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Manpower and training needs in fluid power for Iowa industries

Harold T. Hoghaug
Iowa State University

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by

Harold T. Hoghaug

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INTRODUCTION

Historical Overview

Fluid power technology began approximately three hundred years ago with the discovery of Pascal's Law related to transmission of pressure. One hundred years later, Bernoulli developed his law of conservation of energy in a flowing fluid. By the late 1860's, cities like London and Manchester had industrial hydraulic distribution systems which distributed relatively high pressure water to the factories for powering the machines. With the advent of electricity in the late 1800's, fluid power was neglected.

As industries and technology grew in the early 1900's, fluid power was again considered by engineers for use in certain instances because of its advantages over other systems. The advantages include (9, p. 11): (1) ease of control, (2) multiplication of force, (3) accuracy of control, (4) compactness, (5) simplicity, (6) safety, (7) economy, (8) constant force, and (9) not influenced by the geometry of the machine. As Koenig and Gayde stated (13, p. 44):

> The fluid power industry is witnessing unprecedented growth throughout the United States and world primarily as the result of two factors: The advantages of fluid power systems over conventional electrical and mechanical systems for the transmission of energy and improved equipment design functions.

Two other developments that helped bring fluid power back into the forefront of engineering were (13) an oil fluid power system used for elevating and controlling guns on the U.S.S. Virginia and the "Direct Hydraulic System", a self contained pump, controls and actuator on the specific machine using the components.

In 1945, manufacturers of fluid power systems and components, produced about one third of a billion dollars worth of equipment. Twenty-five years later, the annual sales volume was approximately 1.2-billion dollars. By 1975, the sale of fluid power products is expected to exceed that of the American machine tool industry. It is estimated that today approximately 75 percent of all manufacturing plants in the U.S. use fluid power systems as part of the equipment used to manufacture their products, and 60 percent of all industrial products produced in the U.S. have fluid power systems or components built into them.

Realizing that the potential and expanding growth of any industry is determined to a large extent by the quality and quantity of the personnel trained to work effectively in the particular industry the National Fluid Power Association, the Fluid Power Society, the American Vocational Association and the National Association of Industrial Teacher Educators in 1963 established the Council for Fluid Power Education (13). One of the major concerns of this council was the lack of fluid power curricular content in the vocational and industrial education programs in colleges for teacher education. As a result, in the summer of 1964, Wayne State University in Detroit, Michigan sponsored an Institute in fluid power for teacher educators (3). The institute was designed to help increase the number of qualified instructors trained to teach fluid power. Since that time several institutes and educational institutions have developed curricula designed to train and up-grade individuals in fluid power.

Recent Advances in Fluid Power Technology

Today's fluid power technology is used to push, pull, rotate, motivate, regulate or drive the mechanisms of modern life. One of the newer developments in fluid power is fluidics or "fluid amplifiers". Developed at the Harry Diamond laboratories in Washington, D.C. in 1959, the new technology of fluidics as defined by Mel Brdlik is (4, p. 74):

> . . . nonelectric circuitry controlled by fluids without the use of any mechanical moving parts. As a technology, fluidics is a prodigy of the Sixties; as a science it is as old as the first time man blew out a candle. In essence, fluidics devices and systems use the properties of the flow of liquids or gases most often air-to perform functions of sensing, amplifying and control. The action is not unlike the flow of electron currents through networks of wire and components.

One of the chief advantages of fluidics is its ability to perform control functions in hostile environments such as near a nuclear reactor, blast furnace, or machines that oscillate and vibrate.

As fluidics technology progresses, one drawback becomes more apparent; the critical shortage of trained personnel. Like so many companies attempting to overcome the trained manpower problem the Corning Company (4, p. 81), . . . has set up a cram course to train engineers of clients, customers and even competitors - anyone, in fact, who will come to Corning, New York - in fluidics.

Need for Qualified Fluid Power Personnel

The Occupational Outlook Handbook (28) has suggested that by 1980, 101 million Americans are expected to be in the labor force. The manufacturing industry is expected to increase about 11 percent through the 1970's and reach 21.9 million by 1980. The machinery industry is expected to have the largest need for additional people as employment grows from 2.0 to 2.4 million.

Projections of general occupational areas and levels of employment help to predict the need for potential job opportunities, however, more local data are needed for planning educational and training programs. As Goldstein has suggested (8, p.25):

> Until state and local projections become available, vocational education officials can use these national projections as a rough guide to manpower needs. . . The estimate should be modified on the basis of any information that may be available on the prospective growth of the occupation locally or the age and sex composition of the local workers.

> This method is not intended to supplant more carefully developed projections, but rather to serve as a temporary stop-gap in aiding vocational education officials meet the need for planning their work in the light of employment opportunities available in their communities.

Employers are seeking people who have higher levels of education because jobs are more complex and require greater skill. It was predicted that employment growth will be faster in those occupations requiring the most education and training.

In order to identify manpower requirements of industry, manpower needs surveys must be conducted. Mr. John Ekstam, President of Iowa Industrial Hydraulics suggests:

> It is my opinion that the area of hydraulic cylinders probably shows the lesser sophistication when compared to pumps or motors, and as such, I believe demand some heavy consideration for priority as well as possibly offering greater opportunity for both technicians and skilled workers. Another very firm opinion is that there is a dire need for more education in the entire field. . . We have had a minimal number of applicants who have had any formal training in hydraulics. I think an objective view of the entire field would show that your study is most certainly justified and that there are specific and critical needs to be filled within industry.[1]

Surveys of industry as well as a review of current literature reveals the need for additional personnel trained

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[1]John Ekstam, President, Iowa Industrial Hydraulics Incorporated, Pocahontas, Iowa. Information concerning needs. Private communication. May 6, 1971.

in fluid power technology at all levels of education. As Henke states (10, p. 125):

> Traditionally, an area of technology can grow only if it has a continuing supply of competent well educated individuals to support it. Industry can go only so far in developing a technology. Sooner or later, a partnership must be formed with education so that the supply of trained people is adequate to meet the demands of continued growth. Industry is investing billions of dollars in technology devices required to produce complex aerospace age products. Unless the educational systems of today can produce technically trained people to use and operate that equipment, we will never realize its full capacity or potential.

The impact and advancements of our technological society have compelled industry to seek a closer partnership with the educational community.

Implications for Education

Effective training has been one of the best ways of improving the profitable use of manpower no matter what skill is needed. Education then is a basic need for the efficient and profitable functioning of a company. Proper and adequate education must be based on an assessment of the need for and kind of knowledge that best fits that particular skill or group of skills. Analysis of the future supply-demand conditions for technicians and skilled-workers in the area of fluid power is dependent upon the extent of expansion of post secondary education. As Professor Pritchett stated (17, p. 6):

> The most immediate and pressing educational needs are to supply the trained manpower for technology as it exists today.
> This responsibility lies with technical and vocational schools.
> These schools must educate great numbers of fluid power apprentices who have recently graduated from high school, skilled workers who find their present knowledge of the technology inadequate and technicians who want to specialize in fluid power.
> The schools must also teach salesmen who find that without fluid power fundamentals much of their sales ability is wasted and plant supervisors who make decisions concerning repair and maintenance procedures.

This study was concerned with the technician and skilled worker whose depth of knowledge of fluid power would be commensurate with specific job functions and responsibilities. The vocational-technical training facilities can be of service to industrial concerns by providing the much needed opportunities for training, retraining and up-grading of personnel already in the fluid power industry as well as those individuals desiring to enter the field.

Problem Statement

The purpose of this study was to assess the employment opportunities and the need for fluid power educational programs for skilled workers and technicians in Iowa.

The objectives of this study were:

1. To determine the number of Iowa manufacturers employing technicians and skilled workers involved in fluid power, and the amount of time and area of interest in which these individuals work.

2. To determine the additional manpower needs of the identified manufacturers employing technicians and skilled workers involved in fluid power now and for four years in the future.
3. To determine the technical knowledge and skills which manufacturers employing technicians and skilled workers in fluid power desire these individuals to possess.
4. To determine if there is a need for educational programs designed to train and up-grade technicians and skilled workers in fluid power.

Delimitations

This study was a survey of the state of Iowa, designed in part, to determine if there was a need for educational programs to train technicians and skilled workers in fluid power. It was limited to the geographic boundaries of the state of Iowa. The sample of the population surveyed included firms employing fluid power technicians and skilled workers involved in the manufacture of end-use products in five major categories: (1) industrial, (2) mobil, (3) aerospace, (4) marine, and (5) other military.

Farm implement dealerships, farmers and farm helpers were not included in the study.

Occupational levels considered in this study were:

(1) skilled workers, and (2) technicians.

Assumptions of the Study

It was assumed that the state of Iowa had a sufficiently large number of industries manufacturing end-use products in fluid power equipment and systems to warrant a survey of this nature.

It was further assumed that the state of Iowa would gain industries in sufficient numbers and types to need increasing numbers of qualified fluid power personnel trained to work with the research, design, manufacture, installation, maintenance, operation, and sales of fluid power systems and equipment.

Definitions

The following definitions are presented to clarify the meanings of various terms used within this study.

Advisory committee -- A group of persons selected from industry and education for the purpose of offering advice and counsel to the researcher conducting this study.

Fluidics -- The use of fluids in motion without moving parts which perform sensing control and/or actuation functions.

Fluid power -- Energy transmitted and controlled through the use of a pressurized fluid (liquid or gas).

Hydraulics -- The engineering science pertaining to liquid pressure and flow.

Iowa merged area -- A geographical boundary consisting of two or more county school systems, or parts thereof, merged resources to establish and operate an area vocational school or an area community college in the state.

Manufactured end-use product categories:

Industrial -- Equipment used in fabricating, manufacturing and/or processing operations; or incorporated in products such as machine tools, presses, conveyors, etc.

Mobil -- Equipment used on land vehicles and mobil machines other than passenger cars, such as earth moving and road building equipment, lift trucks, construction machinery, and tractors, including fluid power elements of power steering and hydrostatic transmission.

Aerospace -- Equipment used on aircraft, missiles and spacecraft, military, commercial and private.

Marine -- Equipment used on military, commercial or private ships, boats and other watercraft.

Other military -- Equipment used on all other Armed Service devices not elsewhere reported such as ground support equipment such as trucks, launchers, radar, and similar equipment.

Pneumatics -- The engineering science pertaining to gaseous pressure and flow.

Skilled worker -- An individual who performs the actual manipulative activities with the use of special tools and instruments. He is responsible for diagnosing malfunctions, dismantling, repair, adjustment and assembly of the fluid power systems and equipment.

Technician -- An individual on a level between the skilled worker and the professional scientist or engineer. His technical knowledge permits him to assume some duties formerly assigned to the graduate engineer or scientist. His duties may include the design of a mechanism, compute the cost, write the specifications, organize the production, test and supervise final assembly of the finished product.

REVIEW OF LITERATURE

Manpower Needs of Industry

In general, technological progress is a means to a more abundant life for mankind. Our national investment of funds and manpower in the new technologies has been rewarded by increased life expectancy, rapid increases in productivity, and far-reaching improvements in our standard of living. A nation experiencing substantial technological advance needs a large number of trained personnel to support scientists and engineers.

The fact that so many technicians are hired without having formal preparation obtained through a recognized technical curriculum is an indication of a shortage of fully qualified workers. It also points up the difficulty of establishing firm job definitions and qualifications for the technician group as a whole when current employment of technicians seems to be a matter of "getting along" with whatever people are available rather than hiring people to meet firm job standards.

In a growing economy, the occupational composition of the workforce, as well as the skills required, tend to change through the years. Present manpower needs, it has been suggested, are an uncertain guide to future requirements. However, to plan educational and training programs to meet tomorrow's manpower needs, projections are needed to determine the changing manpower requirements.

As Goldstein has suggested:

> Only by keeping a sharp and constant eye on the future can we do the best possible job today. Congress has reminded us of this by requiring, in recent laws providing federal support for education and training programs, that in planning our programs we must realistically take into account future employment opportunities and manpower needs. (8, p. 18)

Employment needs of engineering and science technicians in the manufacturing industries will be 32,000 each year through the 1970's. Factors related to this growth are, (A) expansion of industry, (B) increased complexity of modern technology, (C) products and processes of manufacturing become more complex, (D) growth in the number of scientists and engineers, (E) trend toward increased automation and growth of new areas of work, and (F) increased growth in research and development of private and public concerns. (28)

In 1968 the number of skilled workers was 10.0 million. More than 200,000 additional workers will be needed each year through the 1970's. (20). Retirements and deaths are expected to account for more than four-fifths as many openings as growth of employment requirements.

Semi-skilled workers made up the largest occupational group in the Nation's labor force in 1968. More than 300,000 semi-skilled workers will be needed yearly through the 1970's, however opportunities for employment in manufacturing will be limited because of increased automation of production processes (21).

Greater substitution of power equipment for unskilled manual labor in lifting, hauling, digging and similar heavy physical work will create other employment openings for semi-skilled workers with additional training and education than these job functions presently require. It was recommended that these persons take courses in evening schools and elsewhere to qualify (28).

Job Identification and Responsibility

Job training and related educational goals can be established only after knowledge of that particular job has been defined. A paper proposed to the Fluid Power Society, Chapter 5, Minneapolis-St. Paul for its consideration and recommendation in the Dictionary of Occupational Titles, is the job classification and definition for the general fluid power technician and mechanic.

An overview of those responsibilities follow (18, p.1):

Fluid Power Mechanic (general)

a. Assembles, disassembles, services and tests fluid power components.

b. Reads and understands component performance graphs and tables.

c. Reads and understands blueprints and schematics.

d. Is knowledgeable of and understands basic rules governing hydraulics, pneumatics, electricity and mathematics as applied to fluid power and its application.

e. Works with hand and machine tools normally used in the fabrication, installation and maintenance of fluid power components and systems.

Fluid Power Technician (general)

a. Assembles, disassembles, services, tests and analysis fluid power components and systems.

b. Is knowledgeable of and understands basic rules, physical and chemical laws governing hydraulic, pneumatic, electricity and mathematics as applied to fluid power and its application.

c. Organizes and makes drawings of fluid power systems and related controls.

d. Operates hand and machine tools normally used in fabrication, maintenance and test facilities related to fluid power components and systems.

e. Directs fluid power mechanics and provides liaison between shop and engineering departments.

The structure of the workforce is important to any study dealing with occupations. By investigating the nature of the labor force it is possible to determine trends important to specific occupations and to the economy as a whole.

The National Scene

In May 1963, the National Fluid Power Association conducted a national survey to determine the availability of manpower trained in fluid power (9). From experience, the researchers knew there would be a shortage of this type of person but they decided to document the need with data from industries across the nation.

A total of 164 companies participated in the survey that represented 34,892 production employees. The companies represented were selected from a random sample in the areas of ordance, metal fabricating, machinery, electrical machinery, equipment and supplies, transportation equipment, and instruments. The participating firms were asked to indicate by category of employee and job responsibility or function within each category, the adequacies of available manpower trained in fluid power.

A summary of the results follows:

	Percent some shortage	Percent serious shortage	Percent total shortage
A. Skilled workers			
Installation	40	14	54
Operations	37	6	43
Maintenance	31	25	56
B. Engineering technicians or aids			
Design	36	29	65
Installation	48	12	60
Operation	40	9	49
Maintenance	44	13	57
Manufacturing and Production methods	37	20	57

(Continued)

	Percent some shortage	Percent serious shortage	Percent total shortage
C. Engineers or the equivalent			
Design	32	33	65
Installation	41	18	59
Operation	37	13	50
Maintenance	41	19	60
Manufacturing and Production methods	36	19	55

The participating companies were also asked to indicate if educational opportunities were available in their locale.

A summary of those responses follows:

Educational Level	Percent adequate	Percent not adequate
trade school	30	70
high school	10	90
technical institute	37	63
college	32	68

The participating companies were asked to respond to the kinds of additional fluid power educational opportunities that would be most helpful in their communities.

A summary of those results follows (9, p. 14):

1. 54 percent wanted more trade school opportunities, primarily on an evening basis, for persons presently employed.

2. 42 percent recommended more fluid power education on the high school level, both day and evening programs.

3. 54 percent recommended more fluid power education on the technical institute or community college level, both day and evening programs.

4. 51 percent recommended more fluid power education on the engineering college level.

Educational Involvement

In 1964, the Fluid Power Society and the National Fluid Power Association in cooperation with Wayne State University in Detroit, Michigan, sponsored a summer institute on fluid power (3). Again during the summer of 1965, the U.S. Office of Education supported as Contract Number OE-5-85-039 under the provisions of section 4 of the Vocational Act of 1963, the first phase of an attack on the basic problems listed below.

1. A serious shortage of skilled workers and technicians trained in fluid power.

2. A serious shortage of teachers qualified to teach fluid power technology in industrial and vocational programs in the nations schools.

3. Since fluid power is a relatively new technology, the programs offer a unique opportunity to investigate the most effective techniques for introducing a new technology to educators.

The contract provided for summer institutes at five colleges in fluid power education, under planning and guidance between representatives of the divisions of Vocational-Technical Education, Office of Education and the Fluid Power

Society.

The objectives of the project were (3, p. 4):

A. To prepare young people for gainful employment in industries which manufacture or use fluid power systems.

B. To provide pre-vocational preparation for young people to continue vocational education in fluid power.

C. To provide the groundwork for a continuing research project to evaluate the institutes, and to research their results and techniques in terms of their effect on the participants, the participants of home schools, and their students.

It was concluded that the summer institute can be a most effective vehicle for introducing a new technology to new teachers, since it offers a controlled environment and the efficient means of bringing together the teachers, industrial and technological authorities. It was further concluded that the professional society of a new technology can effectively act as a coordinating agency of pilot programs involving multiple summer institutes.

A federally funded manpower and training needs study was conducted at Purdue University in 1966 by Pritchett and Lisack (18), who surveyed selected industries in Indiana in an attempt to acquire and analyze selected manpower and educational needs data in the fluid power area (hydraulics and pneumatics only). The data from the study were used as a basis for planning of related vocational and technical educational programs in Indiana.

The objectives of the study follow (18, p. 2):

1. Determine the number of persons now employed in fluid power-related jobs, by industry and locale for the following occupational levels:

    a. Skilled workers
    b. Technical specialists
    c. Engineering or manufacturing technicians
    d. Production or line engineers
    e. Design or research engineers

2. Determine the current number of vacancies (if any) and how many new fluid power trained persons are needed each year for the next five years, for each of the five occupational levels listed above, by industry for the seven largest metropolitan areas of Indiana.

3. Determine the number of companies now conducting fluid power training together with their related occupational levels and lengths of such programs.

4. Ascertain the consensus of views concerning the levels of understandings (cognitive domain) that are used at each occupational level, as represented by subjects in the following areas:

    a. Fluid power courses
    b. Supporting technical courses, and
    c. Supporting non-technical courses

5. Obtain comments and suggestions for Indiana industry representatives concerning manpower and training needs for the fluid power area.

6. Develop conclusions and recommendations which can be used as bases for planning fluid power vocational and technical educational programs.

A pilot survey questionnaire was developed and mailed to 35 selected representatives in Indiana fluid power equipment manufacturing and sales industries in an attempt to develop an adequate survey instrument. The pilot questionnaire was also used to request a list of fluid power firms to whom the final draft of the questionnaire should be sent. The data were acquired through use of the revised mailed questionnaires, supplemented by discussions and personal interviews sent to 265 firms representative of key Indiana industries in which fluid power was relevant. Sixty-three useable questionnaires were received representing a 24 percent response involving 89,455 employed people.

The industries selected were all placed in one of ten Standard Industrial Classification (SIC) titles.

The conclusions of the study were stated as follows (18, p. 22):

1. Although the proportions (percentages) of total employees in various industries needing fluid power related skills and understandings are relatively small (usually only a fraction of one percent at each occupational level) and vary in different industries, when they are applied to large industries the results become significant.

2. The related predicted job vacancies became large enough in some cases to warrant the planning of fluid power courses at certain occupational levels in particular metropolitan areas.

3. Six of the seven largest metropolitan areas in Indiana appear to have an existing and recurring need for specific fluid power courses at particular occupational levels.

4. Derived factors which reflect the percentage of employees at various occupational levels who need some fluid power skills and understandings can be applied to each major industry within a given metropolitan area, and disclose an approximation of the related numbers of

people required. These requirements are assumed to be the lower parameter inasmuch as only the largest needs were included.

5. There is a need for people who have fluid power skills and knowledge at all occupational levels - but who are not employed full time in this specialized field...e.g. fluid power skills supplement and augment other skills.

6. The types of courses (and depth of knowledge in each) required by Skilled Workers and Technical Specialists are quite similar. Also, some of the courses (and depth of knowledge in each) required by Engineering technicians are comparable to those of engineers. The required depth of knowledge increases in every subject area with each higher occupational level.

7. The nature and depths of knowledge required in supporting technical and non-technical subject areas for technicians and technologists, are very similar to some already established technical educational programs such as Mechanical Engineering Technology Associate in Applied Science Degree programs.

8. Comments from selected representatives from industry substantiate and corroborate the statistical data reported in the survey.

The following are generalizations that evolved from the conclusions.

The data should be used by administrators and educators to develop educational programs in fluid power throughout the state of Indiana. The depth of knowledge indicated in statistical treatment of the data should be used as a guide for development of fluid power programs. The findings should be compared to present requirements in Mechanical Engineering Technologies across the state. A series of "applied noncollege" credit courses should have been established on a vocational-technical training level. Students in Mechanical Engineering technology were encouraged to schedule fluid power courses into their programs so they would be better prepared to meet job requirements in the area of fluid power.

In 1968, the Board of Directors of the Fluid Power Society as a result of the urgent need for broad-based multifaceted programs in fluid power education, established the Fluid Power Society Educational Institute (24). The purpose of the institute was to help develop seminars, conferences, symposia and short courses "on a broader base" than the individual chapter could have undertaken. Although the institute was conceived as an international function, all chapters would fall within a region for purposes of educational programming, with assistance given by the institute. Thesis data from this study were to have been a portion of the overall perspective of the need for and types of fluid power education in a portion of the United States and Canada Fluid Power Society Region 16.

In 1968, Wolansky (30) completed the first dissertation conducted in curriculum development for fluid power instruction for industrial education teacher preparation. The following were major objectives of the study (30, p. 17):

1. Determine the specific and appropriate goals for the preparation of industrial education teachers competent to teach fluid power at:
   (a) secondary school level
   (b) post-secondary school level

2. Identify and formulate a framework of the major divisions that would later be developed to contain the content of fluid power technology essential for teacher education preparation.

3. Identify the technical core content through survey and analysis of the literature and report practices of selected programs for secondary and post-secondary school fluid power education and develop an instrument to facilitate the further development and evaluation of proposed units by the Committee of Fluid Power Specialists.

4. Develop an organizational pattern for the selection and codification of titles for units to be systematically organized for suggested content in a unit, course or sequence of courses in fluid power as a model program. Develop an instrument to facilitate the review and recommendations of the proposed model program by the Consulting Committee.

Wolansky stated that a dire need existed to bridge the gap between education and the world of work and that goals should be devised to set the stage for educational effort that guides the individual through learning.

In this study assistance was sought to provide "future-oriented content" appropriate for educational experiences that would lead to expanding opportunities in dynamic and evolving technologies such as fluid power. The instructional framework was defined with the assistance of (1) the professional technical society, (2) manufacturers and users of fluid power equipment, (3) research findings of summer institutes, (4) courses of study in selected schools and, (5) publications in the subject area of fluid power. It was found after exploring industries employment needs related to fluid power that (30, p. 125),

1. Technical skills are based on the ability to manipulate the theory and tools or equipment, and to apply these efficiently, accurately, and with a margin of safety. In fluid power instruction, the theory and hardware needed to be given careful consideration when content is being identified.

2. During their preparation, teachers will need laboratory experiences in applying principles experimentally through the use of hardware components and systems, in order to observe and evaluate what happens in practice in a system, as opposed to theoretical calculations which are affected by the design of components and systems.

3. A student needs to understand the basic function, physical design and how a component works, as well as the compatibility of components and instruments, before he can manipulate these components intelligently.

Some of the conclusions of this study were presented as recommendations briefly reviewed below:

1. Curriculum development for emerging technologies such as fluid power need the cooperative effort of both education and industry for ultimate attainment of the goal-making process.

2. When technical courses are developed, it would be necessary to seek qualified support of industry and education alike.

3. This study offered innovative curriculum procedure development which may be used in other newly emerging technologies.

In the spring of 1971, the following members of an AD HOC committee sponsored by the National Fluid Power Association developed a 2-year post high school fluid power technician curriculum guide.

a. Professor S. L. Pritchett, director, Purdue University

b. Mr. Russ Henke, Engineering consultant.

c. Mr. John Nagohosian, Instructor of fluid power, Henry Ford Community College, Detroit, Michigan.

d. Mr. Fred Renney, Fluid power department head, Area vocational school, Granite Falls, Minnesota.

Funded by the National Fluid Power Foundation, the curriculum guide was based on current knowledge and skills needed by industries using fluid power and included such related knowledge as mathematics, materials and similar content.

The Local Scene

In Iowa during the development of the Area vocational schools, many skill needs surveys of industries were developed within several particular geographically areas. Among these studies was Langerman's (14) completed in 1967 for Area XI. This study was developed to determine the number and kind of semi-skilled, skilled and technician level workers in Area XI. Current (January 1967) as well as anticipated employment needs from September 1968 and September 1970 were queried along with employee turnover, formal in-plant training and estimated availability of trained workers for 218 job titles from the _Dictionary of Occupational Titles_ were determined.

The survey involved a total of 3,751 employers who employed four or more persons. Approximately 36 percent returned questionnaires while 79 percent of the 64 largest employers contacted by personal interview returned questionnaires.

Some of the conclusions of the study are summarized as follows:

1. The work force as of January 1967 was composed of 24,524 semi-skilled, skilled and technician level workers.

2. Current job vacancies in 1967 totaled 1,525 representing 6.21 percent of the employed work force as of January 1967.

3. Projected increases in employment from January 1967 to September 1970 indicated 6,952 additional positions would be realized.

4. The number of newly trained employees through formal in-plant training did not meet the need for new workers needed in industry.

5. The projected need for trained workers in semi-skilled, skilled and technician level jobs was 16,383 by September 1970. With the increased need for trained workers being substantial, additional vocational and technical training programs were recommended to meet the needs of industry.

Langerman's concluding remarks appear to be self evident when he stated that the ... conclusions provide sufficient evidence that more vocational and technical educational programs are needed to train sufficient workers to meet the expanding demands of industry (14, p. 122).

In 1970, a study was conducted by Backens (2) to determine need and development priorities for North Iowa Area Community College programs based on employer needs. The objectives were to determine the number and kind of semi-skilled, skilled and technical workers employed by job title in the North Iowa Area Community College District as well as anticipated manpower and training needs and availability of trained persons. Employment needs were classified according to five occupational divisions.

It was found that the largest number of job titles were represented in the Machine and Industry category with the fewest being represented by the Chemical industrial category.

Current employment for the job titles were reported largest in the Construction, Machine and Industrial, and Office occupational areas. The Engineering and Science Technician occupational division projected need for 1971 ranked third largest of the five divisions. Anticipated formal in-plant trainees for 1971 decreased from the 1968 trainees in all but the Chemical, and Machine and Industrial occupational areas which increased.

Selected findings of Backens study follow:

1. The number of job vacancies for the occupations identified in the study indicated a potential increase of employees of approximately five percent.

2. The projected increase in employees from 1968 to 1969 was computed to be nearly eight percent. When projected from 1968 to 1971 the increase was 16 percent.

3. The number of workers expected to complete formal in-plant training decreased from 429 in 1968 to 249 in 1971.

4. The projected need for additional trained persons by 1971 was approximately 28 percent of the number of persons employed in 1968.

5. More than half of the employers responding to each job title reported that for 40 percent of the jobs, workers are in short supply.

A survey related to the evaluation of the auto mechanics program at the Northern Iowa Area Community College was completed in 1969 (20). Objectives of the study included: (1) determine the need for basic skills and compentencies in order to begin work in the trade, (2) determine the employability of dropouts from the program, (3) determine the order in which skills were taught to most benefit the employer and student, (4) determine the importance of selected traits of persons beginning the auto mechanics traits as rated by the employer, (5) determine the desirability of an existing on-the-job training program and, (6) means by which auto mechanics could have received additional training in automotive repair work.

Special associations dealing with automobiles were used to develop an interview list of 103 garages and dealerships representing 406 employees in five specifically categorized positions. Combination dealerships, businesses and independent garages were visited.

The results indicated that the existing auto mechanic program was adequate and that dropouts skill level would not make a difference in gaining employment. Personality of the individual it was suggested may reflect in the persons ability to secure employment. Other findings indicated that there was no standard that existed by which competency of the auto mechanic applicant could be measured. The study also indicated that employers were in favor of some on-the-job training for auto mechanic students

The following were recommendations of the study:

1. Prospective automechanic students be screened to reduce the attrition rate.
2. Development of a shorter parallel program to train less able students for positions in service stations and similar positions.
3. North Iowa Area Community College develop a short interim on-the-job training program for auto mechanic students in garages and dealerships.
4. A need existed for a testing and certification program relating to auto mechanic skill and knowledge levels in various automotive repair areas.
5. There was a need for up-grading the public image of the repairman.

Using the 1960 U.S. census figures, a study that paralleled the national Industrial Occupational employment picture was conducted by Palomba (15). The study found that the professional, clerical and service occupations would increase their share of employment requirements relative to the other non-farm occupations. Several growth occupations were identified particularly in the professional and craft groups. Palomba's census figures indicated the projected Industrial-Occupational employment trends for Iowa would be 143,429 in the crafts and 213,668 in the operatives by 1975.

It was concluded that the educational attainment of the labor force was more than adequate to satisfy educational requirements of projected jobs in those areas investigated. Closing remarks stated that the lack of any current occupational data severly limited the usefulness of the available projections while more detailed occupations by industry data and even industry data itself would have improved the projections of employment requirements.

In 1967, a study was conducted in Iowa by Weede (29) to determine the personnel and training needs for industrial electronics technicians. This study through a prepostal card questionnaire identified and surveyed 115 industries which employed 99,045 personnel. The 115 industries taking part in the study indicated a need for 205 technicians by January 1, 1968, and 544 electronic technicians needed by January 1, 1972. The main source of trained personnel at the time of the study was from in-company training programs, and from technical schools. This study also surveyed the need for a course to train industrial electronic technicians. A summary of the findings follows:

1. Algebra and trigonometry were the only mathematics indicated to be of significant importance to electronic technicians.

2. Soldering rated highest in the skills needed; followed by drilling, measuring with micrometers, sheet metal fabrication, and various types of welding.

3. In technical drawing topics, blueprint reading ranked first followed by electronic symbols, schematic diagram simplification, electronic circuit drawing, dimensioning and sketching.

4. The four highest rated electronic components and circuit topics were a-c and d-c power supplies, power supply regulation, semiconductor diodes, and transistors.

Communication topics, in general, were at the bottom of the list for the electronics technicians.

From this study Weede concluded that manufacturing firms in Iowa have a definite need for well trained persons in the field of electronics and that these needs vary with size, product and geographical location. He further stipulated that it is difficult to predict future employee needs of Iowa manufacturers beyond one year.

Zook (31) in 1968 studied by means of a mailed questionnaire, all Iowa industries engaged in the manufacture or fabrication of plastics. Ninety-six industries responded to the final form, and 27 personal interviews were conducted.

The objectives of the study were (31, p. 8):

1. To identify Iowa plastics industries.

2. To identify the employee training needs of all Iowa plastic industries

    a. to ascertain the skills and knowledge desired of prospective employees by Iowa industries.

b. to categorize employee training needs for each area school district according to the number of skilled workers needed and the specific skills required.

3. To ascertain the number of trained and skilled employees needed at the present time and in the next five years.

4. To ascertain the present sources of plastics workers hired by the Iowa industries.

5. To ascertain the extent and type of inservice training being conducted by the Iowa plastic industries.

6. To ascertain the production processes used by the various plastic industries in Iowa.

7. To ascertain the production materials used by the Iowa plastic industries and the type of products for which they are used.

8. To ascertain the extent of use of various processes as indicated by the Iowa plastic industries.

9. To draw some implications for the development of instructional programs.

The results of the data show that 28,252 persons were employed in the plastics industries in Iowa, 2,122 being regarded as skilled. In-company training was indicated as the main source of skilled workers in the plastics industries followed by other company training programs. Further results revealed that the larger the plastics industry the greater the number of skilled plastic workers employed. The estimated additional employees needed by the entire plastics industries by January 1, 1969 was 3,287 and 112 openings existed for skilled plastics workers.

In the related areas of industrial automatic control systems knowledge, electrical rated highest followed by hydraulic and pneumatic. Blue printing ranked first in importance of the drafting and technical drawing topics. A-c circuits were rated as the most important phase of electricity for skilled plastics works with d-c second. Other areas of knowledge desired of the skilled plastics worker that ranked first in their respective categories were general mathematics, speech, and thermoplastics.

Conclusions were listed as follows (31, p. 165)

1. The manufacturing industries of Iowa have a definite need for skilled workers in the field of plastics.

2. The training needs vary with the size of the industry, merged area, principle process used, and product manufactured.

3. It is very difficult for industries to predict the number of additional employees beyond one year.

4. The main source of skilled plastic workers is in-company training programs.

5. On-the-job training is the most frequently used type of in-company training by Iowa plastics industries.

6. Molding is the major plastic production process used by plastic industries in Iowa.

7. The major production material used is thermoplastic.

8. There is a need for the development of instructional programs in the field of plastics in the Iowa area vocational schools.

A study related to fluid power curriculum was conducted by the researcher in the spring of 1971 (11). The purpose of the survey was to determine the number and types of fluid power programs that were being offered in the 220 industrial education teacher preparation institutions across the United States. The findings were presented at the American Vocational Association Convention in Portland, Oregon in December 1971.

A summary of the findings is enclosed in Appendix C.

Summary

In summarizing it can be stated that research directly related to the area of fluid power or manpower needs for technicians and skilled workers trained in fluid power is limited.

The research that could be used to assist in determining the need for technicians and skilled workers trained in fluid power in Iowa is non-existent. The results of this review of literature point to the need for this study.

METHOD OF PROCEDURE

The major purpose of this survey was to determine the number of firms employing technicians and skilled workers in the manufacture of fluid power products and to ascertain if there is a need for these persons in Iowa. other goals were to determine the additional manpower needs of the identified firms employing technicians and skilled workers and to secure from firms employing these individuals, the desired knowledge and skills these workers should possess.

This chapter describes the procedures used in the collection and analysis of the data necessary to fulfill the objectives of the study.

Advisory Committee

An advisory committee, consisting of four members, was selected for the purpose of offering advice and recommendations to the researcher conducting this study. The committee members were asked to offer recommendations for for determining the data to be collected by the questionnaire. The advisory committee members were:

Mr. Dick Hook, professional engineer, John Deere Des Moines Works, Ankeny, Iowa.

Mr. Bill Schworm, mechanical designer, physical plant, Iowa State University.

Mr. Morris Sigurdson, training supervisor, The Maytag Company, Newton, Iowa.

Dr. William Wolansky, Professor in charge of Industrial Education, Iowa State University.

Population

The population surveyed for this study include 81 firms that employ technicians and skilled workers involved in fluid power. The manufacturing firms in this study were involved in five major fluid power end-use product categories defined as follows (24, p. 2): (1) industrial, (2) mobil, (3) aerospace, (4) marine, and (5) other military. Most of the firms surveyed were concerned with more than one area of interest including research, design, manufacture, installation, maintenance, operation, and sale of fluid power devices in the products that they manufacture.

The initial list was compiled by the investigator using the Directory of Iowa Manufacturers, eighth edition (12). Mr. Lynn Richardson, field representative for the Center for Industrial Research and Services (CIRAS), provided valuable guidance and assistance. The directories list was updated by consulting with representatives of CIRAS and their current files.

Prequestionnaire

The investigator realized from the beginning of the study that all manufacturers would not necessarily have technicians and skilled workers involved with fluid power in their employ. Therefore, to eliminate these firms as early in the study as possible, 372 double postal card questionnaires were prepared and mailed to all manufacturing firms in the initial population in an attempt to determine if these firms should be included in the study. The postal card questionnaire contained questions designed to determine if the manufacturing firm did employ engineers, aides, technicians, and skilled workers in fluid power. If the response was yes, the respondent was to identify the areas of employment. The respondent was also asked if this type of individual would be employed in the next five years and the name of an individual within the firm from whom additional information may be obtained.

A sample of the double postal card questionnaire is enclosed in Appendix A.

Technical Assistance

It was the opinion of several persons in the Center for Industrial Research and Services, that firms involved primarily with the service of fluid power products including such activities as maintenance, installation and operation only, be eliminated from the study because every individual involved with fluid power products at this level would produce little in the way of significant information in determining manpower and training needs.

Instrument

The use of a questionnaire was determined to be the most effective method of gathering data from such a large geographical area as the state of Iowa. The main questionnaire was designed so that one form would provide all of the needed data.

The first draft of the main questionnaire was constructed and submitted to 16 different persons with backgrounds varying from industry to education. As a result of the pilot survey, corrections were made and a revised copy was mailed to a specific person whose name either appeared on the postal card questionnaire or was found in the directory of Iowa Manufacturers Association under the selected firms name.

Except for a few areas, the main questionnaire had two response columns; one for technicians involved with fluid power, and one for skilled workers involved with fluid power. This was done in an attempt to gain a more indepth analysis of the individual occupational level needs of the two groups.

Each manufacturing firm was asked to identify the type of fluid power medium it was involved with as well as indicating which end-use product categories it was presently concerned. In addition, the main questionnaire asked for information concerning the number of technicians and skilled workers employed or expected to be employed for the year 1972 through 1975 as well as the number of vacancies occurring at the time the main questionnaire was received. These questions were an attempt to determine manpower demand and turnover for the near future.

Questions related to the source of training of currently employed technicians and skilled workers involved with fluid power were asked to determine where these individuals received their training. Each manufacturing firm was also asked how many technicians and skilled workers presently employed would benefit from various types of fluid power educational programs and how many would actually attend these programs. These questions were an attempt to determine the need for such programs in the Area Schools and Community Colleges of the state of Iowa. Questions were asked to determine if the firm was sponsoring its own in-plant training program, would they perform this function in their plant, and would the firm hire qualified persons trained in fluid power at the technician and skilled worker occupational level if they were available. These questions were an attempt to determine how the employees gain a portion of their technical training as well as the need for qualified persons trained in fluid power.

Additional questions were asked to provide a more complete picture of the nature of the work force in question.

In an attempt to place a numerical value to items of knowledge and skill in the area of fluid power, a five point rating scale was developed. All items were placed in three major interest areas of hydraulics, pneumatics, and fluidics at both the technician and skilled worker occupational level. Within the major interest areas, there were item groupings that included communication skills, mathematics, supporting technical information, principles of hydraulics, power fluids and fluid conditioning, hydraulic power distribution, sources of hydraulic power, control of hydraulic power, hydraulic power actuators, hydraulic circuits and components, principles of pneumatics, pneumatic components, principles of fluidics, and fluid power maintenance and safety. The 14 item groupings were subdivided into specific items related to the major interest area and item grouping. The data were also analyzed in terms of the manpower needs in each of the Iowa Merged Areas and manufacturing firm size.

A copy of the main questionnaire is included in Appendix B.

Collection of Data

Because of the diversity of the manufacturing firms locations throughout the state of Iowa, it was decided to mail the main questionnaire. A cover letter signifying the importance of the information to the study and the firm involved was attached to the questionnaire.

Two weeks and six days after the first mailing, a follow-up questionnaire and second cover letter were sent to each non-responding manufacturing firm. Again two weeks later, it was decided to contact the remainder of the non-responding manufacturers by telephone or personal interview. Telephone contact was made to all geographically isolated manufacturing firms and interview trips were made to the remainder in the locale of Des Moines, Waterloo, Cedar Falls, Cedar Rapids and surrounding areas.

A copy of the second cover letter is included in Appendix B.

Analysis of the Data

The main questionnaires were examined for completeness as they were received. The data were recorded on coded tally sheets, then the data were transferred to key punched Hollerith 80-column cards. An IBM 360 model 65 was used to analyze the data.

Arithmetic frequencies and totals were tabulated for various responses to the questions concerned with the type of fluid power medium the firm used, end-use categories, number of technicians and skilled workers, their ages, hours per week directly related to fluid power, education, and so forth.

Tables were developed from the data to depict current and projected manpower needs for technicians and skilled workers involved with fluid power as well as the distribution of the surveyed manufacturing firms as they relate to end-use categories, merged areas and firm size. Tables were also used to show sources of training of currently employed individuals in the manufacturing firms surveyed as well as where persons trained in fluid power may be placed within their plant.

In the items pertaining to fluid power technicians and skilled workers and persons studying to become these types of individuals, frequencies and means were determined for each item answered by a response on a five point rating scale. The means were calculated by assigning to the rating scale a value of five for the category "essential", four to the category "highly desirable", three to "desirable", two to "background knowledge only", and one to "very little importance". The means are represented by a numerical value from zero to five indicating the relative importance of each item as it was viewed by a representative in the manufacturing firms employing technicians and skilled workers involved with fluid power in Iowa.

FINDINGS

The purpose of this study was to determine the number of firms employing technicians and skilled workers in the manufacture of fluid power products and to ascertain if there is a need for these types of persons in Iowa.

The findings were presented in three major divisions to fulfill the objectives of the study. These divisions were: (1) general findings concerning the industries surveyed, (2) information concerning the technicians and skilled workers in the industries surveyed, and (3) information concerning the knowledge and skills needed by technicians and skilled workers involved with fluid power in the industries surveyed.

General Findings Concerning the Industries Surveyed

Distribution of participating manufacturing firms, by merged area

Data concerned with the distribution of the participating manufacturing firms by merged area were presented in Table 1.

Eighty-one questionnaires were sent to industries that used fluid power in the products that they manufactured. Useable questionnaires were returned from 61 industries (75 percent) distributed throughout the state of Iowa and were identified geographically by a specific merged area. The largest number of industries identified in this study was 16 found in Iowa merged area XI followed by area VII and area IX each with 12 firms. With the exception of merged areas XIII and XIV, all areas had at least one industry.

Table 1. Distribution of questionnaires by participating manufacturing firms, by merged area

Iowa merged area	Questionnaires			
	Total mailed	Returned		Not Returned
		Useable	Not useable	
I	5	5		
II	4	3		1
III	1	1		
IV	2	2		
V	3	2	1	
VI	4	3	1	
VII	12	12		
IX	12	7	1	4
X	9	7		2
XI	16	12	1	3
XII	6	4		2
XIII				
XIV				
XV	5	3	1	1
XVI	2	—	1	1
TOTAL	81	61	6	14

Distribution of fluid power technicians and skilled workers by merged area

The total number of technicians involved in the study as reported in Table 2 was 254. Iowa merged area VI had the largest group with 107 followed by area VII with 47 and area XI with 23 technicians. With the exception of

Table 2. Distribution of fluid power technicians and skilled workers by merged area

Iowa merged area	Technicians	Skilled workers	Total
I	6	11	17
II	2	11	13
III	2	3	5
IV		5	5
V	12	10	22
VI	107	4	111
VII	47	71	118
IX	12	82	94
X	22	99	121
XI	23	68	91
XII	7	28	35
XIII			
XIV			
XV	14	28	42
XVI			
TOTAL	254	420	674

merged area IV, XIII, XIV and XVI, all areas identified two or more technicians. The total number of skilled workers involved in the study was 420 with Iowa merged area X having the largest number totaling 99 followed by area XI with 82 and area VII with 71. The combined total of all technicians and skilled workers employed by industries surveyed in the study was 674 of which Iowa merged area X had 121 followed by area VII with 118 and area VI with 111 respectively.

Distribution of industries by medium, and area of interest

Several of the surveyed industries identified in Table 3 veyed were involved with more than one fluid power medium. Of the three fluid power mediums used by the industries, hydraulics was largest with 56 reported followed by pneumatics with 26 and fluidics with 12. Hydraulics is used by 12 industries in Iowa merged area VII, followed by area XI with 11 and area X with seven. In the pneumatics fluid power medium, merged area XI listed six industries while areas VII and IX each had five. Three industries in merged area VII indicated they used fluidics as a fluid power medium while merged areas I, II and VI each indicated two.

From Table 4 it was determined that several of the 61 industries that returned useable questionnaires were involved with the manufacture of fluid power products used in more than one end-use category. The end-use categories involved were industrial, mobil, other military, aerospace

Table 3. Distribution of industries by type of fluid power medium and merged area

Iowa merged area	Fluid power medium Hydraulics	Pneumatics	Fluidics
I	4	1	2
II	3	1	2
III	1		1
IV	2		
V	2		
VI	2	2	2
VII	12	5	3
IX	6	5	1
X	7	3	
XI	11	6	
XII	3	2	
XIII			
XIV			
XV	3	1	1
XVI			
TOTAL	56	26	12

and marine involving 41, 39, 8, 5 and 3 industries respectively. A total of 96 end-use categories were reported in Table 4. Iowa merged area VII had the largest single total number of industries within the identified end-use categories with 23 followed by area XI with 19 and area X with 11.

Table 5 lists the fluid power end-use categories by fluid power medium. Hydraulics is most often used as a fluid power medium in the manufacture of end-use products

Table 4. Distribution of end-use product categories of firms by merged area

Iowa merged area	End-use product categories					Total
	Aero-space	Mobil	Industrial	Marine	Other Military	
I		2	4			6
II		2	2			4
III			1			1
IV		2	1			3
V		2	1			3
VI		1	3	1		5
VII	2	7	9	2	3	23
IX	1	3	5		1	10
X		6	3		2	11
XI	1	9	8		1	19
XII	1	3	2		1	7
XIII						
XIV						
XV		2	2			4
XVI		2	2			4
TOTAL	5	39	41	3	8	96

Table 5. Distribution of end-use categories of firms by fluid power medium

Categories	Fluid Power Medium Hydraulics	 Pneumatics	 Fluidics	Total
Industrial	36	21	11	68
Mobil	39	14	5	58
Aerospace	3	4	2	9
Marine	3	2	2	7
Other Military	8	4	1	13
TOTAL	89	45	21	155

by 89 industries while 45 industries indicated they used pneumatics and 21 industries used fluidics. The total of the three fluid power mediums used by manufacturers in the various end-use categories was 155. The industrial end-use category was the largest single user of the three types of fluid power medium with 68, followed by mobil and other military with 58 and 13 respectively.

In an effort to provide an overall view of the products and areas of interest the industries were involved with, Table 6 was developed. A total of 924 various combinations of products and areas of interest were identified. Eleven firms were involved with research on valves while 16 firms actually manufactured this product and 36 firms indicated that they installed this type of fluid power product. In

Table 6. Response by firms to number of fluid power products by areas of interest

Areas	Fluid power products: Cylinders	Boosters	Rotary actuators	Motors	Compressors	Valves	Accumulators	Pumps	Filters and filter elements	Vacuum pumps	Fluidic devices	Hydrostatic transmissions	Other	Total
Research	10	1	3	3		11	2	5	4	1	2	3	3	48
Design	26	4	4	7		21	5	12	10	2	4	7	4	108
Manufacture	23	1	3	5	1	16	4	11	7	3	3	4	5	86
Installation	34	9	9	26	11	36	14	33	31	8	7	13	2	232
Maintenance	33	10	9	19	10	31	10	28	23	8	7	8	5	201
Operation	27	8	7	17	9	28	7	24	22	6	5	8	3	171
Sales	17	2	3	8	1	14	3	12	7	1	2	5	3	78
Other	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	170	35	38	85	34	157	45	125	103	29	30	48	25	924

the research of cylinders, 10 firms were identified with 23 firms manufacturing the product and 34 firms indicated that they installed them. Thirty listings were made for the various areas of interest related to fluidic devices. Other fluid power products listed were systems, rotary joints, hydraulic hoses and fittings, and hydraulic couplings.

Information Concerning the Technicians and Skilled Workers in the Industries Surveyed

Distribution of responding firms by employee group size, merged area, and occupational level

Table 7 was developed to depict by merged area, the number of technicians and skilled workers employed by firms involved in fluid power. Technician group size 1-2 contained 31 responses followed by group 3-4 and group 9-10 with 12 and three responses respectively. Group size 1-2 in the skilled worker occupational level was largest with 21 followed by group 3-4 and the over 10 group with 16 and nine respectively. Iowa merged area VII had 11 firms that responded concerning the employment of technicians with the 1-2 and 3-4 group sizes each containing five responses. One response was identified in the over 10 group. Merged area XI had nine responses followed by areas IX and X with six responses apiece. Iowa merged area VII also had 11 firms responding about the employment of skilled workers. Groups 1-2, 3-4 and over 10 had five, three and two responses

Table 7. Distribution of responding firms by employee group size and merged area

Iowa merged area	Technician group size 1-2	3-4	5-6	7-8	9-10	over 10	Total	Skilled workers group size 1-2	3-4	5-6	7-8	9-10	over 10	Total
I	3	1					4	3	2					5
II	2						2	1	1	1				3
III	1						1		1					1
IV								1	1					2
V	1				1		2	1			1			2
VI		2				1	3	1						1
VII	5	5				1	11	5	3	1			2	11
IX	4	2					6	2	1		2		2	7
X	4			1	1		6	2	3				2	7
XI	6	1	2				9	2	4	2		1	1	10
XII	4						4	1		1		1	1	4
XIII														
XIV														
XV	1	1			1		3	2					1	3
XVI														
TOTAL	31	12	2	1	3	2	51	21	16	5	3	2	9	56

respectively. The total number of firms of any size that employed technicians was 51 while skilled workers group size totaled 56. This indicated that not all 61 responding firms hired both technicians and skilled workers.

Table 8. Distribution of responding firms by fluid power medium and occupational level

Fluid power medium	Technicians	Skilled Workers
Hydraulics	239	398
Pneumatics	174	192
Fluidics	128	49

Table 8 identified 398 skilled workers were involved with hydraulics while 49 were involved with fluidics. This table indicated that the technician and skilled worker may work with more than one type of fluid power medium in their particular job function. One hundred seventy-four technicians and 192 skilled workers were involved with pneumatics in their respective job capacities. The fluidics fluid power medium involved 128 technicians and 49 skilled workers.

Industries employment needs

In Table 9, forty-two firms were identified as having difficulty finding qualified individuals trained in fluid power. Iowa merged area VII had eight industries respond

Table 9. Employment needs of firms employing fluid power technicians and skilled workers by merged area

Employment needs	Iowa Merged Areas															
	I	II	III	IV	V	VI	VII	IX	X	XI	XII	XIII	XIV	XV	XVI	Total
1. Difficulty finding qualified personnel	4	3	1	1	1	1	8	6	5	6	3			3		42
2. Desirability of hiring qualified personnel	5	3			1	1	9	4	4	7	3			2		39

concerning their difficulty while areas IX and XI each had six. Thirty-nine firms reported that they would hire qualified individuals if it were possible to find such an individual. Iowa merged area VII recorded nine responses to the question followed by area XI with seven and area I with five.

The data in Table 10 summarized the difficulty of finding qualified individuals trained in fluid power by medium and the desire to hire these types of individuals should they be

Table 10. Employment needs of firms employing technicians and skilled workers by fluid power medium

Employment needs	Fluid power medium		
	Hydraulics	Pneumatics	Fluidics
1. Difficulty finding qualified personnel	39	17	9
2. Desirability of hiring qualified personnel	35	14	8

available. Thirty-nine firms reported difficulty finding qualified individuals trained in hydraulics, 17 firms reported the same difficulty in pneumatics, while nine firms were listed under fluidics. Thirty-five firms reported that it would be desirable to hire qualified individuals in hydraulics if it were possible to find such individuals. In the medium of pneumatics, 14 firms suggested it would be desirable to hire qualified individuals while in fluidics only eight firms would hire qualified individuals.

According to Table 11, 16 firms indicated that "lack of applicants" was the reason for the difficulty in finding qualified individuals of which merged area VII and IX each had three responses. Twenty-six firms indicated that the applicant lacked necessary qualification as the reason for the difficulty in finding qualified individuals. Merged area VII and IX each had six firms respond while merged areas I, X, and XV had three apiece. Other reasons given for difficulty in finding qualified individuals trained in fluid power included salary requirements not fitting the job needs, the engineers do the work, need for a part-time man only in fluid power, can not afford to keep qualified men working in the fluid power area alone, hydraulics knowledge is needed only as a part of a general design and testing knowledge and a need for installers and trouble shooters only.

Table 12 categorizes the reasons for difficulty in finding qualified individuals in fluid power. Several industries are involved in more than one medium and were therefore listed more than once in the table. Sixteen industries reported that in the medium of hydraulics the reason for difficulty in finding qualified individuals

Table 11. Response as to reasons for difficulty in finding individuals qualified in fluid power by merged area

Reasons for difficulty	Iowa Merged Areas															
	I	II	III	IV	V	VI	VII	IX	X	XI	XII	XIII	XIV	XV	XVI	Total
1. Lack of applicants	1	2		1			3	3	2	1	1			2		16
2. Applicant lacks necessary qualifications	3	1				1	6	6	3	4	1			3		28
3. Other							1	1		1				1		4

Table 12. Response as to reasons for difficulty in finding individuals qualified in fluid power by medium

Reasons for difficulty	Fluid power medium		
	Hydraulics	Pneumatics	Fluidics
1. Lack of applicants	16	8	3
2. Applicant lacks necessary qualifications	26	13	6
3. Other	3	1	

trained in fluid power was a lack of applicants. Eight industries associated with pneumatics gave the same reason as did three in fluidics. Twenty-six firms involved with the hydraulics medium, 13 in the pneumatics medium and six in the fluidics medium indicate that the applicant lacked necessary qualifications as the reason for difficulty in finding qualified individuals trained in fluid power.

Employment needs

In Table 13 are listed the present and projected employment needs of fluid power technicians by merged area. The number of technicians employed in the responding industries was 254 as of April 1971. Merged area VI had 107 followed by area VII with 47 and area XI with 23. The data also indicated that by 1975, 311 technicians would be needed by the responding industries. This projected need

Table 13. Present and projected employment of fluid power technicians by merged area

Iowa merged area	Present: Number of technicians[a]	Present: Number of vacancies[a]	Projected: 1972	Projected: 1973	Projected: 1974	Projected: 1975	Change 1972-1975
I	6	2	4	5	5	6	
II	2		2	4	4	5	+3
III	2		2	2	3	3	+1
IV							
V	12	2	14	17	20	24	+12
VI	107		106	107	107	108	+1
VII	47	2	49	52	56	59	+12
IX	12	1	13	14	15	16	+4
X	22		24	27	29	30	+8
XI	23		24	26	27	31	+8
XII	7		9	10	12	12	+5
XIII							
XIV							
XV	14	1	16	17	17	17	+3
XVI							
TOTAL	254	8	263	281	295	311	+57

[a]April 1971.

represents 57 individuals or an 18.3 percent increase in the time period from 1971 to 1975. Merged areas V and VII anticipated a need for 12 technicians each, followed by areas X and XI each with eight. The number of job vacancies for fluid power technicians that existed the day the questionnaire was received totaled eight.

Data in Table 14 indicate the present and projected employment needs for fluid power skilled workers by merged area. The number of skilled workers employed in the responding industries was 420 as of April 1971. Merged area X had 99 followed by area IX with 82 and area XI with 68. The table indicated that by 1975, 559 skilled workers would be needed by the responding industries. This projected need represents 139 individuals or a 24.8 percent increase in the time period from 1971 to 1975. Merged area VII anticipated the largest gain with 37 followed by areas X and V with 29 and 19 skilled workers respectively. The number of job vacancies for skilled workers that existed the day the questionnaire was received was 16.

Table 15 identified by merged area, the current and projected replacements of fluid power technicians. Since January 1971 a total of six technicians had been replaced in 56 industries. Merged area VII and X accounted for two each. The total projected replacement of technicians from January 1971 to December 1975 was 11 individuals. Merged

Table 14. Present and projected employment of fluid power skilled workers by merged area

Iowa merged area	Present: Number of skilled workers[a]	Present: Number of vacancies[a]	Projected: 1972	Projected: 1973	Projected: 1974	Projected: 1975	Change 1972-1975
I	11	1	11	13	14	16	+5
II	11		12	18	19	24	+13
III	3		4	4	5	6	+3
IV	4		5	5	6	6	+1
V	10	2	12	17	21	29	+19
VI	4		4	4	4	5	+1
VII	71	7	84	91	100	108	+37
IX	82		81	81	81	86	+4
X	99		106	114	123	128	+29
XI	68	3	67	70	71	74	+6
XII	28	1	33	37	42	45	+17
XIII							
XIV							
XV	28	2	29	30	30	32	+4
XVI							
TOTAL	420	16	448	484	516	559	+139

[a]April 1971.

Table 15. Projected replacement needs of fluid power technicians by merged area

Iowa merged area	Replaced since January 1971	Projected replacement need: Jan.-Dec. 1971	Jan.-Dec. 1972	Jan.-Dec. 1973	Jan.-Dec. 1974	Jan.-Dec. 1975	Total projected replacement	Total number of firms
I								5
II								3
III					1		1	1
IV								2
V								2
VI								3
VII	2						2	11
IX								7
X	2			2			4	5
XI				1			1	12
XII	1	1					2	3
XIII								
XIV								
XV	1						1	2
XVI								
TOTAL	6	1		3	1		11	56

area X had the largest number of replacements with four. The time period from January to December 1973 found the industries surveyed as needing three technicians.

Table 16 summarized by merged area, the current and projected replacements of fluid power skilled workers. The number of skilled workers replaced since January 1971 was eight in 56 industries. Merged areas X and XV accounted for four and two vacancies respectively. The total projected replacements of skilled workers from January 1971 to December 1975 was 48. The largest single gain was in area XI with 15 individuals. The greatest number of projected replacements was identified at 11 in the time period between January and December 1972.

Employees ages and hours worked

An examination of Table 17 revealed that the median age for technicians employed in the responding industries was 34.7. The highest median age of 42.0 was associated with merged area XV and the lowest median age of 26.2 was associated with merged area VI. Thirty-seven percent of the technicians were in the 30 to 39 years of age bracket. Only two individuals from merged area VII were identified in the 60 to 69 age group. A total of sixteen technicians' ages were given for area VII resulting in a median age of 32.8 years.

Table 18 disclosed that the median age of 38.9 was

Table 16. Projected replacement needs of fluid power skilled workers by merged area

Iowa merged area	Replaced since January 1971	Projected replacement need Jan.-Dec. 1971	Jan.-Dec. 1972	Jan.-Dec. 1973	Jan.-Dec. 1974	Jan.-Dec. 1975	Total projected replacement	Total number of firms
I								5
II		1	1	1	1	1	5	3
III				1	1	1	3	1
IV								2
V				1			1	2
VI								3
VII	1	2	4	1	1	2	4	11
IX	1	1	1	1	1	1	6	6
X	4	4	3	3	1		15	5
XI			1	1	1	1	4	12
XII			1				1	4
XIII								
XIV								
XV	2						2	2
XVI								
TOTAL	8	8	11	9	6	6	48	56

Table 17. Distribution of fluid power technicians by age categories and merged area

Iowa merged area	Age categories: 20-29 years	30-39 years	40-49 years	50-59 years	60-69 years	Total	Median age
I	1	1	2			2	39.5
II	1	1				2	29.5
III	1	3				4	32.8
IV							
V	2	2	2	1		7	37.0
VI	3	1				4	26.2
VII	6	6	1	1	2	16	32.8
IX	2	1		2		5	34.5
X	2	1	3	1		7	41.2
XI	2	6	2	1		11	35.3
XII		3		1		4	36.2
XIII							
XIV							
XV	2	1	2	2		7	42.0
XVI							
TOTAL	22	26	12	9	2	71	34.7
Percent	31.7	37.7	17.2	12.9	.5	100.0	

Table 18. Distribution of fluid power skilled workers by age categories and merged area

Iowa merged area	Age categories 20-29 years	30-39 years	40-49 years	50-59 years	60-69 years	Total	Median age
I	3	1	4			8	39.5
II	5	4	2			11	30.8
III							
IV	1	4				5	33.3
V	2	4	1	1	1	9	35.8
VI		1	2	2		5	47.0
VII	14	20	18	14	3	69	39.7
IX		11	7	3		21	39.0
X	11	2	7	1	1	22	29.5
XI	2	19	16	8		45	40.4
XII	5	4	3	3	1	16	35.8
XIII							
XIV							
XV	3	7	8	8		26	43.3
XVI							
TOTAL	46	77	68	40	6	237	38.9
Percent	19.6	32.8	30.3	17.0	.3	100.0	

given for skilled workers in the responding industries. The highest median age was 47.0 reported by merged area VI and the lowest median age of 29.5 was associated with merged area X. Thirty-two percent of the skilled workers were found in the 30 to 39 age bracket, followed by 30 percent for the 40 to 49 age group of the 237 employees listed by age in the table. Sixty-nine skilled workers were in merged area VII where the median age was 39.7.

Tables 19 and 20 were developed to depict by Iowa merged area and employee firm size, the average hours per week technicians worked directly with fluid power. At first glance it is evident that no technicians were listed under the 30 to 39 average hours per week group in either table.

Table 19 indicated that 33.4 percent or 15 of the 45 technicians listed, worked directly with fluid power less than 10 hours per week. Eleven or 24.4 percent of the technicians listed, worked 40 or more hours directly with fluid power each week. The highest median average hours per week the technicians worked directly with fluid power was 39.9 in merged area XII. The lowest median average hours per week was 17.0 identified with merged areas I, VI and XV. The overall median average hours per week technicians worked directly with fluid power was 17.0

Table 20 disclosed that industries employing 1-2 technicians had them work an average median number of 20.1

Table 19. Hours per week technicians work directly with fluid power by merged area

Iowa merged area	Less than 10	10-19	20-29	30-39	40 or more	Total number of technicians	Median
I	2		1			3	17.0
II			2			2	24.5
III			1			1	24.5
IV							
V		1			1	2	29.5
VI	2	1				3	17.0
VII	2	4	2		3	11	18.3
IX	1	1	1		1	4	19.5
X		1	2		1	4	24.5
XI	5	1			2	8	17.5
XII	1				3	4	39.9
XIII							
XIV							
XV	2	1				3	17.0
XVI							
TOTAL	15	10	9		11	45	17.0
Percent	33.4	22.2	20.0		24.4	100	

Table 20. Hours per week technicians work directly with fluid power by firm size

Firm size by employed technicians	Less than 10	10-19	20-29	30-39	40 or more	Total number of technicians	Median
1-2 technicians	8	5	8		6	27	20.1
3-4 technicians	4	4	1		2	11	13.3
5 6 technicians	1				1	2	24.5
7-8 technicians					1	1	44.5
9-10 technicians	1				1	2	24.5
over 10 technicians	1	1	—	—	—	2	9.5
TOTAL	15	10	9		11	45	17.0
Percent	33.4	21.5	20.2		24.9	100.0	

hours per week directly with fluid power. Table 20 also showed that the largest percent of technicians or 33.4 percent were in the less than 10 average hours per week group, followed by 24.9 percent of the technicians in the 40 or more hours per week group.

Tables 21 and 22 were developed to depict by Iowa merged area and employee firm size, the number of hours per week skilled workers worked directly with fluid power.

Table 21 indicated that 33.4 percent or 17 of the 51 skilled workers listed, worked directly with fluid power 40 or more average hours per week. Fourteen individuals representing 27.5 percent of the skilled workers worked less than 10 hours per week with fluid power, while only 9.8 percent of the workers were listed as working 30 to 39 average hours per week directly with fluid power. The overall median average hours per week worked by the 51 skilled workers was 23.7 percent as listed in the table. Merged area XII listed all four of its skilled workers in the 40 or more average hours bracket. Both areas V and VI had median average hours per week worked by employed skilled workers at 29.5 each.

Table 22 disclosed that the firm size employing 1-2 skilled workers had 18 individuals working an average median number of 29.5 hours per week directly with fluid power. The table also showed that the minimum average median hours per week worked directly in the fluid power by skilled

Table 21. Hours per week skilled workers work directly with fluid power by merged area

Iowa merged area	Less than 10	10-19	20-29	30-39	40 or more	Total number of skilled workers	Median
I	2		1		1	4	14.5
II		1	1		1	3	24.5
III							
IV	1			1		2	19.5
V		1			1	2	29.5
VI		1			1	2	29.5
VII	2	3	1	1	4	11	24.5
IX	2	1		1	1	5	14.5
X			2	1	3	6	39.5
XI	5	2	1		1	9	18.5
XII					4	4	39.9
XIII							
XIV							
XV	2			1		3	17.0
XVI							
TOTAL	14	9	6	5	17	51	23.7
Percent	27.5	17.6	11.7	9.8	33.4	100	

Table 22. Hours per week skilled workers work directly with fluid power by firm size

Firm size by employed skilled workers	Less than 10	10-19	20-29	30-39	40 or more	Total number of skilled workers	Median
1-2 skilled workers	4	4	1	3	6	18	29.5
3-4 skilled workers	4	3	4		3	14	19.5
5-6 skilled workers	2	1	1	1	1	6	19.5
7-8 skilled workers	1				1	2	24.5
9-10 skilled workers		1			1	2	29.5
over 10 skilled workers	3	—	—	1	5	9	39.6
TOTAL	14	9	6	5	17	51	23.7
Percent	27.5	17.7	11.7	9.7	33.4	100	

workers were firms employing 3-4 persons and 5-6 persons, was 19.5 hours each. A total of 17 individuals representing 33.4 percent of the skilled workers were listed in the 40 or more hours per hour bracket.

Sources of and attitudes toward fluid power training

Tables 23 and 24 summarized the sources of training that technicians had received in fluid power.

According to Table 23, 25.1 percent of the 79 technicians received training on the job, while 18.7 and 15.1 percent received fluid power training in college technical programs and manufacturing training schools respectively. Firms employing 1-2 technicians indicated that a total of 40 individuals received some type of fluid power training, while in the over 10 firm size category, only four persons were listed as having received some fluid power training. A few firms indicated that their technicians had received more than one type of fluid power training and thereby identified more than one source. No other sources of training were identified by the respondents.

Table 24 disclosed that a greater number of the technicians received training in fluid power while on the job than in college technical programs identified as 25.1 percent and 20.2 percent respectively. Only 9.1 percent of the technicians received some fluid power training in the military service schools. Iowa merged area VII had the

Table 23. Source of training of fluid power technicians by firm size

Firm size by employed technicians	H.S. Vocational courses	Area school	Mfg. training school	Military Service school
1-2 technicians	2	5	6	1
3-4 technicians	1	2	2	3
5-6 technicians	2	1		1
7-8 technicians				
9-10 technicians	1	2	3	1
over 10 technicians	—	1	1	1
TOTAL	6	11	12	7
Percent	8.5	13.6	15.1	9.1

On-the-job training	Corre-spondence courses	College technical programs	Other source of training	Total
12	4	10		40
6	2	2		18
1	1	1		7
1	1	1		10
—	—	1	—	4
20	8	15		79
25.1	9.9	18.7		100.0

Table 24. Source of training of fluid power technicians by merged area

Iowa merged area	H.S. Vocational courses	Area school	Mfg. training school	Military Service school
I				1
II	1	1	1	
III			1	
IV				
V			1	
VI		1	1	1
VII	2	3	3	2
IX	2	1	1	1
X		1		
XI		2	2	
XII		1		1
XIII				
XIV				
XV	1	1	1	1
XVI	—	—	—	—
TOTAL	6	11	11	7
Percent	8.5	13.6	13.6	9.1

On-the-job training	Correspondence courses	College technical programs	Other sources of training	Total
				3
2		1		6
1		1		3
		1		2
	1	1		5
6	1	2		19
2	1	1		9
2	2	2		7
3	2	4		13
1		2		5
1	1	1		7
—	—	—	—	—
20	8	16		79
25.1	9.9	20.2		100.0

largest number of technicians, a total of 19, with some form of training in fluid power. Other selected merged areas from the table, indicating some form of fluid power training were XI and IX with 13 and nine technicians respectively.

Tables 25 and 26 summarized the sources of training in fluid power that skilled workers had received.

According to Table 25, 50.6 percent of the skilled workers received training on-the-job while 16.0 and 10.3 percent received training by college technical programs and manufacturing training schools respectively. Firms employing over 10 skilled workers indicated that a total of 157 individuals received some type of fluid power training. All 10 skilled workers listed in the over 10 category, received their fluid power training on-the-job.

Table 26 disclosed that 177 or 50.6 percent of the skilled workers received training in fluid power while on-the-job. The second largest single training program category is college technical programs of which 16.3 percent of the skilled workers received fluid power training. Less than two percent of the skilled workers received training through correspondence courses. Iowa merged area XV identified 81 skilled workers with some form of fluid power training, followed by area X with 58 and VII with 53.

According to Table 27 a total of 88 technicians would benefit from part-time fluid power programs. Those tech-

Table 25. Source of training of fluid power skilled workers by firm size

Firm size by employed skilled workers	H.S. Vocational courses	Area school	Mfg. training school	Military Service school
1-2 skilled workers	2	2	5	3
3-4 skilled workers	6			7
5-6 skilled workers	2	10		15
7-8 skilled workers	2	8	4	4
9-10 skilled workers				
over 10 skilled workers	—	22	24	—
TOTAL	12	34	37	29
Percent	3.3	9.7	10.3	8.4

On-the-job training	Corre-spondence courses	College technical programs	Other source of training	Total
18		32		62
29				42
24		2		53
15				29
10				10
81	6	24	—	157
177	6	56		351
50.6	1.7	16.0		100.0

Table 26. Source of training of fluid power skilled workers by merged area

Iowa merged area	H.S. Vocational courses	Area school	Mfg. training school	Military Service school
I			1	
II	2		1	
III				
IV				
V			8	
VI				1
VII		10		18
IX	4			4
X		22		
XI	4	2	2	
XII				1
XIII				
XIV				
XV			25	1
XVI				
TOTAL	10	34	37	29
Percent	3.0	9.7	10.3	8.4

On-the-job training	Corre-spondence courses	College technical programs	Other sources of training	Total
6		30		37
8		2		13
				4
		2		10
2				3
25				53
32				40
36				58
16				24
27				28
25	6	24	—	81
177	6	58		351
50.6	1.7	16.3		100.0

Table 27. Attitude toward training needs of fluid power technicians by respondent by merged area (N = 254)

Iowa merged area	Number of technicians who would benefit from part-time programs	Number of technicians who would have an interest in attending part-time programs
I	3	3
II	2	2
III	2	2
IV		
V	15	15
VI	4	2
VII	19	12
IX	3	3
X	9	6
XI	7	34
XII	7	56
XIII		
XIV		
XV	17	5
XVI		
TOTAL	88	139
Percent of all technicians employed April 1971	34.6	54.7

nicians represented 34.6 percent of all technicians employed in the responding industries. Nineteen technicians were from merged area VII, 15 from area V and nine from area X. It was suggested that a total of 139 technicians would probably attend part-time training programs in fluid power. That figure represents 54.7 percent of all the technicians employed. Fifty-six were from merged area XII, 34 from area XI, and 15 from area V.

An examination of Table 28 revealed that there were 205 skilled workers who would benefit from part-time programs in fluid power. This figure represents 48.8 percent of the total number of skilled workers employed as of April 1971. Merged area XI had the largest number with 48 skilled workers followed by area XV with 30, and 29 each for merged areas VII and X. It was suggested that a total of 121 or 28.8 percent of the skilled workers would probably attend the part-time training programs. Of the total number listed, merged area XI indicated 41 skilled workers would probably attend, while area VII and area X suggested 18 and 13 respectively.

Data in Table 29 disclosed by merged area, the numbers and types of programs that were desired to train individuals in fluid power. Because each respondent was asked to identify one or more types of programs, the overall total in the table exceeds the number of firms returning useable questionnaires. Evening programs were the most popular with 37 followed by workshops with 26 and seminars with 19 listings. No other type of program was suggested by the respondents.

Table 28. Attitude toward training needs of fluid power skilled workers by respondent by merged area (N = 420)

Iowa merged area	Number of skilled workers who would benefit from part-time programs	Number of skilled workers who would have an interest in attending part-time programs
I	8	8
II	7	4
III		
IV	4	
V	10	10
VI	2	1
VII	29	18
IX	28	4
X	29	13
XI	48	41
XII	10	2
XIII		
XIV		
XV	30	20
XVI	—	—
TOTAL	205	121
Percent of all skilled workers employed April 1971	48.8	28.8

Table 29. Programs desired by the firm to train individuals in fluid power as reported by respondent

Iowa merged area	Types of programs Evening	Seminar	Workshop	Full-time	Other
I	2	2	5		
II	3	1	1		
III	1	1	1		
IV	1				
V	1	1			
VI	1	1	1		
VII	9	5	4	1	
IX	3	1	4	2	
X	5	3	3		
XI	6	2	4		
XII	3	1	1		
XIII					
XIV					
XV	2	1	2		
XVI					
TOTAL	37	19	26	3	

Table 30 examined the number of in-service training programs in fluid power offered by the industries surveyed by merged area. It was found that a total of 22 industries representing 36 percent of those surveyed, do offer in-service training programs in fluid power for their employees. Twenty-five industries representing 41 percent of those surveyed, consented to host such a program at their facility.

Table 30. Number of firms who offer or would host in-service fluid power training programs by merged area (N = 61)

Iowa merged area	Number who offer in-service training programs	Number who would host in-service training programs at their facility
I	2	3
II	1	1
III	1	
IV		
V	1	1
VI	1	1
VII	3	8
IX	3	1
X	2	2
XI	3	3
XII	3	3
XIII		
XIV		
XV	2	2
XVI		
TOTAL	22	25
Percent of industries surveyed	36	41

Areas where currently employed individuals work

According to the data presented in Table 31, a total of 160 job responsibilities were identified where qualified technicians could be employed in the responding industries. Several of the industries identified more than one area.

Table 31. Areas in which fluid power technicians work in responding firms by medium

Area	Fluid power medium Hydraulics	Pneumatics	Fluidics	Total
Research	15	4		19
Design	30	11	4	45
Manufacture	14	2	1	17
Installation	16	6	4	26
Maintenance	17	8	5	30
Operation	6	3	2	11
Sales	4	3		7
Others	3	1	1	5
TOTAL	105	38	17	160
Percent	65.7	23.7	10.6	100.0

Design is the largest single interest area with 45 listings followed by installation with 30 and manufacture with 26. The hydraulics medium had 105 listings representing 65.7 percent of the total. Pneumatics was next with 38 listings representing 23.7 percent and fluidics 17 for 10.6 percent of the total. Other areas of interest included cost analysis and service.

Table 32 identified a total of 151 listings in various job responsibilities where qualified skilled workers could be employed in the responding industries. In hydraulics,

Table 32. Areas in which fluid power skilled workers work in responding firms by medium

Area	Fluid power medium Hydraulics	Pneumatics	Fluidics	Total
Research	5	1		6
Design	8	1		9
Manufacture	16	3	1	20
Installation	20	5	1	26
Maintenance	27	12	2	41
Operation	6	2		8
Sales	8	1	30	39
Others	2	—	—	2
TOTAL	92	25	34	151
Percent	60.9	16.7	22.4	100.0

92 or 60.9 percent of the listings were identified while pneumatics had 25 for 16.7 percent and fluidics had 34 for 22.4 percent of the total. A total of 41 maintenance listings were realized followed by operation with 29. A total of six listings were made for skilled workers in research covering all three mediums.

Table 33 disclosed the areas where currently employed fluid power technicians work by medium. Because the technicians job responsibilities require the individual to function in more than one capacity at the same time, several

Table 33. Areas in which fluid power technicians work by responding firms by area of interest and merged area

Area	Iowa Merged Area															Total
	I	II	III	IV	V	VI	VII	IX	X	XI	XII	XIII	XIV	XV	XVI	
Research	5	3	1	2	1	2	7	6	5	9	2			2		45
Design	4	3		1		1	4	3	3	7				1		27
Manufacture	3	3		1		2	8	5	6	11	3			3		45
Installation	3	1	1	1	2	3	6	5	7	8	3			3		43
Maintenance	2	2		1	1	3	8	4	5	6	4			2		42
Operation	5	2	1	2	2	3	10	6	7	6	4			3		55
Sales	5	3	1	1	2	3	11	5	7	12	3			3		56
Other	5	3	1	2	2	2	12	6	7	12	3			3		58
TOTAL	32	20	5	11	10	19	66	40	47	79	22			20		371

of the responding industries checked more than one area of interest for their employees. A total of 371 combinations of areas of interest were listed. Sales was identified with 56, while 27 positions were identified in design. Other areas of interest included cost analysis and service Iowa merged area XI had the largest number of positions identified at 79 with area VII having 66 and area X with 47.

The data in Table 34 identified by fluid power medium, the areas where currently employed fluid power skilled workers work. Because the job responsibilities of skilled workers involve more than one function at the same time, several of the responding industries identified more than one area of interest for their employees. A total of 394 combinations of areas of interest were listed. Areas of interest defined as research, design, operation, sales, and the other category each had more than 50 position listings. Merged area XI identified 78 positions while area VII, X, and IX had 74, 48, and 47 listings respectively.

Areas where newly hired individuals would work

According to Table 35, hydraulics is the single largest medium where industries involved in fluid power desired technicians to work. Pneumatics listed 36 and fluidics was identified with 14 positions. Design was identified as the most popular area of interest with 41 technicians listed. The least popular area of interest was identified as sales.

Table 34. Areas in which fluid power skilled workers work by responding firms by area of interest and merged area

Area	Merged Area															Total
	I	II	III	IV	V	VI	VII	IX	X	XI	XII	XIII	XIV	XV	XVI	
Research	4	3	1	2	2	1	10	7	7	12	4			2		55
Design	3	3	1	2	2	3	12	5	6	11	3			2		53
Manufacture	3	2		2	1	2	8	6	3	11	2			2		42
Installation	3	1	1	1	1	3	6	5	6	8	2			3		40
Maintenance	4	2		1		3	5	3	5	5	1			3		32
Operation	5	3	1	2	2	3	9	7	7	9	4			3		55
Sales	5	2		2	2	3	12	7	7	11	3			3		57
Other	5	3	1	2	2	3	12	7	7	11	4			3		60
TOTAL	32	19	5	14	12	21	74	47	48	78	23			21		394

Nine listings were indicated in that category.

Table 35. Number of firms indicating the medium where they would desire fluid power technicians to work by area of interest

Area	Fluid power medium Hydraulics	Pneumatics	Fluidics	Total
Research	10	3		13
Design	29	10	2	41
Manufacture	9	3		12
Installation	21	7	4	32
Maintenance	14	6	4	34
Operation	9	5	3	17
Sales	6	2	1	9
Other				
TOTAL	98	36	14	148

Table 36 disclosed that there were 158 desired positions where fluid power skilled workers would work. The responding industries identified 105 hydraulic, 38 pneumatic and 15 fluidic positions by fluid power medium. Maintenance was the most popular area of interest with 44 followed by installation, operation and manufacture with 37, 26 and 23 respectively. One other area of interest was checked but not identified by title.

Table 36. Number of firms indicating the medium where they would desire fluid power skilled workers to work by area of interest

Area	Fluid power medium Hydraulics	Pneumatics	Fluidics	Total
Research	8	1		9
Design	8	2		10
Manufacture	17	4	2	23
Installation	25	8	4	37
Maintenance	27	12	5	44
Operation	15	8	3	26
Sales	4	3	1	8
Other	1	—	—	1
TOTAL	105	38	15	158

Tables 37 and 38 identified by merged area, the desired fluid power technician and skilled worker occupational positions listed by the responding industries.

A total of 99 positions were desired in the hydraulics medium for technicians with 34 listed for pneumatics and 13 in fluidics. Table 38 revealed that merged area VII had a total of 34 positions in all mediums while area XI had 28 and area IX had 26 listings each. Area IV identified only one position in hydraulics for a fluid power technician.

Table 38 revealed that there were 95 positions desired in the hydraulics medium for skilled workers while pneumatics

Table 37. Number of firms indicating the medium in which they would desire fluid power technicians to work by merged area

Iowa merged area	Fluid power medium			Total
	Hydraulics	Pneumatics	Fluidics	
I	3		2	5
II	8	3	3	14
III				
IV	1			1
V	5			5
VI	2	2		4
VII	28	2	4	34
IX	15	11		26
X	11	1		12
XI	14	10	4	28
XII	7	2		9
XIII				
XIV				
XV	6	3	—	10
TOTAL	99	34	13	148

and fluidics each had 38 and 15 respectively. Iowa merged area VII listed 24 positions in hydrualics, six in pneumatics and four in fluidics for a total of 34. Other merged areas listing over 30 skilled worker positions by fluid power medium were XI and IX.

Table 38. Number of firms indicating the medium in which they would desire fluid power skilled workers to work by merged area

Iowa merged area	Fluid power medium			Total
	Hydraulics	Pneumatics	Fluidics	
I	6	1		7
II	7	3	3	13
III			3	3
IV	2			2
V	5			5
VI	1	1		2
VII	24	6	4	34
IX	17	14		31
X	9			9
XI	19	8	5	32
XII	7	5		12
XIII				
XIV				
XV	5	3		8
XVI				
TOTAL	95	38	15	158

Information Related to Knowledge and Skill Requirements Needed of Individuals in Fluid Power

This section described the findings concerned with the various items of knowledge and skills needed by technicians and skilled workers in fluid power. The items were divided into seven major categories. They were: (1) importance of communications skills, (2) importance of mathematics, (3) importance of supporting technical information, (4) importance of hydraulics and related information, (5) importance of pneumatics and related information, (6) importance of fluidics and related information, and (7) importance of maintenance and safety. Each of these categories had a rating scale and a statistical mean value used to associate a numerical quantity to the importance of each particular item. No other topic items were listed in the various categories by the respondents. The scale was as follows: (1) very little importance, (2) background knowledge only, (3) desirable, (4) highly desirable, and (5) essential.

The items in each table were presented in descending order of importance as determined by their respective mean ratings. The rating most often listed by the respondent.

Importance of communication skills

Tables 39 and 40 summarized the data concerning the importance of communications skills for fluid power technicians and skilled workers.

Table 39. Importance of communications skills to fluid power technicians, as reported by supervisor (N = 52)

Topic Item	Rating 1	2	3	4	5	Mean
Skill in listening			11	14	27	4.31
Skill in reading			11	17	24	4.25
Skill in speaking		1	18	20	13	3.94
Ability to write reports and letters	3		13	18	18	3.92
Knowledge of sentence structure	3	3	26	11	9	3.38
Good spelling skills	2	3	27	14	5	3.35
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

In Table 39, "skills in listening" rated highest for technicians with a mean rating of 4.31. The next most important skill in communications was identified as "reading" with a 4.25 mean rating. The least important topic item was identified as "good spelling skills" which rated a mean of 3.35.

According to Table 40, "skill in listening" was identified as the most important communication skill for

Table 40. Importance of communications skills to fluid power skilled workers as reported by supervisor (N = 57)

Topic Item	Rating 1	2	3	4	5	Mean
Skill in listening		3	22	16	16	3.79
Skill in reading		4	27	15	11	3.58
Skill in speaking	3	11	30	10	3	2.98
Ability to write reports and letters	12	8	27	6	4	2.68
Good spelling skills	9	11	31	5	1	2.61
Knowledge of sentence structure	15	11	22	5	4	2.51
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

skilled workers with a mean rating of 3.79. The next most important communication skill in the table was identified as "skill in reading" with 3.50 followed by "skill in speaking" with a mean rating of 2.98. The least important item identified was "knowledge in sentence structure" with a 2.51 mean rating.

Importance of mathematics

Information in Tables 41 and 42 revealed the importance of mathematics for fluid power technicians and skilled workers.

Table 41. Importance of mathematics to fluid power technicians, as reported by supervisor (N = 52)

Topic Item	Rating 1	2	3	4	5	Mean
Arithmetic			5	10	37	4.62
Basic slide rule	1	1	9	14	27	4.25
Fundamental Algebra	4	1	8	13	26	4.07
Geometry	2	2	15	11	22	3.94
Ratio, proportion variations	3	2	18	14	15	3.69
Trigonometry	4	4	19	11	14	3.52
Exponents, radicals and complex numbers	6	6	20	10	10	3.23
Logarithms	6	9	17	7	13	3.23
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 41 identified "arithmetic", "basic slide rule" and "fundamental algebra" as the three most important items in mathematics for technicians. The mean rating for these three were 4.62, 4.25 and 4.07 respectively. The lowest rated item was "logarithms" with a mean of 3.23.

Table 42. Importance of mathematics to fluid power skilled workers, as reported by supervisor (N = 57)

Topic Item	Rating					Mean
	1	2	3	4	5	
Arithmetic	5	10	18	9	15	3.33
Basic slide rule	16	18	17	3	3	2.28
Fundamental Algebra	17	18	17	3	2	2.21
Geometry	17	19	17	2	2	2.18
Trigonometry	21	22	11	1	2	1.96
Exponents, radicals and complex numbers	26	20	7	2	2	1.84
Logarithms	27	19	8	1	2	1.81
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 42 disclosed that "arithmetic" was the most important item in mathematics for skilled workers to know. The overall mean rating for this item was 3.33. "Logarithms" and "exponents, radicals and complex numbers" received the two lowest ratings with 1.81 and 1.84 respectively.

Importance of supporting technical information

Tables 43 and 44 provided the data concerning the importance of supporting technical information for fluid power technicians and skilled workers.

Table 43 revealed that the "blueprint reading" topic item had the highest average rating in the category for fluid power technician. Other topics in the supporting technical information category that had a highly desirable rating were "drafting", "machine design" and "principles relating to mechanical advantage". The lowest rated topic item was "electro-mechanical machines and controls" with a mean value of 3.57.

Table 44 disclosed that only "blueprint reading" was rated highly desirable for fluid power skilled workers with an overall mean rating of 4.21. "Machine design" had the lowest rating in the supporting technical information category with a 2.12 mean rating.

Table 43. Importance of supporting technical information to fluid power technicians as reported by supervisor (N = 53)

Topic Item	Rating 1	2	3	4	5	Mean
Blueprint reading			3	8	42	4.74
Drafting		2	11	12	28	4.25
Machine design	1	2	14	22	14	4.25
Principles relating to mechanical advantage	1	2	9	18	23	4.13
Strength of materials	1	1	13	22	16	3.96
Industrial materials and processes	1	1	15	22	14	3.89
Physics	2	2	15	16	18	3.87
Machining processes	2	1	18	19	13	3.74
Principles of electricity	3	6	10	19	15	3.70
Electro-mechanical machines and control	4	5	14	17	13	3.57
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 44. Importance of supporting technical information to fluid power skilled workers as reported by supervisor (N = 57)

Topic Item	Rating 1	2	3	4	5	Mean
Blueprint reading	1	3	10	12	31	4.21
Machining processes	11	10	19	9	8	2.88
Principles relating to mechanical advantage	11	12	21	9	4	2.70
Industrial materials and processes	13	12	22	6	4	2.58
Principles of electricity	13	13	20	8	3	2.56
Electro-mechanical machines and control	17	16	17	6	1	2.44
Physics	16	16	17	5	3	2.35
Strength of materials	19	15	14	8	1	2.25
Drafting	18	17	14	7	1	2.23
Machine design	19	19	13	5	1	2.12
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Importance of hydraulics and related information

Tables 45 and 46 provided the data concerning the importance of the knowledge of hydraulics and related information for the fluid power technician and skilled worker.

Table 45 revealed that the topics "relationship of force, pressure and area", "fluid flow concepts", "volumes and displacement", "system capacities" and "cylinder displacement" had average ratings of highly desirable for the fluid power technicians. "Reynold's equation" and "Darcy's formula" received the lowest ratings, suggesting that they were only desirable knowledge.

Table 46 disclosed that for skilled workers "relationship of force, pressure and area" was the only topic item rated desirable with a 3.15 mean. The two lowest rated topic items were "Reynold's equation" and "Darcy's formula" with means of 1.83 and 1.85 respectively.

Tables 47 and 48 disclosed the importance of the knowledge of power fluids and fluid conditioning for fluid power technicians and skilled workers.

Knowledge of "strainers and filters" was rated most important in the fluids and fluid conditioning category, with a mean value of 3.78. "Strainers and filters" and "heat exchangers" ranked second and third each with a mean rank of 3.72. "Fire resistant fluids" was lowest in the category with a mean value of 3.22 which suggested that

Table 45. Importance of the principles of hydraulics to fluid power technicians as reported by supervisor (N = 51)

Topic Item	Rating 1	2	3	4	5	Mean
Relationship of force, pressure and area		1	4	7	39	4.65
Fluid flow concepts		2	4	14	31	4.45
Volumes and displacement	1	2	7	14	27	4.25
Cylinder displacement	1	3	6	15	26	4.22
System capacities	2	2	9	19	19	4.00
Bernoulli's equation	6	3	9	18	15	3.65
Laminar and turbulent flow	6	3	11	17	14	3.59
Continuity equation	9	2	14	15	11	3.33
Toricelli's theorem	9	2	17	13	10	3.25
Hagen Poiseville Law for Laminar flow	8	5	17	11	10	3.20
Reynold's number	8	6	19	8	10	3.12
Reynold's equation	8	6	20	7	10	3.10
Darcy's formula	8	7	19	7	10	3.10
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 46. Importance of the principles of hydraulics to fluid power skilled workers as reported by supervisor (N = 54)

Topic Item	Rating 1	2	3	4	5	Mean
Relationship of force, pressure and area	7	8	22	4	13	3.15
Fluid flow concepts	9		19	6	8	2.85
Cylinder displacement	9	14	19	6	6	2.74
Volumes and displacement	11	11	20	7	5	2.70
System capacities	12	11	23	4	4	2.57
Laminar and turbulent flow	22	16	10	4	2	2.04
Continuity equation	23	13	13	4	1	2.02
Bernoulli's equation	23	15	11	4	1	1.98
Hagen Poiseville Law for Laminar flow	22	17	12	2	1	1.94
Toricelli's theorem	24	16	10	3	1	1.91
Reynold's number	24	17	11	1	1	1.85
Darcy's formula	24	17	11	1	1	1.85
Reynold's equation	25	16	11	1	1	1.83
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 47. Importance of power fluids and fluid conditioning to fluid power technicians as reported by supervisor (N = 50)

Topic Item	Rating 1	2	3	4	5	Mean
Strainers and filters	2	5	12	14	17	3.78
Hydraulic reservoirs	2	5	14	13	16	3.72
Heat exchangers	2	4	14	13	16	3.72
Base fluids	1	6	18	12	13	3.60
Oxidation, rust and foaming	2	6	15	16	11	3.56
Petroleum base fluids	2	7	17	12	12	3.50
Anti-wear properties	4	5	14	18	9	3.46
Viscosity index and control	3	7	15	17	8	3.40
Pour point	5	5	16	15	9	3.36
Chemical reactions	5	7	16	15	7	3.24
Fire resistant fluids	5	7	17	14	7	3.22
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

that it was desirable knowledge.

Table 48 indicated that all topic items for fluid power skilled workers, are considered "background knowledge only". The highest individually ranked item was "strainers and filters" at 2.72. The lowest individually ranked item was "chemical reactions" with 2.09.

The data in Tables 49 and 50 were concerned with the importance of the knowledge of hydraulic power distribution for fluid power technicians and skilled workers.

All but one of the topic items listed in Table 49 had a rating of "highly desirable" for technicians. All but one item had the majority of responses in the number 5 rating column. The highest individual topic item mean rating was "operating pressures" with 4.42. The lowest topic item, "vibration", had a 3.92 mean rating.

The two most important topic items listed in Table 50 for fluid power skilled workers were "connectors and installation" and "operating pressures" with means of 3.18 and 3.10. The lowest mean rating of 2.61 was given for "vibration".

The data in Tables 51 and 52 described the importance of the knowledge of sources of hydraulic power for fluid power technicians and skilled workers.

Information in Table 51 revealed that the importance of all but two of the topic items related to sources of

Table 48. Importance of power fluids and fluid conditioning to fluid power skilled workers as reported by supervisor (N = 53)

Topic Item	Rating 1	2	3	4	5	Mean
Strainers and filters	12	14	13	5	9	2.72
Hydraulic reservoirs	13	15	13	7	5	2.55
Base fluids	13	15	16	5	4	2.47
Heat exchangers	14	16	13	5	5	2.45
Petroleum base fluids	18	15	12	5	3	2.25
Oxidation, rust and foaming	16	16	16	3	2	2.23
Fire resistant fluids	16	17	16	2	2	2.19
Viscosity index and control	20	12	17	2	2	2.13
Anti-wear properties	17	17	15	3	1	2.13
Pour point	19	17	12	3	2	2.09
Chemical reactions	18	20	9	4	2	2.09
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 49. Importance of hydraulic power distribution to fluid power technicians as reported by supervisor (N = 48)

Topic Item	Rating 1	2	3	4	5	Mean
Operating pressures		1	6	13	28	4.42
Pressure drop		1	8	15	24	4.29
Tubing and flexible hoses		1	9	17	21	4.21
Fluid velocity		1	8	20	19	4.19
Connectors and installation		1	12	13	22	4.17
Vibration	1	1	16	13	17	3.92
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 50. Importance of hydraulic power distribution to fluid power skilled workers as reported by supervisor (N = 51)

Topic Item	Rating 1	2	3	4	5	Mean
Connectors and installation	5	8	21	7	10	3.18
Operating pressures	6	9	20	6	10	3.10
Tubing and flexible hoses	5	8	24	5	9	3.10
Pressure drop	6	13	19	7	6	2.88
Fluid velocity	9	13	21	3	5	2.65
Vibration	11	12	17	8	3	2.61
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 51. Importance of sources of hydraulic power to fluid power technicians as reported by supervisor (N = 50)

Topic Item	Rating 1	2	3	4	5	Mean
Input horsepower	1	1	7	13	28	4.32
Positive displacement pumps	1	3	8	19	19	4.04
Pump design, theory and classes	1	3	10	18	18	3.98
Fixed delivery pumps	2	1	11	21	15	3.92
Variable volume pumps	3	1	11	19	16	3.88
Gear type pumps	2	2	12	19	15	3.86
Vane type pumps	2	2	13	18	15	3.84
Piston pump	3	1	13	18	15	3.82
Non-positive displacement pumps	3	2	12	19	14	3.78
Screw type pumps	5	4	12	16	13	3.56
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 52. Importance of sources of hydraulic power to fluid power skilled workers as reported by supervisor (N = 53)

Topic Item	Rating 1	2	3	4	5	Mean
Gear type pumps	12	16	15	6	4	2.51
Vane type pumps	12	17	14	6	4	2.49
Piston pumps	12	15	18	4	4	2.49
Positive displacement pumps	12	18	14	5	4	2.45
Fixed delivery pumps	12	19	12	6	4	2.45
Variable volume pumps	13	18	13	5	4	2.42
Input horsepower	12	19	11	7	4	2.40
Pump design, theory and classes	15	17	13	5	3	2.32
Non-positive displacement pumps	13	19	14	5	2	2.32
Screw type pumps	15	20	11	4	3	2.25
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

hydraulic power for fluid power technicians were "desirable". The two most important items in this category were "input horsepower" and "positive displacement pumps". The average mean values assigned these items were 4.32 and 4.04 respectively. The least important single item was "screw type pumps" with a mean of 3.56.

Information in Table 52 revealed that the importance of all of the topic items related to sources of hydraulic power for fluid power skilled workers had a rating of "background knowledge only". The highest rated item was "gear type pumps" with a 2.51 while the lowest rated item was "screw type pumps" with a 2.25.

The data in Tables 53 and 54 were concerned with the importance of the knowledge of the control of hydraulic power for fluid power technicians and skilled workers.

All but one of the topic items in the "control of hydraulic power for fluid power technicians" category had a mean value greater than 4.00. "Pressure controls" and "flow control valves" each had a 4.28 mean, while "directional control valves" was assigned a mean value of 4.26. All of the topic items received most of their numerical ratings in the 5 column. See Table 53.

All of the topic items in the "control of hydraulic power for fluid power skilled workers" category had a "background knowledge only" rating. The most important topic

Table 53. Importance of control of hydraulic power to fluid power technicians as reported by supervisor (N = 50)

Topic Item	Rating 1	2	3	4	5	Mean
Pressure controls		1	8	17	24	4.28
Flow control valves		1	9	15	25	4.28
Directional control valves		2	8	15	25	4.26
Restrictors		1	9	18	22	4.22
Pressure-compensated flow control		2	10	15	23	4.18
Deceleration flow control	3	2	13	14	18	3.84
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 54. Importance of control of hydraulic power to fluid power skilled workers as reported by supervisor (N = 53)

Topic Item	Rating 1	2	3	4	5	Mean
Pressure controls	8	12	19	7	7	2.87
Flow control valves	9	13	21	5	5	2.70
Directional control valves	10	13	19	6	5	2.68
Restrictors	9	14	21	6	3	2.62
Pressure-compensated flow control	13	14	15	9	2	2.49
Deceleration flow control	17	15	14	5	2	2.25
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

item was "pressure controls" with a mean value of 2.87 followed by "directional control values" with 2.70 and "flow control valves" with a 2.68 mean. The least important item was "deceleration flow control". See Table 54.

The data in Tables 55 and 56 depicted the importance of the knowledge of hydraulic actuators for fluid power technicians and skilled workers.

Table 55. Importance of hydraulic power actuators to fluid power technicians as reported by supervisor (N = 49)

Topic Item	Rating 1	2	3	4	5	Mean
Actuating cylinders		2	8	14	25	4.27
Seals and sealing materials		2	7	17	23	4.24
Cylinder velocity		2	10	17	20	4.12
Cushioning	1	4	10	18	16	3.90
Acceleration and decelerating principles	1	2	16	17	13	3.88
Piston-type motors	4	2	10	16	17	3.82
Gear-type fluid motors	4	1	12	16	16	3.80
Vane-type motors	4	2	13	13	17	3.76
Axial piston fluid motors	5	1	10	18	15	3.76
Radial piston fluid motors	5	3	12	16	13	3.59
Rotary actuators	4	4	15	12	14	3.57
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 56. Importance of hydraulic power actuators to fluid power skilled workers as reported by supervisor (N = 51)

Topic Item	Rating 1	2	3	4	5	Mean
Actuating cylinders	10	12	15	8	6	2.76
Seals and sealing materials	8	14	22	3	4	2.63
Piston-type motors	11	14	17	5	4	2.5
Gear-type fluid motors	11	14	18	4	4	2.53
Vane-type motors	12	13	18	3	5	2.53
Cushioning	11	17	17	2	4	2.43
Axial piston fluid	13	15	15	5	3	2.41
Cylinder velocity	11	17	18	3	2	2.37
Radial piston fluid motors	14	14	16	4	3	2.37
Rotary actuators	15	14	17	2	3	2.29
Acceleration and deceleration principles	14	17	16	2	2	2.24
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

A study of Table 55 revealed that three of the topic items related to "hydraulic power actuators" had a highly desirable rating for fluid power technicians. The least important item in this category is "rotary actuators" with a mean rating of 3.57. "Gear type fluid motors" had a bimodal rating of sixteen for both the 4 and 5 numerical value columns.

Table 56 identified knowledge of "actuating cylinders" as being the most important topic item for skilled workers. The mean value associated with this item was 2.76. The three least important topic items in this category were "acceleration and deceleration principles", "rotary actuators" and "radial piston fluid motors" with mean values of 2.24, 2.29 and 2.37 respectively. Two of the items in this group had bimodal ratings in the numerical value columns.

Tables 57 and 58 summarized the importance of the knowledge of hydraulic circuits and components for fluid power technicians and skilled workers.

"Reading hydraulic circuits", "linear circuits" and "electrically controlled circuits", were determined to be highly desirable for fluid power technicians. Of those two, "reading hydraulic circuits" was considered the most important receiving a 4.40 mean value. The least important topic item was "boost systems" which received a 3.42 mean value. See Table 57.

Table 57. Importance of hydraulic circuits and components to fluid power technicians as reported by supervisor (N = 50)

Topic Item	Rating 1	2	3	4	5	Mean
Reading hydraulic circuits	1	1	4	15	29	4.40
Linear circuits	1	2	10	17	20	4.06
Electrically controlled circuits	3	3	9	15	20	3.92
Regenerative circuits	3	2	12	18	15	3.80
Accumulator circuits	3	2	12	19	14	3.78
Torque motors	4	4	12	17	13	3.62
Intensifier circuits	4	5	14	15	12	3.52
Hydrostatic transmissions	5	5	13	16	11	3.46
Fluidic controlled circuits	4	7	13	14	12	3.38
Boost systems	5	5	14	16	10	3.42
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

In Table 58, "reading hydraulic circuits" was rated highest in importance of knowledge for all topic items in the "hydraulic circuits and components" category as they related to skilled workers. A mean rating of 3.04 was associated with this item. The table also revealed that the least important item was "boost systems" with a mean value of 2.26.

Importance of pneumatics and related information

Tables 59 and 60 summarized the importance of the knowledge of principles of pneumatics for fluid power technicians and skilled workers.

Knowledge of the "measuring of air flow" was rated the most important topic item for technicians in the "principles of pneumatics" category. The item mean value was 3.67. "Properties of air" and "compressed air and gas laws" were ranked second and third with means of 3.30 and 3.12 respectively. The "adiabatic and isothermal compression" topic item was ranked last with a mean value of 2.81 associated with it.

Table 60 indicated that "properties of air" was rated the most important topic item for skilled workers in the principles of pneumatics category. The item mean value was 2.25. "Air distribution systems" and "types of compressors" were ranked second and third with means of 2.14 and 2.12 respectively. The "adiabatic and isothermal compression"

Table 58. Importance of hydraulic circuits and components to fluid power skilled workers as reported by supervisor (N = 53)

Topic Item	Rating 1	2	3	4	5	Mean
Reading hydraulic circuits	9	10	15	8	11	3.04
Linear circuits	12	14	18	4	5	2.62
Electrically controlled circuits	12	12	19	6	4	2.58
Accumulator circuits	13	16	16	4	4	2.43
Torque motors	13	15	17	5	3	2.43
Regenerative circuits	14	15	16	4	4	2.42
Intensifier circuits	15	16	14	4	4	2.36
Hydrostatic trans-missions	14	14	19	4	2	2.36
Fluidic controlled circuits	15	17	16	1	4	2.28
Boost systems	16	15	16	4	2	2.26
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 59. Importance of principles of pneumatics to fluid power technicians as reported by supervisor (N = 43)

Topic Item	Rating 1	2	3	4	5	Mean
Measuring of air flow	9	3	12	13	6	3.67
Properties of air	7	4	12	9	11	3.30
Compressed air and gas laws	8	5	11	12	7	3.12
Types of compressors	8	5	12	10	8	3.12
Free air and standard air	9	5	12	10	7	3.02
Air distribution systems	9	5	13	9	7	3.00
Positive and non-positive displacement compressors	9	6	12	9	7	2.98
Capacity coefficient	9	7	13	10	4	2.84
Adiabatic and isothermal compression	11	6	12	8	6	2.81
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 60. Importance of principles of pneumatics to fluid power skilled workers as reported by supervisor (N = 43)

Topic Item	Rating 1	2	3	4	5	Mean
Properties of air	16	9	9	9		2.25
Air distribution systems	19	8	9	5	2	2.14
Types of compressors	19	8	10	4	2	2.12
Measuring of air flow	19	9	9	5	1	2.07
Positive and non-positive displacement compressors	19	9	10	3	2	2.07
Compressed air and gas laws	19	13	8	2	1	1.91
Capacity coefficient	20	9	12	2		1.91
Free air and standard air	19	8	11	2	3	1.88
Adiabatic and isothermal compression	20	12	9	1	1	1.86
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

topic item was ranked last with a mean value of 1.86 associated with it.

The data in Tables 61 and 62 described the importance of knowledge of pneumatic components for fluid power technicians and skilled workers.

Information in Table 61 revealed that "pneumatic controls" "regulators" and "pneumatic control systems" ranked most important for the fluid power technician. All but one of the topic items in this category received a mean value of 3.00 or greater. The least important item was identified as "pneumatic logic control". It had a mean value of 2.93.

It was observed in Table 62 that all but one topic item in the category related to "knowledge of pneumatic components" for skilled workers had mean values ranging from a high of 2.42 to a low of 1.93. These extreme items were identified as "regulators" and "pneumatic logic control" respectively. These mean ratings indicated that for skilled workers, only background knowledge was necessary with any one of the items listed in the category.

Importance of fluidics and related information

Tables 63 and 64 summarized the importance of the knowledge of the principles of fluidics for fluid power technicians and skilled workers.

Knowledge of "fluidics theory and terminology" was rated the most important topic item for technicians in the

Table 61. Importance of pneumatic components to fluid power technicians as reported by supervisor (N = 43)

Topic Item	Rating 1	2	3	4	5	Mean
Pneumatic controls	7	6	7	10	13	3.37
Regulators	7	6	7	12	11	3.33
Solenoid valves	8	5	8	12	10	3.26
Filtration	7	6	8	15	7	2.21
Types and designs of pneumatic directional control valves	8	4	11	11	9	3.21
Lubricators	7	8	6	14	8	3.19
Vane-type air motors	7	8	9	10	9	3.14
Mufflers	8	9	5	13	8	3.09
Rotary air motors	9	7	10	9	8	3.00
Pneumatic logic control	8	9	9	12	5	2.93
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 62. Importance of pneumatic components to fluid power skilled workers as reported by supervisor (N = 43)

Topic Item	Rating 1	2	3	4	5	Mean
Regulators	15	9	10	4	5	2.42
Pneumatic controls	17	7	10	3	6	2.40
Lubricators	16	9	10	4	4	2.33
Filtration	16	10	8	6	3	2.30
Solenoid valves	18	8	9	4	4	2.26
Mufflers	18	8	10	4	3	2.21
Types and designs of pneumatic directional control valves	18	10	8	3	4	2.19
Vane-type air motors	19	8	8	5	3	2.19
Pneumatic control systems	19	9	7	5	3	2.16
Rotary air motors	19	9	8	4	3	2.14
Pneumatic logic control	21	10	7	4	1	1.93
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 63. Importance of principles of fluidics to fluid power technicians as reported by supervisor (N = 32)

Topic Item	Rating 1	2	3	4	5	Mean
Fluidics theory and terminology	7	4	10	6	5	2.94
Application of fluidics	7	6	9	7	3	2.78
Vortex amplifiers	8	5	10	6	3	2.72
Turbulence amplifiers	8	5	11	5	3	2.69
Focused jet amplifiers	8	6	10	5	3	2.66
Direct impact modulator	8	6	11	4	3	2.63
Double leg elbow amplifiers	8	6	11	4	3	2.63
Stream interaction amplifiers	8	6	11	4	3	2.63
Induction amplifiers	8	7	10	4	3	2.59
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

Table 64. Importance of principles of fluidics to fluid power skilled workers as reported by supervisor (N = 34)

Topic Item	Rating 1	2	3	4	5	Mean
Fluidics theory and terminology	17	6	8	2	1	1.94
Application of fluidics	18	7	6	2	1	1.85
Vortex amplifiers	18	8	7		1	1.76
Turbulence amplifiers	18	9	6		0	1.74
Direct impact modulator	18	9	6		1	1.74
Focused jet amplifiers	19	8	6		1	1.71
Stream interaction amplifiers	19	8	6	1		1.68
Induction amplifiers	19	8	7			1.65
Double leg elbow amplifiers	19	8	7			1.65
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

"principles of fluidics" category. The item mean value was 2.94. "Applications of fluidics", and "vortex amplifiers" were ranked second and third with means of 2.78 and 2.72 respectively. "Induction amplifiers" was ranked last with a mean value of 2.59 associated with it. All of the topic items in this category received their greatest amount of numerical ratings in the 3.0 column which is identified as a desirable rating.

Table 64 revealed that "fluidics theory and terminology" ranked first in desirable knowledge for skilled workers in the "principles of fluidics" category. Ranked second was the item "application of fluidics". These topic items received means of 1.94 and 1.85 respectively. The lowest ranked items were "induction amplifiers" and "double leg elbow amplifiers" each with a mean of 1.65. A further study of the table revealed that all of the topic items received their greatest number of responses in the 1.0 numerical colum. That column was identified with a very little importance rating.

Importance of maintenance and safety

Tables 65 and 66 provided data concerned with the importance of knowledge of maintenance and safety for fluid power technicians and skilled workers.

It was observed that all topic items in Table 65 had a mean value of 4.0 or greater. "Safety rules" was considered the most important item for fluid power technicians with a mean of 4.35 given it. Least important in this group of items was "corrective maintenance". It received a mean value of 4.07. It can be noted that all of the topic items in this group received the majority of their responses in the 5.0 numerical column. That column is identified with an essential rating.

Table 65. Importance of fluid power maintenance and safety to fluid power technicians as reported by supervisor (N = 46)

Topic Item	Rating 1	2	3	4	5	Mean
Safety rules		1	8	11	26	4.35
Preventative maintenance		1	10	13	22	4.22
Trouble-shooting analysis and techniques		2	8	16	20	4.17
Corrective maintenance	1	1	12	12	20	4.07
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

An examination of Table 66 revealed that each topic item had a mean value of 3.5 or greater. "Safety rules" was considered the most important item for fluid power skilled workers with a mean of 3.79 given it. The least important item in this group was "trouble-shooting analysis and techniques". It received a mean value of 3.62. It can be observed that all of the topic items in this group received the majority of their responses in the 5.0 numerical column. An essential rating was associated with that value.

Table 66. Importance of fluid power maintenance and safety to fluid power skilled workers as reported by supervisor (N = 52)

Topic Item	Rating 1	2	3	4	5	Mean
Safety rules	4	4	12	11	21	3.79
Preventative maintenance	4	5	13	10	20	3.71
Corrective maintenance	4	5	15	10	18	3.63
Trouble-shooting analysis and techniques	4	6	15	8	19	3.62
Other						

Rating scale:
1 - Very little importance
2 - Background knowledge only
3 - Desirable
4 - Highly desirable
5 - Essential

DISCUSSION

This study was conducted in an attempt to determine the need for technicians and skilled workers in the manufacture of fluid power products and the desired knowledge these individuals should possess.

It is the researcher's opinion that there exists a need for persons qualified in fluid power in the state of Iowa. This statement can be substantiated by the data identifying the projected number of technicians and skilled workers needed by the responding firms. Many persons entering the labor market are unfamiliar with the word fluid power as well as the concepts associated with it. The researcher feels that the supply and demand of qualified individuals are associated with the lack of knowledge and information relative to fluid power until the individual is on the job.

The number of persons qualified in fluid power that are needed at both the technician and skilled worker occupational levels are also indicated by the predicted replacement needs. Until industries grow in size and number, and new uses for fluid power are developed and applied, it is the researcher's opinion that the need for the number of qualified fluid power personnel in the state of Iowa will continue to remain the same.

The data further suggest that industries in Iowa employing qualified fluid power technicians and skilled workers are not large enough to support a large number of qualified fluid power replacement personnel in Iowa at the present time.

The results of this study suggested that the technician performs a large variety of job functions associated with fluid power such as design, manufacture and maintenance. This may be an indication that there has not been the education necessary to train persons in the specific skilled trades. Since firms are becoming more involved with fluid power, job functions are becoming more broad and complex with the result that more training is needed. The data indicating the job diversity and desired fluid power educational programs of employed technicians and skilled workers substantiate these statements. Similar data seem to indicate that because a large number of the firms surveyed employ 1-2 technicians, the job requirements of those individuals spanned a broad spectrum of job activities. Several of these limited yet diversified job activities required by the responding industries are listed below. (1) Salary requirements not fitting job needs, (2) engineers do the work, (3) the need for part-time qualified man in fluid power, (4) inability to keep qualified men working in fluid power area alone, (5) hydraulics knowledge is needed only as a part of the general design and testing knowledge, and (6) require installers and trouble-shooters only.

It was observed in the data that 17 percent of the technicians' time and 24 percent of the skilled workers' time is directly involved with fluid power. It has been suggested that qualified fluid power personnel should have a proportionate amount of time in fluid power education as that spent working with the various mediums of fluid power.

It is the researcher's opinion that one reason for the low values assigned the importance of the various fluid power topic items is that the respondent has more preception when making a distinction between the technician and skilled worker in general areas of knowledge such as blueprint reading, arithmetic, etc., than in specific fluid power topic items.

Respondents to the questionnaire suggested that 35 percent of the employed technicians and 49 percent of the skilled workers would benefit from fluid power programs. This would indicate a need to upgrade individuals in fluid power presently employed in industry. The data suggest that 50 to 60 percent of the training of the currently employed individuals was provided by the industries. In a number of industries, personnel are trained in a limited and highly specialized scope of knowledge related to the product the firm produces. The effectiveness of this type of training is desirable for immediate needs but limits the individual employee to adapt to other job functions and

and reduces job mobility.

Evidence in the data revealed that 60 percent of the training is accomplished on-the-job and in the plant. It may be desirable for educators and industries employing technicians and skilled workers involved in fluid power to evaluate their existing in-plant training programs to see if the area vocational-technical schools could offer similar and additional training to benefit the industries' employees. This action would reduce the efforts of the industries to train their own personnel while increasing the individual employees job potential in the area of fluid power and related knowledge.

Because of the diversity of the products manufactured and the variety of job functions of both the technicians and skilled workers in the industries surveyed, broad and in-depth educational fluid power programs should be considered. The Iowa Area Vocational-Technical Schools would be the ideal institutions for these programs because of their desirable geographical locations throughout the state.

The researcher does not feel that it would be advisable to offer one large fluid power program at this time because of the distribution of the industries and the individuals involved, but rather, establish several evening courses, workshops, and seminars specifically designed to train and up-grade technicians and skilled workers in the knowledge and concepts related to fluid power as well as those desiring to enter the trade. It may be necessary in a few years to reassess the need for more fluid power educational programs throughout the state of Iowa as industries increase in size and number.

Iowa merged areas VII and XI should be given immediate consideration for the above mentioned type of fluid power training programs as a result of their consistently high demand for qualified personnel.

Individuals involved with the development of curriculum content designed to train and up-grade technicians and skilled workers should seriously consider the importance of the ratings given the various topic items by the respondents in the field.

It was suggested that sales and supervisory personnel would benefit from fluid power programs. This indicates the increased need for more technical knowledge of all individuals involved with fluid power and the increasing complexity and sophistication of the field.

Respondents from several industries suggested that they would host fluid power programs in their facilities. The Area Vocational-Technical Schools should consider this offer if a limited amount of fluid power equipment exists with which to train interested personnel. It was also suggested by several respondents that experience was a valuable ingredient in training individuals in fluid power. The use of several different plants' facilities would assist in helping depict the diversity and application of fluid power as well as provide a "hands-on" approach to the training programs needed.

Representatives from industry who are educated and specialized in fluid power should be encouraged to assist and supplement the fluid power programs. A stipend or other form of gratuity might be offered them for their services.

Finally, individuals employed in firms other than those directly related to the manufacture of fluid power end-use products may benefit from fluid power educational programs. The researcher thinks this point is best summarized by the following statement written by one of the respondents.

> "We serve the agricultural and the construction industries. By comparison hydraulic technicians, facilities, information service, etc., are just a great mystery in the agriculture field. The big agric. equipment dealerships sometimes have the equipment and know how but on an overall basis it is a desert. Our company is trying to implement a Service Dept. Program to help equip our dealers with test equipment at a reasonable cost. We are generating service bulletins to inform our dealers' service personnel. Many do not understand the simple basics of hydraulics and we get into trouble. It is my opinion that the customers will not tolerate this condition much longer. The dealers will have to find qualified personnel to service the equipment in their place of business at the time the customer brings in his unit. Long delays in todays economy are not and will not be acceptable."

On the basis of the study, the following recommendations were made:

1. A committee consisting of guidance personnel, instructors associated with fluid power edu- tion and representatives from interested industries meet for the purpose of inter- preting the data of this study that could be used for guidance purposes.
2. A committee consisting of industry personnel and educators interested in promoting fluid power education should meet for the purpose of interpreting the data of this study that could be used to develop more specific objectives as they relate to fluid power educational programs in the state of Iowa.
3. The Iowa Area Vocational-Technical Schools should contact management personnel in the industries interested in up-grading their employees, to develop fluid power educational programs through evening courses, seminars and workshops.
4. More emphasis should be placed on exposing students in career education programs at the secondary school level to the opportunities available to them in the area of fluid power.

5. More emphasis should be placed on teaching students in career education programs at the secondary school level the concepts of fluid power technology.
6. Consideration should be given each topic item rated in this study, when curriculum and objectives related to fluid power educational programs are developed in the state of Iowa.

The following recommendations were made for further study:

1. Conduct a study of the interests of individuals involved in fluid power and those interests of high school students in an attempt to disclose similarities that may be used to identify those individuals with the potentials and capabilities necessary for successful employment in the field of fluid power.
2. Conduct a study of non-manufacturing firms in the state of Iowa that employ personnel who work with fluid power systems and equipment in an attempt to determine if there are manpower and training needs as they relate to fluid power skill and knowledge.
3. Identify more clearly, the job analysis

of the technicians and skilled workers involved with fluid power so that clear and concise educational objectives can be developed for occupational skills needed by persons studying and preparing to fill these occupational skill level roles.

SUMMARY

The purpose of this study was to survey the number of firms employing technicians and skilled workers in the manufacture of fluid power products and to ascertain if there is a need for these types of persons in Iowa.

The specific objectives of this study were:

1. To determine the number of Iowa manufacturers employing technicians and skilled workers involved in fluid power, and the amount of time and area of interest in which these individuals work.
2. To determine the additional manpower needs of the identified manufacturers employing technicians and skilled workers involved in fluid power now and for four years in the future.
3. To determine the technical knowledge and skills which manufacturers employing technicians and skilled workers in fluid power desire these individuals to possess.
4. To determine if there is a need for educational programs designed to train and up-grade technicians and skilled workers in fluid power.

The objectives of the study were fulfilled by means of

a mailed questionnaire to all industries that employed technicians and skilled workers involved with fluid power in the manufacture of end-use products in five major categories. These categories are: (1) industrial, (2) mobil, (3) aerospace, (4) marine and (5) other military. The final list of firms was compiled from the Directory of Iowa Manufacturers and representatives of the Center for Industrial Research and Services. A double postal card questionnaire was addressed to 372 firms. The purpose of the postal card questionnaire was to determine if the manufacturing firms should be included in the survey. If the response was "yes" to the question of employment of either fluid power technicians or skilled workers, the firm was included in the final population and received the questionnaire.

Sixty-eight of the 81 questionnaires were returned. The questionnaire was developed with the assistance of a four man advisory committee plus the researcher. A preliminary form of the questionnaire was submitted to 16 different individuals for suggestions on the overall improvement of the format and content. Eighty-one questionnaires were mailed out of which 68 were eventually returned.

General Findings Concerning the Industries Surveyed

The 61 industries surveyed by this study employed as of April 1971, a total of 254 technicians and 420 skilled workers involved with fluid power. Iowa merged area VI employed the largest number of technicians with 107 while merged area X employed the largest number of skilled workers with 99.

Fifty-six of the responding industries were involved with the hydraulics medium as were 26 in pneumatics and 12 in fluidics. Several of the industries were identified in more than one end-use product category. Forty-one firms were identified in the industrial category with only three in the marine category. In the area of fluid power medium, in the five major end-use categories, 39 firms were involved in mobil hydraulics, 21 in industrial pneumatics, and 11 in industrial fluidics.

A total of 924 various combinations of products and areas of interest were identified. Installation of control valves was the largest single category. Eighty-six responses were made for the manufacture of the various types of fluid products listed.

Information Concerning the Technicians and Skilled Workers in the Industries Surveyed

Approximately 61 percent of the firms surveyed had only 1-2 technicians employed while 37 percent of the firms had 1-2 skilled workers employed. There were 239 technicians and 398 skilled workers involved with hydraulics while only 128 technicians and 49 skilled workers worked with fluidics.

Forty-two of the industries stated that it was difficult to find qualified individuals trained in fluid power. Thirty-nine industries said that it would be desirable to hire qualified individuals if it were possible to find them. Twenty-eight firms stated that the main reason for the difficulty in finding qualified fluid power personnel was that the applicant lacked the necessary qualifications for the job. Lack of applicants was also indicated as a major problem.

The projected number of fluid power technicians needed by 1975 was 311 representing an 18.3 percent increase from 1972 to 1975. Iowa merged areas V and VII indicated the largest need for technicians with 12 each. The total number of replacements was 11 with eight vacancies existing in the industries in 1971.

The projected number of fluid power skilled workers needed by 1975 is 559 representing a 24.8 percent increase from 1972 to 1975. Iowa merged areas VII and X indicated the most with 37 and 29 respectively. The total number of replacements was 48 with 16 job vacancies identified for skilled workers at the time the questionnaire was received.

The overall median age for fluid power technicians was 34.7 while 37.7 percent of these individuals were identified as being 30 to 39 years of age. Seventy-seven or 32.8 percent of the skilled workers were identified in 30 to 39 years of age bracket while the median age of skilled workers was determined to be 38.9 years.

The overall median hours per week technicians work directly with fluid power was 17.0. Eleven technicians work 40 or more hours per week in fluid power while 15 work less than 10 hours in the various mediums of fluid power. Skilled workers were identified as working an average of 23.7 hours directly with fluid power

On-the-job training was indicated as the main source of training for both fluid power technicians and skilled workers. A total of 88 technicians and 205 skilled workers were identified as individuals who would benefit from part-time fluid power programs. It was suggested that 139 technicians and 121 skilled workers would actually attend these programs. The evening type program was most desired to train individuals in fluid power. Twenty-two companies stated that they offered in-service training programs and 25 of the firms said they would host an in-service training program in their facility.

According to the data, technicians as well as skilled workers function in more than one fluid power medium and area of interest at the same time. A total of 45 technicians work in design in the three different areas of fluid power, while only nine skilled workers are involved in the design of hydraulics and pneumatics products. Iowa merged area XI had the largest number of technicians with 79 and skilled workers with 78, that worked in the various fluid power areas of interest.

In the data concerning the fluid power medium and area of interest where the responding firms would desire individuals to work, a total of 148 technicians and 158 skilled workers were listed. Hydraulics alone had 98 listings in the various areas of interest while a total of 105 skilled workers were listed for the same area. Merged area VII had the largest single listing of technicians and skilled workers with 34 for each occupational level.

Information Related to Knowledge and Skill Requirements Needed of Individuals in Fluid Power

To determine the various knowledge and skills needed by technicians and skilled workers in fluid power, the respondent was asked to rate the various topic items on a five point scale. The scale was: (1) very little importance, (2) background knowledge only, (3) desirable, (4) highly desirable and (5) essential.

In the area of communications skills important to fluid power technicians, skill in listening was rated first with a mean of 4.31 followed by skill in reading with 4.25. The same two topic items ranked first and second in importance to skilled workers with mean ratings of 3.79 and

3.58 respectively.

In mathematics, arithmetic was most important for technicians with a 4.62 mean while for skilled workers the same topic item was considered most important at a 3.33 mean rating.

In the supporting technical information area important to technicians, blueprint reading ranked first followed by drafting and machine design. It was determined that for skilled workers, blueprint reading, machining processes and principles relating to mechanical advantage were the three most important topic items.

The data revealed in the principles of hydraulics topic items that relationship of force, pressure and area, and fluid flow concepts, were among the top two items of importance to technicians. Skilled workers also had the same two topic items determined as the most important for them.

Knowledge of hydraulic reservoirs, strainers and filters, and heat exchangers were identified as the most important information for technicians to know in the area of power fluids and fluid conditioning. It was suggested that for skilled workers, knowledge in the topics of strainers and filters, hydraulic reservoirs and base fluids should be among the most important.

All but one of the topic items in the area of hydraulic power distribution for fluid power technicians ranked highly desirable while for skilled workers similar knowledge was considered desirable.

In the area of the control of hydraulic power,important to both technicians and skilled workers, pressure controls, flow control valves and directional control valves ranked first, second and third respectively.

In determining the importance of knowledge for technicians and skilled workers in the area of the control of hydraulic power, pressure controls, flow control valves and directional control valves ranked first, second and third respectively for both occupational skill level groups.

Highly desirable is the rating given three of the topic items considered important for technicians in the area of hydraulic power actuators. Skilled workers on the other hand need background knowledge only for all of the items listed.

When referring to hydraulic circuits and components, knowledge in reading hydraulic circuits, linear circuits and electrically controlled circuits were ranked first, second and third in order of importance for technicians. For skilled workers, the same topic items mentioned previously were in similar order of importance.

Technicians knowledge of all the topic items listed in the area of pneumatics principles and components, had a desirable rating of importance. For skilled workers, ratings of background knowledge only and very little importance were associated with the various topic items in the same category.

Knowledge of various topic items related to fluidics were rated as desirable for both technicians and background knowledge only for skilled workers.

In the area of importance of maintenance and safety to fluid power technicians and skilled workers, it was observed that all of the topic items in this group received the majority of their responses in the 5.0 numerical column. An essential rating of importance is associated with that value.

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APPENDIX A: DOUBLE POSTAL CARD QUESTIONNAIRE

If any answers below are yes, please check area(s) of employment

Do you employ individuals in the field of fluid power as:	No	Yes	Total number	Design	Installation	Operation	Maintenance	Manufacture Production & Methods	Other
Engineers	_	_	_	_	_	_	_	_	_
Aides	_	_	_	_	_	_	_	_	_
Technicians	_	_	_	_	_	_	_	_	_
Skilled Workers . .	_	_	_	_	_	_	_	_	_

In the next five years, will you employ such people? Yes _ No _

Name and title of person in charge of fluid power specialists where additional information may be obtained.

____

Dear Sirs:

The attached questionnaire is an attempt to determine Iowa industries' need for adequately trained personnel in the field of fluid power (hydraulics and pneumatics).

The purpose of the questionnaire is to determine whether your company may be included in the study and whom in your company should be contacted for further information.

Your cooperation is desired by completing the attached card and returning it at your earliest convenience.

Thank you.

Lowell L. Carver

Lowell L. Carver, Professor
Industrial Education

Harold T. Hoghaug

Harold T. Hoghaug, Instructor
Industrial Education
Iowa State University

APPENDIX B: QUESTIONNAIRE AND COVER LETTER

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY
Ames, Iowa 50010

COLLEGE OF EDUCATION
INDUSTRIAL EDUCATION

Dear Sir:

An important research study is presently under way in Iowa to determine the need for fluid power technicians and skilled workers. The results of the study will help in making recommendations on educational programs designed to train specialists in the field of fluid power. Fluid power is referred to as power transmitted and controlled through the use of a pressurized fluid (liquid or gas).

Your company's response to a post card pre-questionnaire has helped in selecting you as an individual qualified to provide the valuable information in this study.

The need for this study is reflected by both industrial personnel and educators alike agreeing that the rapid expansion of the fluid power industry is creating a demand for greater numbers of specialists trained in the installation, repair, and technical service. A survey by the National Fluid Power Association found in 1963 that the nationwide average manpower shortage of fluid power specialists was approximately 50 per cent in the field of fluid power and the trend is continuing today.

This study hopes to determine the present manpower shortage of fluid power technicians and skilled workers in Iowa. In addition, it is hoped that the study will provide information which can be used in recommending educational programs for Area Schools and Community Colleges.

In this study a technician is defined as an individual on a level between the skilled worker and the professional scientist or engineer. His technical knowledge permits him to assume some duties formerly assigned to the graduate engineer or scientist. For example, technicians may design a mechanism, compute the cost, write the specifications, organize the production, test and supervise final assembly of the finished product.

A skilled worker, in terms of this study, performs the actual manipulative activities with the use of special tools and instruments. He is responsible for diagnosing malfunctions, dismantling, repair, adjustment and assembly of the fluid power systems and equipment.

We request your cooperation in completing and returning the attached questionnaire. All information will be held in strictest confidence and will be used only for analysis of the state's needs.

Your time, effort and cooperation is greatly appreciated.

Sincerely,

Lowell L. Carver

Lowell L. Carver, Professor
Industrial Education
Iowa State University

Harold T. Hoghaug

Harold T. Hoghaug
Industrial Education
Iowa State University

QUESTIONNAIRE

The items on the following pages refer to Fluid Power skilled workers and technicians and points of interest relative to their occupations.

IF THE ITEM APPLIES, MARK THAT ITEM WITH AN "X".

IF THE ITEM DOES NOT APPLY, MARK THAT ITEM WITH AN "O".

1. FLUID POWER SPECIALIZATION

A. With which type of fluid power medium is your firm concerned? (Please check one or more.)

1. Hydraulics--the engineering science pertaining to liquid pressure and flow. ____
2. Pneumatics--the engineering science pertaining to gaseous pressure and flow. ____
3. Fluidics --the use of fluids in motion without moving parts which perform sensing control and/or actuation functions. ____

B. With which of the following end-use categories is your firm concerned? (Check one or more.)

1. Industrial (equipment used in fabricating, manufacturing and/or processing operations; or incorporated in products such as machine tools, presses, conveyors, etc.) . . ____
2. Mobile (equipment used on land vehicles and mobile machines other than passenger cars, such as earth moving and road building equipment, lift trucks, construction machinery, farm machinery, and tractors, including fluid power elements of power steering, and hydrostatic transmission) . . . . ____
3. Aerospace (equipment used on aircraft, missiles and spacecraft, military, commercial and private) . . . . . . ____
4. Marine (equipment used on military, commercial or private ships, boats and other watercraft) . . . . ____
5. Other Military (equipment used on all other Armed Services devices not elsewhere reported such as ground support equipment such as trucks, launchers, radar, and similar equipment) . . . . ____

*A technician is defined as an individual on a level between the skilled worker and the professional scientist or engineer. His technical knowledge permits him to assume some duties formerly assigned to the graduate engineer or scientist. For example, technicians may design a mechanism, compute the cost, write the specifications, organize the production, test and supervise final assembly of the finished product.

**A skilled worker, in terms of this study, performs the actual manipulative activities with the use of special tools and instruments. He is responsible for diagnosing malfunctions, dismantling, repair, adjustment and assembly of the fluid power systems and equipment.

Specialist refers to both skilled workers and technicians together.

Please place in the appropriate blank, the number that best describes the conditions as they presently exist in your firm.

2. FLUID POWER MANPOWER

	*Technicians	**Skilled Workers
A. Employed as of April 1, 1971		
B. Expected to be employed by		
1. January, 1972		
2. January, 1973		
3. January, 1974		
4. January, 1975		
C. Replaced since January 1, 1971		
D. Expected to be replaced in the year		
1. January 1, 1971 to December 31, 1971		
2. January 1, 1972 to December 31, 1972		
3. January 1, 1973 to December 31, 1973		
4. January 1, 1974 to December 31, 1974		
5. January 1, 1975 to December 31, 1975		
E. How many unfilled vacancies exist now?		
F. How many fluid power specialists with ages from		
1. 20 to 29?		
2. 30 to 39?		
3. 40 to 49?		
4. 50 to 59?		
5. 60 to 65?		
G. On the average, how many hours a week do the specialists that you employ, work with fluid power?		
1. less than 10		
2. 10 to 19		
3. 20 to 29		
4. 30 to 39		
5. 40 or more		
H. How many specialists have received training through		
1. high school vocational courses? . .		
2. area schools?		
3. manufacturers training schools? . .		
4. military service schools?		
5. on the job training only?		
6. correspondence courses?		
7. college technical programs?		
8. other? (Specify)		
I. How many specialists do you feel would benefit from night classes or other in-service training, if provided by Area Schools?		
J. How many specialists do you think would attend in-service training programs if provided by the Area Schools? . .		

K. What types of fluid power education program would you like to see offered by the Area Schools? (Check one or more.)

1. Evening	
2. Seminars	
3. Workshops	
4. Full-time	
5. Other (Specify)	

L. Do you offer your own in-service training program? _____ Yes _____ No

M. Would you host such a program in your facilities for your staff and others?
_____ Yes _____ No

N. Is it difficult to find qualified fluid power specialists? _____ Yes _____ No

O. If your answer above was yes, why? (Check one or more.)
1. Lack of applicants . . . . _____
2. Applicant lacks necessary qualifications _____
3. Other (Specify) . . . . _____

P. Would you hire trained fluid power specialists if they were available?
_____ Yes _____ No

3. FLUID POWER PRODUCT AND PROCESS

A. Which fluid power products and areas of interest is your firm concerned with at the present time? (Check one or more.)

PRODUCT	Research	Design	Manufacture	Installation	Maintenance	Operation	Sales	Other
1. cylinders								
2. boosters (intensifiers)								
3. rotary actuators								
4. motors								
5. compressors								
6. valves								
7. accumulators								
8. pumps								
9. filters and filter elements . .								
10. vacuum pumps								
11. fluidic devices								
12. hydrostatic transmissions . . .								
13. other (specify)								
__________								
__________								
__________								

B. Please indicate the number of fluid power specialists you employ in the areas listed below. (Fill one or more.)

	Technicians			Skilled Workers		
	Hydraulics	Pneumatics	Fluidics	Hydraulics	Pneumatics	Fluidics
1. Research						
2. Design						
3. Manufacture						
4. Installation						
5. Maintenance						
6. Operation						
7. Sales						
8. Other (Specify)						

C. If you were to hire fluid power specialists, in which areas would you like them to work? (Check one or more.)

	Technicians			Skilled Workers		
	Hydraulics	Pneumatics	Fluidics	Hydraulics	Pneumatics	Fluidics
1. Research						
2. Design						
3. Manufacture						
4. Installation						
5. Maintenance						
6. Operation						
7. Sales						
8. Other (Specify)						

Instructions

Please check the relative importance of each item below as it pertains to fluid power technicians and skilled workers and persons studying to become these types of specialists.

RATING SCALE: (Check the most appropriate rating.)

1	2	3	4	5
VERY LITTLE IMPORTANCE	BACKGROUND KNOWLEDGE ONLY	DESIRABLE	HIGHLY DESIRABLE	ESSENTIAL

4. COMMUNICATION SKILLS

	Technicians					Skilled Workers				
	1	2	3	4	5	1	2	3	4	5
A. Skill in reading										
B. Skill in speaking										
C. Skill in listening										
D. Good spelling skills										
E. Knowledge of sentence structure										
F. Ability to write reports and letters										
G. Other (Specify)										

5. MATHEMATICS

	Technicians					Skilled Workers				
	1	2	3	4	5	1	2	3	4	5
A. Arithmetic										
B. Basic Slide Rule										
C. Fundamental Algebra										
D. Geometry										
E. Exponents, radicals and complex numbers										
F. Ratio, proportion, variations .										
G. Logarithms										
H. Trigonometry										
I. Other (Specify)										

RATING SCALE: (Check the most appropriate rating.)

1	2	3	4	5
VERY LITTLE IMPORTANCE	BACKGROUND KNOWLEDGE ONLY	DESIRABLE	HIGHLY DESIRABLE	ESSENTIAL

6. SUPPORTING TECHNICAL INFORMATION

	Technicians					Skilled Workers				
	1	2	3	4	5	1	2	3	4	5
A. Blue print reading										
B. Drafting										
C. Industrial materials and processes										
D. Strength of materials										
E. Machining rocesses										
F. Machine design										
G. Electro-mechanical machines and control										
H. Principles relating to mechanical advantage										
I. Principles of electricity . .										
J. Physics										
K. Other (Specify)										

7. PRINCIPLES OF HYDRAULICS

	1	2	3	4	5	1	2	3	4	5
A. Relationship of force, pressure, and area										
B. Fluid flow concepts										
C. Bernoulli's equation										
D. Continuity equation.										
E. Toricelli's theorem										
F. Laminar and turbulent flow . .										
G. Hagen Poiseville Law for Laminar flow										
H. Reynold's number										
I. Reynold's equation										
J. Darcy's formula										
K. System capacities										
L. Volumes and displacement . . .										
M. Cylinder displacement										
N. Other (Specify)										

RATING SCALE: (Check the most appropriate rating.)

1	2	3	4	5
VERY LITTLE IMPORTANCE	BACKGROUND KNOWLEDGE ONLY	DESIRABLE	HIGHLY DESIRABLE	ESSENTIAL

8. POWER FLUIDS AND FLUID CONDITIONING

	Technicians					Skilled Workers				
	1	2	3	4	5	1	2	3	4	5
A. Base fluids										
B. Petroleum base fluids										
C. Viscosity index and control . .										
D. Oxidation, rust and foaming . .										
E. Fire resistant fluids										
F. Anti-wear properties										
G. Pour point										
H. Chemical reactions										
I. Hydraulic reservoirs										
J. Heat exchangers										
K. Strainers and filters										
L. Other (Specify)										

9. HYDRAULIC POWER DISTRIBUTION

	1	2	3	4	5	1	2	3	4	5
A. Operating pressures										
B. Pressure drop										
C. Fluid velocity										
D. Vibration										
E. Tubing and flexible hoses . . .										
F. Connectors and installation . .										
G. Other (Specify)										

10. SOURCES OF HYDRAULIC POWER

	1	2	3	4	5	1	2	3	4	5
A. Input horsepower										
B. Pump design, theory and classes										
C. Positive displacement pumps . .										
D. Non-positive displacement pumps										
E. Fixed delivery pumps										
F. Variable volume pumps										
G. Gear type pumps										
H. Screw type pumps										
I. Vane type pumps										
J. Piston type pumps										
K. Other (Specify)										

RATING SCALE: (Check the most appropriate rating.)

1	2	3	4	5
VERY LITTLE IMPORTANCE	BACKGROUND KNOWLEDGE ONLY	DESIRABLE	HIGHLY DESIRABLE	ESSENTIAL

11. CONTROL OF HYDRAULIC POWER

	Technicians					Skilled Workers				
	1	2	3	4	5	1	2	3	4	5
A. Pressure controls										
B. Directional control valves . .										
C. Flow control valves										
D. Restrictors										
E. Pressure-compensated flow control										
F. Deceleration flow control . . .										
G. Other (Specify)										

12. HYDRAULIC POWER ACTUATORS

	1	2	3	4	5	1	2	3	4	5
A. Actuating cylinders										
B. Cylinder velocity										
C. Seals and sealing materials . .										
D. Cushioning										
E. Acceleration and deceleration principles										
F. Rotary actuators										
G. Gear-type fluid motors										
H. Vane-type motors										
I. Piston-type motors										
J. Axial piston fluid motors . . .										
K. Radial piston fluid motors . .										
L. Other (Specify)										

13. HYDRAULIC CIRCUITS AND COMPONENTS

	1	2	3	4	5	1	2	3	4	5
A. Reading hydraulic circuits . .										
B. Linear circuits										
C. Regenerative circuits										
D. Accumulator circuits										
E. Intensifier circuits										
F. Hydrostatic transmissions . . .										
G. Electrically controlled circuits										
H. Fluidic controlled circuits . .										
I. Torque motors										
J. Boost systems										
K. Other (Specify)										

RATING SCALE: (Check the most appropriate rating.)

1	2	3	4	5
VERY LITTLE IMPORTANCE	BACKGROUND KNOWLEDGE ONLY	DESIRABLE	HIGHLY DESIRABLE	ESSENTIAL

14. PRINCIPLES OF PNEUMATICS

	Technicians 1	2	3	4	5	Skilled Workers 1	2	3	4	5
A. Properties of air										
B. Measuring of air flow										
C. Free air and standard air . . .										
D. Compressed air and gas laws . .										
E. Adiabatic and Isothermal compression										
F. Types of compressors										
G. Positive and non-positive displacement compressors										
H. Capacity coefficient										
I. Air distribution systems . . .										
J. Other (Specify)										

15. PNEUMATIC COMPONENTS

	Technicians 1	2	3	4	5	Skilled Workers 1	2	3	4	5
A. Pneumatic controls										
B. Filtration										
C. Regulators										
D. Lubricators										
E. Mufflers										
F. Types and designs of pneumatic directional control valves . .										
G. Solenoid valves										
H. Rotary air motors										
I. Vane-type air motors										
J. Pneumatic control systems . . .										
K. Pneumatic logic control										
L. Other (Specify)										

RATING SCALE: (Check the most appropriate rating.)

1	2	3	4	5
VERY LITTLE IMPORTANCE	BACKGROUND KNOWLEDGE ONLY	DESIRABLE	HIGHLY DESIRABLE	ESSENTIAL

16. PRINCIPLES OF FLUIDICS

	Technicians					Skilled Workers				
	1	2	3	4	5	1	2	3	4	5
A. Fluidics theory and terminology										
B. Application of fluidics										
C. Vortex amplifiers										
D. Turbulence amplifiers										
E. Focused jet amplifiers										
F. Direct impact modulator										
G. Induction amplifiers										
H. Double leg elbow amplifiers . .										
I. Stream interaction amplifiers .										
J. Other (Specify)										

17. FLUID POWER MAINTENANCE AND SAFETY

	1	2	3	4	5	1	2	3	4	5
A. Safety rules										
B. Preventative maintenance . . .										
C. Corrective maintenance										
D. Trouble-shooting analysis and techniques										
E. Other (Specify)										

Position of person answering questionnaire: ______________________

Comments: ______________________

____

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY
Ames, Iowa 50010

COLLEGE OF EDUCATION
INDUSTRIAL EDUCATION

Dear Sir:

Recently you were asked to participate in a study relating to manpower and training needs for fluid power specialists. The object of this study is to gather information which will help in making recommendations on educational programs to train specialists in the fluid power field.

You are the key to the success of this study. Only you can provide the answers to the questions. The more responses received the more meaningful the results will be.

Iam sure that you, working in industry, realize the importance of a 100% effort.

Another questionnaire has been enclosed in case you may have misplaced the first one.

Sincerely,

Harold T. Hoghaug

Harold T. Hoghaug, Researcher
Industrial Education
Iowa State University

Enclosure

APPENDIX C: SUMMARY OF INDUSTRIAL EDUCATION TEACHER PREPARATION FLUID POWER PROGRAMS

PREFACE

Although hydraulics, pneumatics, and fluidics are finding their application in more diversified and complex systems, the rate of expansion of educational opportunities at all levels has not kept pace with industries' needs.

As in other technologies, it is generally agreed, that the essential element in successful technical programs is the teacher. This survey of the current status of fluid power education, at the teacher education preparation level, was conducted with the explicit purpose of determining what growth in fluid power education opportunities have occurred since 1968.

It is abundantly evident that significant increase in opportunities for fluid power instruction is occurring at the undergraduate and graduate levels in teacher preparation.

The findings of this survey should be of interest to those teacher educators planning to add fluid power instruction in their teacher preparation program or expand their offerings. Mr. Harold Hoghaug, the researcher, found the respondents to his survey instrument to be enthusiastic and helpful in providing him with the most recent information about their programs.

William D. Wolansky

RESULTS OF FLUID POWER QUESTIONNAIRE

POPULATION:

The population of the survey consisted of 220 Industrial Education teacher preparation curriculums identified by Dr. G. S. Wall in the Industrial Teacher Education Directory; 1970-71.

DATA COLLECTED:

The data was collected during Spring Quarter, 1971. All institutions responding to the questionnaire in some manner are included in the results listed in the succeeding pages of findings.

RESPONSE TO THE INSTRUMENT:

A. Original mailing: 139 received of 220 for a 63% return.
B. Follow-up: 44 received of the remaining 137 for a 32% return
C. Total reply: 186 received of 220 for an 83% return.

ITEM 1 - Do you offer, in your Industrial Education teacher preparation curriculum, a unit in fluid power as a part of a course such as power mechanics, physics, transportation, or similar courses?

A. YES - 98
B. NO - 83
C. No response - 5

ITEM 2 - Do you offer one or more courses in fluid power for teachers or future teachers of Industrial Education?

A. YES - 52
B. NO - 127
C. No response - 7

ITEM 3 - Will you offer one or more fluid power courses for teachers of Industrial Education within the next three years?

A. YES - 90
B. NO - 90
C. No response - 7

ITEM 4 - Do you offer an introductory course in fluid power for undergraduate credit?

A. YES - 54
B. NO - 45
C. No response - 86

ITEM 5 - Is the undergraduate introductory course in fluid power offered during:

A. ACADEMIC YEAR - 63
B. SUMMER SESSION - 17
C. No Response - 118

ITEM 6 - Do you offer an introductory course in fluid power for graduate credit?

A. YES - 23
B. NO - 78
C. No response - 85

ITEM 7 - Is the introductory course in fluid power for graduate credit offered during:
A. ACADEMIC YEAR - 15
B. SUMMER SESSION - 15
C. No Response - 156

ITEM 8 - Do you offer one or more <u>advanced</u> courses in fluid power at the undergraduate level?
A. YES - 18
B. NO - 80
C. No Response - 88

ITEM 9 - Do you offer one or more advanced courses in fluid power at the graduate level?
A. YES - 8
B. NO - 87
C. No Response - 91

ITEM 11 - Do you offer <u>undergraduate</u> level fluid power <u>seminars</u>?
A. YES - 9
B. NO - 84
C. No Response - 93

ITEM 12 - Do you offer <u>undergraduate</u> level fluid power <u>workshops</u>?
A. YES - 15
B. NO - 83
C. No Response - 88

ITEM 13 - Do you offer <u>graduate</u> level fluid power <u>seminars</u>?
A. YES - 8
B. NO - 86
C. No Response - 92

ITEM 14 - Do you offer <u>graduate</u> level fluid power <u>workshops</u>?
A. YES - 14
B. NO - 81
C. No Response - 91

ITEM 15 - Check the appropriate blanks that correspond to the course content of the fluid power courses offered at your institution at the appropriate level(s).

	Undergraduate	Graduate
Physical Laws	72	19
Symbols	66	19
Pipes	57	15
Fittings	58	15
Fluids	67	17
Pumps	70	19
Compressors	67	20
Accumulators	61	19
Intensifiers	51	19
Cylinders	65	18
Circuitry Design	55	22
Valving	65	18
Servo Valve	44	20
Filtration	55	14
Heat Exchangers	46	16
Troubleshooting	41	17
Pneumatics	59	18
Fluidics	42	17
Others	6	3
No Response to ITEM 15	114	163

ABSTRACT OF ITEMS 16 THROUGH 20:

A. The number of fluid power instructors teaching the courses range from one to four with a few institutions reporting that all of their instructors teach the fluid power courses at one time or another.

B. The number of Cooperating Industry Plant Schools varies from zero to three or more with a few institutions reporting that this factor varies from time to time.

C. The number of undergraduate courses available in fluid power varied from one to six with several institutions indicating that a unit in fluid power is offered in conjunction with another course such as power mechanics and similar courses.

D. The number of undergraduate quarter hours of credit reported varied from three to thirty-two. Some of the courses will be offered for the first time beginning in the 1971-72 academic year. Several institutions reported that an undergraduate course in fluid power is required in their program. Several institutions reported that some of their undergraduate fluid power courses could be taken as independent study, for graduate credit under certain conditions, and similar circumstances.

E. The number of graduate quarter hours of credit reported varied from one to fifteen with several institutions reporting that their undergraduate courses may be taken for graduate credit under certain circumstances. A few institutions reported that their graduate level courses are of the independent study type.

F. General comments indicated that several institutions are going to offer one or more undergraduate and graduate level fluid power courses in the near future (within three years); however, the questionnaire did not allow for a specific date when the courses would begin.