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Hydraulics

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Preface

This field manual (FM) serves as a guide for personnel who operate and maintain military equipment using hydraulic-powered control systems. It includes general information covering basic hydraulics and describes the properties and characteristics of fluids and several types of pumps, motors, valves, and controls. This manual also deals with piping, tubing, and hoses used to convey fluid under pressure. It describes the functions and types of reservoirs, strainers, filters, and accumulators. It discusses the purposes and types of seals and packings used in fluid power systems.

The contents of this manual are applicable to both nuclear and nonnuclear warfare.

The Appendix contains an English to metric measurement conversion chart.

ACKNOWLEDGEMENTS

Acknowledgment is gratefully made to the organizations listed below for permitting the use of copyrighted material in preparing this manual.

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Moline, Illinois
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Vickers, Inc.
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Industrial Hydraulics Manual, Third Edition 1993.

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Unless otherwise stated, masculine nouns and pronouns do not refer exclusively to men.

CHAPTER 1

Hydraulic Basics

Hydraulics is the science of transmitting force and/or motion through the medium of a confined liquid. In a hydraulic device, power is transmitted by pushing on a confined liquid. Figure 1-1 shows a simple hydraulic device. The transfer of energy takes place because a quantity of liquid is subject to pressure. To operate liquid-powered systems, the operator should have a knowledge of the basic nature of liquids. This chapter covers the properties of liquids and how they act under different conditions.

1-1. Pressure and Force. Pressure is force exerted against a specific area (force per unit area) expressed in pounds per square inch (psi). Pressure can cause an expansion, or resistance to compression, of a fluid that is being squeezed. A fluid is any liquid or gas (vapor). Force is anything that tends to produce or modify (push or pull) motion and is expressed in pounds.

a. *Pressure.* An example of pressure is the air (gas) that fills an automobile tire. As a tire is inflated, more air is squeezed into it than it can hold. The air inside a tire resists the squeezing by pushing outward on the casing of the tire. The outward push of the air is pressure. Equal pressure throughout a confined area is a characteristic of any pressurized fluid. For example, in an inflated tire, the outward push of the air is uniform throughout. If it were not, a tire would be pushed into odd shapes because of its elasticity.

There is a major difference between a gas and a liquid. Liquids are slightly compressible (Figure 1-2, page 1-2). When a confined liquid is pushed on, pressure builds up. The pressure is still transmitted equally throughout the container. The fluid's behavior makes it possible to transmit a push through pipes, around corners, and up and down. A hydraulic system uses a liquid

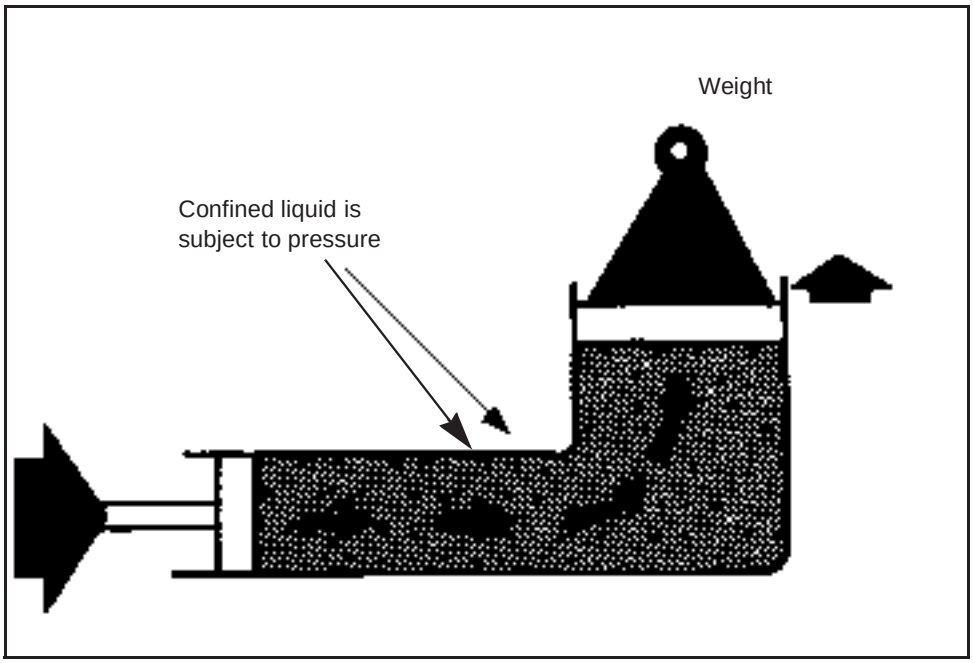

Figure 1-1. Basic hydraulic device

because its near incompressibility makes the action instantaneous as long as the system is full of liquid.

Pressure can be created by squeezing or pushing on a confined fluid only if there is a resistance to flow. The two ways to push on a fluid are by the action of a mechanical pump or by the weight of the fluid. An example of pressure due to a fluid's weight would be in an ocean's depths. The water's weight creates the pressure, which increases or decreases, depending on the depth.

By knowing the weight of a cubic foot of water, you can calculate the pressure at any depth. Figure 1-3 shows a column of water 1 foot square and 10 feet high, which equates to 10 cubic feet. (One cubic foot of water weighs 52.4 pounds.) The total weight of water in this column is 624 pounds. The weight at the bottom covers 1,445 square inches (1 square foot). Each square inch of the bottom is subject to 1/144 of the total weight, or 4.33 pounds. Thus, the pressure at this depth is 4.33 psi. You can also create an equal pressure of 4.33 psi in a liquid using the pump and figures shown in Figure 1-4, page 1-4.

Before pressure, head was the only way to express pressure measurement. It was expressed as feet of water. Today, head is still the vertical distance between two levels in a fluid. In Figure 1-3, the head between the top and bottom of the water is 10 feet, which is equivalent to 4.33 psi. Therefore, each foot of water is equal to 0.433 psi.

The earth has an atmosphere of air extending 50 miles up, and this air has weight. This air creates a head of pressure that is called atmospheric pressure. A column of air 1 square inch in cross section and the height of the atmosphere would weigh 14.7 pounds at sea level. Thus, the earth's atmospheric pressure is 14.7 psi at sea level. The role of atmospheric pressure in

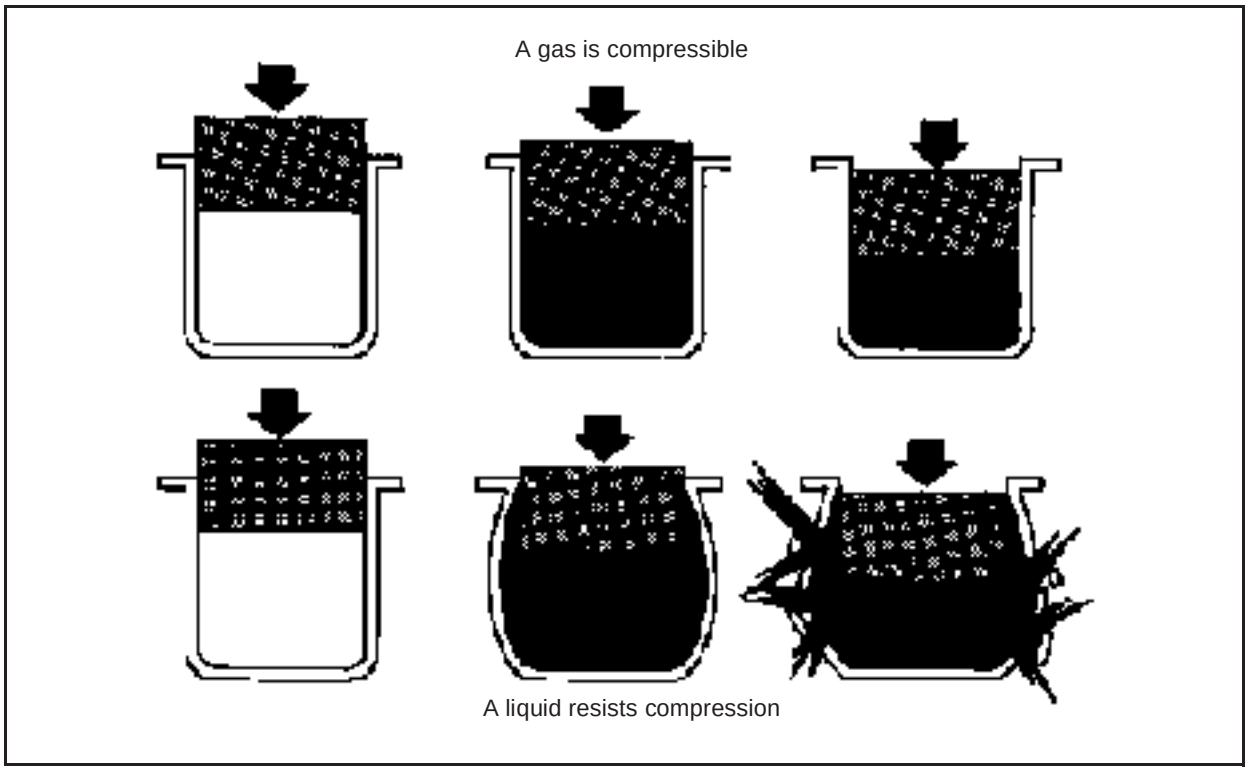

Figure 1-2. Compressibility