FM 1-509

FUNDAMENTALS OF AIRCRAFT PNEUDRAULICS

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TABLE OF CONTENTS

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PREFACE

This manual--

- Provides guidance for repairing pneumatic and hydraulic systems.
- Covers basic hydraulic principles.
- Describes hydraulic systems used in United States Army aircraft.
- Discusses aircraft in general, not specific types of aircraft.

Military personnel holding MOS 68H (aircraft pneudraulics repairer) will use this manual as a guide in repairing pneumatic/hydraulic systems. For instructions in repairing hydraulic systems on a particular aircraft, refer to the technical manual written for that aircraft. More information about hydraulics can be found in TM 9-243, TM 55-1500-204-25/1, TB 55-1500-334-25, TB 750-103, and NAVPERS 10310-B.

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Unless otherwise stated, whenever the masculine gender is used, both men and women are included.

CHAPTER 1

HYDRAULIC SYSTEMS

FUNCTIONS

Hydraulic systems perform a variety of functions in Army aircraft. They are used in fixed-wing aircraft to change the propeller pitch and operate the landing gear, wing flaps, wheel brakes, and shock struts. Also, they are used in helicopters to start engines and operate brakes, shock struts, dampers, flight control systems, loading ramps, folding pylons, winch hoists, and hydraulic clutches.

ADVANTAGES

A hydraulic system has many advantages:

- It is almost 100 percent efficient. The slight loss of efficiency (a fraction of 1 percent) is due to internal friction in the system machinery.
- Moving parts of a hydraulic system are lightweight and can quickly be put into motion or brought to rest. The valves in a hydraulic system quickly start or stop the flow of fluid under pressure; very little effort is needed to operate them. For these reasons, the system Is easy for the operator to control.
- Hydraulic lines can be routed almost anywhere. Unlike mechanical systems which must follow straight pathways, the lines of a hydraulic system can easily be bent around obstructions. Also, major parts of hydraulic systems can be located in a wide variety of places.
- Since components of a hydraulic system are smaller than those of other systems, the space requirement is small.
- Most of the parts of a hydraulic system operate in a bath of oil, making the system practically self-lubricating.

USE OF LIQUIDS AND AIR

<u>Liquids.</u>

Characteristics. The aircraft hydraulic system transmits engine power to distant points in the aircraft. The force is carried by a liquid (oil) confined in-a system of tubes. To understand this system, certain characteristics of liquid must be understood; the primary one is fluidity. Fluids--substances that flow--can be liquids or gases, but the two differ in degree of fluidity. Liquids cannot expand indefinitely to fill containers as gases do. Liquids have three physical qualities:

- Incompressibility. For practical purposes, liquids are incompressible. Even under extremely high pressure, a liquid cannot be made smaller. The brake system in a car takes advantage of this physical law. When you push the pedal, the brakes are applied instantly because no time is lost in compressing the liquid. Consider how much longer the brake stroke would be if the master cylinder contained air.
- Expansion and contraction. Liquids expand (become larger) and contract (become smaller) with changes in temperature. When a liquid in a closed container is heated, it expands and puts pressure on the walls of the container. As the liquid cools, the pressure decreases.
- Pressure transmission. Pressure applied to a confined liquid is transmitted equally. Again, a car's brake system shows how this principle works. When a force (a foot on the brake pedal) is applied to a liquid in a closed container (the car's master cylinder), the resulting pressure is sent out equally in all directions; that is, the same amount of pressure is exerted on each wheel of the car.

Types. Hydraulic fluids are classified generally as petroleum base, synthetic base, and vegetable base. Vegetable-base fluid is no longer authorized in Army aircraft. For most operations, the Army is converting from petroleum-base fluid MIL-H-5606 to MIL-H-83282, which has a synthetic hydrocarbon base. There are several reasons for this change. MIL-H-83282 contains additives that provide better antiwear characteristics and help stop oxidation and corrosion. It also has an operational high-temperature limit of 400°F as compared to 275°F for MIL-H-5606. Flash point, fire point, and spontaneous ignition temperatures of MIL-H-83282 exceed those of MIL-H-5606 by more than 200°F. Also, tests show that MIL-H-83282 stops burning when the outside source of flame or heat is removed. MIL-H-83282 is compatible with all materials used in systems presently employing hydraulic fluid MIL-H-5606. It may be combined with the latter fluid with no bad effects except that it may reduce the fire-resistant properties of MIL-H-5606. However, amounts of MIL-H-5606 exceeding 3 percent by volume will compromise the fire-resistant performance of MIL-H-83282. Although MIL-H-83282 exceeds the performance of MIL-H-5606 at normal temperatures, the viscosity of MIL-H-83282 increases at low temperatures. For this reason, MIL-H-5606 is still used for cold weather operations.

Petroleum-base fluid MIL-H-6083 is also authorized in Army aircraft. This fluid is supplied in only one grade. It should be used as a preservative oil in shock struts, hydraulic equipment, and spare parts, and as a testing and flushing oil for some hydraulic components. MIL-H-6083 should not be used in composite aircraft hydraulic systems.

NOTE: Use only the fluid authorized for a particular component or system. To determine the correct fluid, consult the applicable technical manual. Also, read the instruction plate affixed to the individual unit or reservoir, and check the color of the fluid contained in the system.

> CAUTION
>
> EVEN THOUGH VEGETABLE-BASE FLUID IS NOT AUTHORIZED IN ARMY AIRCRAFT, IT MIGHT BY CHANCE GET INTO THE MAINTENANCE SHOP. NEVER USE THIS FLUID WHEN WORKING WITH HYDRAULIC SYSTEMS. IT DETERIORATES THE SYNTHETIC RUBBER SEALS USED IN SYSTEMS DESIGNED FOR PETROLEUM- OR SYNTHETIC-BASE FLUIDS. VEGETABLE-BASE FLUID IS READILY DISTINGUISHED BY ITS BLUISH COLOR.

Resistance. Resistance to liquid flow is a factor that must be dealt with in hydraulic systems. Resistance results partly from the viscosity (or thickness) of the liquid itself. The greater the viscosity, the greater the resistance. Resistance also occurs as liquids flow through tubing. This movement creates a shearing action between the wall of the tube and the liquid. This action results in a turbulent flow (a nonsmooth whirling flow) along the walls. Turbulence working against the smooth flow of a liquid causes resistance, which causes the temperature to rise; this, in turn, causes a loss of energy.

When engineers design an aircraft hydraulic system, they have to consider energy loss. Accordingly, they design the tubing and other units to reduce the resistance as much as possible. Power pumps (like the power-steering pump in a car) are made large enough to take care of the aircraft's operational needs, plus the energy loss. No resistance occurs when the liquid is not moving in the system. When it starts to move, resistance begins and increases as the speed of flow increases. For this reason, an orifice plate or restriction is sometimes installed in a line to limit the rate of flow. For example, when a landing gear is being extended, it tends to drop with great force. A restrictor installed in the hydraulic return line (the up line, in this case) decreases the speed of fluid flow. This decrease reduces the speed when the landing gear comes down and prevents possible structural damage.

Computing Force, Area, and Pressure. Hydraulic systems are designed to take advantage of liquid characteristics as they relate to force, area, and pressure. These terms, as used in hydraulics, are defined as follows:

- Force is the amount of push or pull applied to an object. For example, the force applied to a piston head is the energy applied to the total area of the piston head. In this manual, force is measured in pounds.

- Area is the measurement of a surface. In the aircraft hydraulic system, the areas of piston heads are a main concern. If these areas are known, the amount of force needed can be computed to start a mechanism moving. In this manual, area is measured in square inches.

- Pressure is the force applied to one unit of area--usually 1 square inch. For example, the pressure on a piston head develops the force that operates a mechanism. In this manual, pressure is measured in pounds per square inch (psi).

If any two of the above factors are known, the third can be computed by using the equation in Figure 1-1. To apply this equation, multiply the two lower factors together to get the top factor; then divide the top factor by the known lower factor to get the unknown lower factor. If the area in square inches and the pressure in psi are known, simply multiply the area (A) times the pressure (P) to obtain the force (F) in pounds. Similarly, if the force in pounds and the area in square inches are known, divide F by A to obtain P in psi. Finally, to obtain the area in square inches, divide F in pounds by P in psi. For example, a pressure of 50 pounds psi acts on a piston whose surface area is 5 square inches. What force is acting on the piston? Using the equation in Figure 1-1, multiply P (50 psi) times A (5 square inches) to obtain F. The answer is that a 250-pound force acts on the surface of the piston.

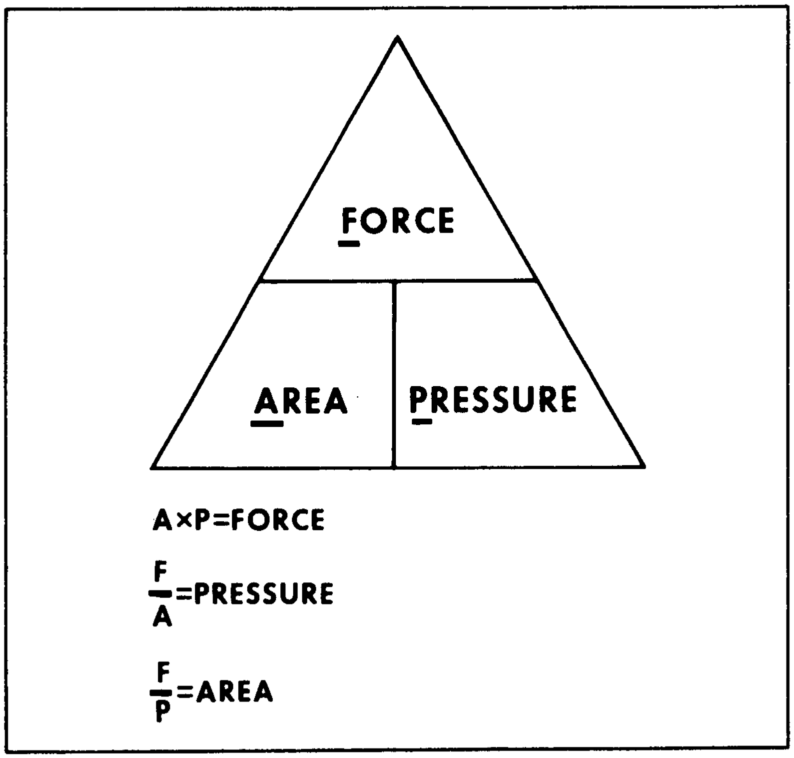

Figure 1-1. Force, area, and pressure formula.

Computing Volume, Area, and Length of Stroke. The same type of triangular equation can be used to compute volume, area, and length of stroke. These terms, as used in hydraulics, are defined as follows:

- Volume is a measurement of quantity expressed in cubic inches. For example, the volume is the amount of liquid in a cylinder or the amount of liquid displaced by a pump or actuating cylinder.