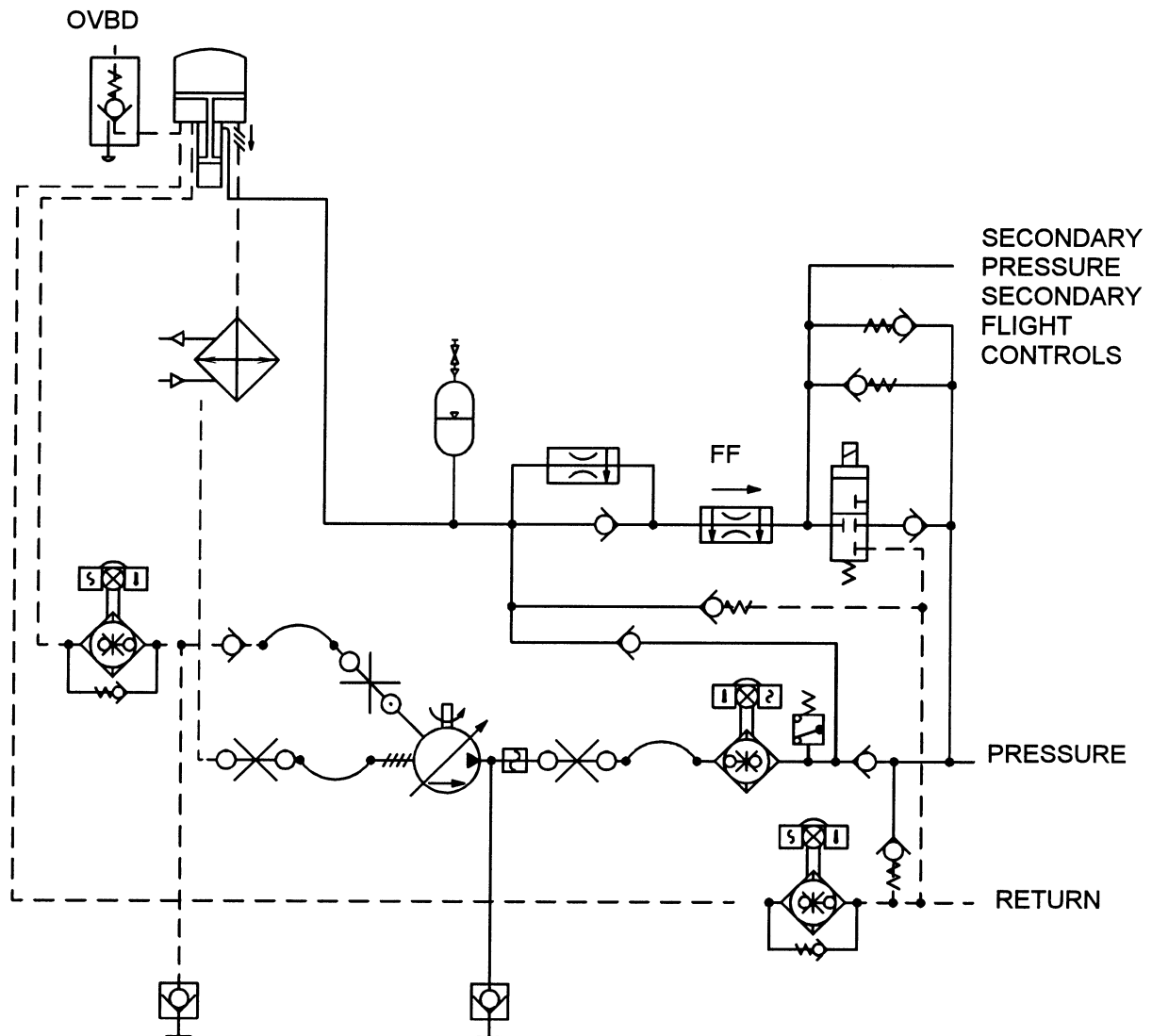


FIGURE 12 - F-14A Power System

4.3 Boeing F-15A:

4.3.1 Design Requirements: MIL-H-5440E

4.3.2 System Pressure: 3000 psi (20,690 kPa)

4.3.3 Hydraulic Fluid: MIL-H-5606/MIL-PRF-83282

4.3.4 Number of Hydraulic Systems: 3

4.3.5 System Temperature: -65 to 275 °F (-54 to 135 °C) Fluid

4.3.6 Main Hydraulic Pump Data:

Engine Driven Pump: 4

Type of Pump: Variable displacement, pressure compensated, inline piston

	PC Sys	Utility Sys
Rated Flow	56 gpm	56 gpm
Pressure	3000 psig	3000 psig
Displacement	3.0 in ³ /rev	3.0 in ³ /rev
Rated Speed	4600 rpm	4600 rpm
Ground Idle	2570 rpm	2890 rpm
Cruise	3360 rpm	3710 rpm
Take-off	3780 rpm	4340 rpm
Approach	2970 rpm	3110 rpm
Rotation from shaft end	CCW	CCW
Eng/Pump Speed Ratio	0.262	0.292

4.3.7 Backup Pump Data:

None

4.3.8 Hydraulic Motor Data:

System	Displacement in ³ /rev	Speed rpm	Pressure psi	Flow gpm	Torque in-lb
Gun Dr.	0.97	6200	2578	26	300
Emer Gen	0.52	12,000	3000	27	244

4.3.9 Accumulator Data:

2 at Jet Fuel Starter (JFS) 1 in Canopy System

Type: Piston, gas charged,
Self Displacing

Volume: 215 in³ Gas, 145 in³ Oil

Precharge Pressure: 1860 psi

Type: Piston, gas charged

Volume: 48 in³ Gas, 45 in³ Oil

Precharge Pressure: 925 psi

4.3.10 Reservoir Data:

	PC Systems	Utility System
Type:	Bootstrap	Bootstrap
Full Volume	237 in ³	590 in ³
Total Volume	355 in ³	950 in ³
System Volume	1065 in ³	3350 in ³
Return Press	48 psi	56 psi

4.3.11 Relief Valve Data:

Main System Relief Valve: 3 per Aircraft
PC Systems

Utility Systems

Relief Press Full Flow 3500 psig max
Min Reseat Pressure 3250 psid
Cracking Pressure 3450 psig
Rated Flow 45 gpm

3500 psig
3250 psid
3450 psig
104 gpm