NONRESIDENT TRAINING COURSE

July 1990

Fluid Power

NAVEDTRA 14105

Although the words "he," "him," and "his" are used sparingly in this course to enhance communication, they are not intended to be gender driven or to affront or discriminate against anyone.

COMMANDING OFFICER
NETPDTC
6490 SAUFLEY FIELD RD
PENSACOLA, FL 32509-5237

ERRATA #3 19 Oct 99

Specific Instructions and Errata

FLUID POWER

1. This errata supersedes all previous erratas. No attempt has been made to issue corrections for errors in typing, punctuation, etc., that do not affect your ability to answer the question or questions.

2. To receive credit for deleted questions, show this errata to your local course administrator (ESO/scorer). The local course administrator is directed to correct the course and the answer key by indicating the question deleted.

3. Assignment Booklet

Delete the following questions, and leave the corresponding spaces blank on the answer sheets:

Questions	Questions
2-6	4-52
2-9	5-22
2-15	5-67
3-5	

Make the following changes:

Question	Change
1-19	In the questions, change the question to read "In the metric system, the density of a substance is expressed as..."
1-52	In the question, line 5, "60 cubic centimeters" is equivalent to 60 milliliters.
3-32	In the blurb before the question, line 2, delete "and 3-33."
4-15	In alternative 3, change "form" to ‘from."
4-18	In the question. line 2, change "instead" to "installed."
4-28	In alternative 2, change "el" to "element."
5-8	In the blurb preceding the question, line 1, change "1-8" to "5-8."
5-52/5-55	In the column under "COMPONENTS", in alternative 3, add "mover" after "prime."
5-67	In the blurb preceding the question, line 2, change "5-71" to " 5-70."

PREFACE

By enrolling in this self-study course, you have demonstrated a desire to improve yourself and the Navy. Remember, however, this self-study course is only one part of the total Navy training program. Practical experience, schools, selected reading, and your desire to succeed are also necessary to successfully round out a fully meaningful training program.

COURSE OVERVIEW: In completing this nonresident training course, you will demonstrate a knowledge of the subject matter by correctly answering questions on the following: fundamental physics as appropriate to fluids at rest and in motion; types and characteristics of hydraulic and pneumatic fluids; major components of basic fluid power systems and diagrams used to illustrate these systems; proper procedures and precautions for handling and replacing lines, connectors, and sealing devices; proper procedures for eliminating contaminants; purpose, operation, application of pumps, reservoirs, strainers, filters, accumulators, flow control and measuring devices, directional control valves, and actuators; arrangement and operation of representative fluid power systems including the function and interrelationship of major components.

THE COURSE: This self-study course is organized into subject matter areas, each containing learning objectives to help you determine what you should learn along with text and illustrations to help you understand the information. The subject matter reflects day-to-day requirements and experiences of personnel in the rating or skill area. It also reflects guidance provided by Enlisted Community Managers (ECMs) and other senior personnel, technical references, instructions, etc., and either the occupational or naval standards, which are listed in the *Manual of Navy Enlisted Manpower Personnel Classifications and Occupational Standards*, NAVPERS 18068.

THE QUESTIONS: The questions that appear in this course are designed to help you understand the material in the text.

VALUE: In completing this course, you will improve your military and professional knowledge. Importantly, it can also help you study for the Navy-wide advancement in rate examination. If you are studying and discover a reference in the text to another publication for further information, look it up.

1990 Edition Prepared by
MMC Albert Beasley, Jr.

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Sailor's Creed

"I am a United States Sailor.

I will support and defend the Constitution of the United States of America and I will obey the orders of those appointed over me.

I represent the fighting spirit of the Navy and those who have gone before me to defend freedom and democracy around the world.

I proudly serve my country's Navy combat team with honor, courage and commitment.

I am committed to excellence and the fair treatment of all."

CONTENTS

CREDITS

The companies listed below have provided permission to use certain tradenames/trademarks in this edition of *Fluid Power*. Permission to use these tradenames/trademarks is gratefully acknowledged. Permission to reproduce or use these tradenames/trademarks must be obtained from the source.

SOURCE	TEXT ON PAGE
DuPont	5-8
Greene, Tweed and Company	7-5
Minnesota Rubber	7-15

INSTRUCTIONS FOR TAKING THE COURSE

ASSIGNMENTS

The text pages that you are to study are listed at the beginning of each assignment. Study these pages carefully before attempting to answer the questions. Pay close attention to tables and illustrations and read the learning objectives. The learning objectives state what you should be able to do after studying the material. Answering the questions correctly helps you accomplish the objectives.

SELECTING YOUR ANSWERS

Read each question carefully, then select the BEST answer. You may refer freely to the text. The answers must be the result of your own work and decisions. You are prohibited from referring to or copying the answers of others and from giving answers to anyone else taking the course.

SUBMITTING YOUR ASSIGNMENTS

To have your assignments graded, you must be enrolled in the course with the Nonresident Training Course Administration Branch at the Naval Education and Training Professional Development and Technology Center (NETPDTC). Following enrollment, there are two ways of having your assignments graded: (1) use the Internet to submit your assignments as you complete them, or (2) send all the assignments at one time by mail to NETPDTC.

Grading on the Internet: Advantages to Internet grading are:

- you may submit your answers as soon as you complete an assignment, and
- you get your results faster; usually by the next working day (approximately 24 hours).

In addition to receiving grade results for each assignment, you will receive course completion confirmation once you have completed all the assignments. To submit your assignment answers via the Internet, go to:

http://courses.cnet.navy.mil

Grading by Mail: When you submit answer sheets by mail, send all of your assignments at one time. Do NOT submit individual answer sheets for grading. Mail all of your assignments in an envelope, which you either provide yourself or obtain from your nearest Educational Services Officer (ESO). Submit answer sheets to:

COMMANDING OFFICER
NETPDTC N331
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32559-5000

Answer Sheets: All courses include one "scannable" answer sheet for each assignment. These answer sheets are preprinted with your SSN, name, assignment number, and course number. Explanations for completing the answer sheets are on the answer sheet.

Do not use answer sheet reproductions: Use only the original answer sheets that we provide—reproductions will not work with our scanning equipment and cannot be processed.

Follow the instructions for marking your answers on the answer sheet. Be sure that blocks 1, 2, and 3 are filled in correctly. This information is necessary for your course to be properly processed and for you to receive credit for your work.

COMPLETION TIME

Courses must be completed within 12 months from the date of enrollment. This includes time required to resubmit failed assignments.

PASS/FAIL ASSIGNMENT PROCEDURES

If your overall course score is 3.2 or higher, you will pass the course and will not be required to resubmit assignments. Once your assignments have been graded you will receive course completion confirmation.

If you receive less than a 3.2 on any assignment and your overall course score is below 3.2, you will be given the opportunity to resubmit failed assignments. **You may resubmit failed assignments only once.** Internet students will receive notification when they have failed an assignment--they may then resubmit failed assignments on the web site. Internet students may view and print results for failed assignments from the web site. Students who submit by mail will receive a failing result letter and a new answer sheet for resubmission of each failed assignment.

COMPLETION CONFIRMATION

After successfully completing this course, you will receive a letter of completion.

ERRATA

Errata are used to correct minor errors or delete obsolete information in a course. Errata may also be used to provide instructions to the student. If a course has an errata, it will be included as the first page(s) after the front cover. Errata for all courses can be accessed and viewed/downloaded at:

http://www.advancement.cnet.navy.mil

STUDENT FEEDBACK QUESTIONS

We value your suggestions, questions, and criticisms on our courses. If you would like to communicate with us regarding this course, we encourage you, if possible, to use e-mail. If you write or fax, please use a copy of the Student Comment form that follows this page.

For subject matter questions:

E-mail: n314.products@cnet.navy.mil
Phone: Comm: (850) 452-1001, Ext. 1826
DSN: 922-1001, Ext.1826
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC N314
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32509-5237

For enrollment, shipping, grading, or completion letter questions

E-mail: fleetservices@cnet.navy.mil
Phone: Toll Free: 877-264-8583
Comm: (850) 452-1511/1181/1859
DSN: 922-1511/1181/1859
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
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6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32559-5000

NAVAL RESERVE RETIREMENT CREDIT

If you are a member of the Naval Reserve, you may earn retirement points for successfully completing this course, if authorized under current directives governing retirement of Naval Reserve personnel. For Naval Reserve retirement, this course is evaluated at 8 points. (Refer to *Administrative Procedures for Naval Reservists on Inactive Duty*, BUPERSINST 1001.39, for more information about retirement points.)

Student Comments

Course Title: *Fluid Power*

NAVEDTRA: 14105 **Date**: _____

We need some information about you:

Rate/Rank and Name: _____ SSN: _____ Command/Unit _____

Street Address: _____ City: _____ State/FPO: _____ Zip _____

Your comments, suggestions, etc.:

Privacy Act Statement: Under authority of Title 5, USC 301, information regarding your military status is requested in processing your comments and in preparing a reply. This information will not be divulged without written authorization to anyone other than those within DOD for official use in determining performance.

NETPDTC 1550/41 (Rev 4-00

CHAPTER 1

INTRODUCTION TO FLUID POWER

Fluid power is a term which was created to include the generation, control, and application of smooth, effective power of pumped or compressed fluids (either liquids or gases) when this power is used to provide force and motion to mechanisms. This force and motion maybe in the form of pushing, pulling, rotating, regulating, or driving. Fluid power includes hydraulics, which involves liquids, and pneumatics, which involves gases. Liquids and gases are similar in many respects. The differences are pointed out in the appropriate areas of this manual.

This manual presents many of the fundamental concepts in the fields of hydraulics and pneumatics. It is intended as a basic reference for all personnel of the Navy whose duties and responsibilities require them to have a knowledge of the fundamentals of fluid power. Consequently, emphasis is placed primarily on the theory of operation of typical fluid power systems and components that have applications in naval equipment. Many applications of fluid power are presented in this manual to illustrate the functions and operation of different systems and components. However, these are only representative of the many applications of fluid power in naval equipment. Individual training manuals for each rate provide information concerning the application of fluid power to specific equipment for which the rating is responsible.

A brief summary of the contents of this training manual is given in the following paragraphs:

Chapter 2 covers the characteristics of liquids and the factors affecting them. It also explains the behavior of liquids at rest, identifies the characteristics of liquids in motion, and explains the operation of basic hydraulic components.

Chapter 3 discusses the qualities of fluids acceptable for hydraulic systems and the types of fluids used. Included are sections on safety precautions to follow when handling potentially hazardous fluids, liquid contamination, and control of contaminants.

Chapter 4 covers the hydraulic pump, the component in the hydraulic system which generates the force required for the system to perform its design function. The information provided covers classifications, types, operation, and construction of pumps.

Chapter 5 deals with the piping, tubing and flexible hoses, and connectors used to carry fluids under pressure.

Chapter 6 discusses the classification, types, and operation of valves used in the control of flow, pressure, and direction of fluids.

Chapter 7 covers the types and purposes of sealing devices used in fluid power systems, including the different materials used in their construction. Additionally, the guidelines for selecting, installing, and removing O-rings are included.

Chapter 8 discusses the operation of devices used to measure and regulate the pressure of fluids and to measure the temperature of fluids.

Chapter 9 describes the functions and types of reservoirs, strainers, filters, and accumulators, and their uses in fluid power systems.

Chapter 10 discusses the types and operation of actuators used to transform the energy generated by hydraulic systems into mechanical force and motion.

Chapter 11 deals with pneumatics. It discusses the origin of pneumatics, the characteristics and compressibility of gases, and the most commonly used gases in pneumatic systems. Also, sections are included to cover safety precautions and the potential hazards of compressed gases.

Chapter 12 identifies the types of diagrams encountered in fluid power systems. This chapter also discusses how components of chapters 4, 5, 6, 8, 9, and 10 are combined to form and operate together as a system.

A glossary of terms commonly used in fluid power is provided in appendix I. Appendix II provides symbols used in aeronautical mechanical

systems, and appendix III provides symbols used in nonaeronautical mechanical systems.

The remainder of chapter 1 is devoted to the advantages and problems of fluid power applications. Included are brief sections on the history, development, and applications of hydraulics, and the states of matter.

ADVANTAGES OF FLUID POWER

The extensive use of hydraulics and pneumatics to transmit power is due to the fact that properly constructed fluid power systems possess a number of favorable characteristics. They eliminate the need for complicated systems of gears, cams, and levers. Motion can be transmitted without the slack inherent in the use of solid machine parts. The fluids used are not subject to breakage as are mechanical parts, and the mechanisms are not subjected to great wear.

The different parts of a fluid power system can be conveniently located at widely separated points, since the forces generated are rapidly transmitted over considerable distances with small loss. These forces can be conveyed up and down or around corners with small loss in efficiency and without complicated mechanisms. Very large forces can be controlled by much smaller ones and can be transmitted through comparatively small lines and orifices.

If the system is well adapted to the work it is required to perform, and if it is not misused, it can provide smooth, flexible, uniform action without vibration, and is unaffected by variation of load. In case of an overload, an automatic release of pressure can be guaranteed, so that the system is protected against breakdown or strain. Fluid power systems can provide widely variable motions in both rotary and straight-line transmission of power. The need for control by hand can be minimized. In addition, fluid power systems are economical to operate.

The question may arise as to why hydraulics is used in some applications and pneumatics in others. Many factors are considered by the user and/or the manufacturer when determining which type of system to use in a specific application. There are no hard and fast rules to follow; however, past experience has provided some sound ideas that are usually considered when such decisions are made. If the application requires speed, a medium amount of pressure, and only fairly accurate control, a pneumatic system may be used. If the application requires only a medium amount of pressure and a more accurate control, a combination of hydraulics and pneumatics may be used. If the application requires a great amount of pressure and/or extremely accurate control, a hydraulic system should be used.

SPECIAL PROBLEMS

The extreme flexibility of fluid power elements presents a number of problems. Since fluids have no shape of their own, they must be positively confined throughout the entire system. Special consideration must be given to the structural integrity of the parts of a fluid power system. Strong pipes and containers must be provided. Leaks must be prevented. This is a serious problem with the high pressure obtained in many fluid power installations.

The operation of the system involves constant movement of the fluid within the lines and components. This movement causes friction within the fluid itself and against the containing surfaces which, if excessive, can lead to serious losses in efficiency. Foreign matter must not be allowed to accumulate in the system, where it will clog small passages or score closely fitted parts. Chemical action may cause corrosion. Anyone working with fluid power systems must know how a fluid power system and its components operate, both in terms of the general principles common to all physical mechanisms and of the peculiarities of the particular arrangement at hand.

HYDRAULICS

The word *hydraulics* is based on the Greek word for water, and originally covered the study of the physical behavior of water at rest and in motion. Use has broadened its meaning to include the behavior of all liquids, although it is primarily concerned with the motion of liquids.

Hydraulics includes the manner in which liquids act in tanks and pipes, deals with their properties, and explores ways to take advantage of these properties.

DEVELOPMENT OF HYDRAULICS

Although the modern development of hydraulics is comparatively recent, the ancients were familiar with many hydraulic principles and their applications. The Egyptians and the ancient people of Persia, India, and China conveyed water