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ABSTRACT

A task analysis of nuclear technician occupations in selected organizations in the Southern Interstate Nuclear Board Region was conducted as part of a research and development project leading to a nuclear technician manpower information system for these 17 states. In order to answer 11 questions focusing on task performance frequency and importance, career ladders, job clusters, and educational requirements, demand questionnaires were mailed to 1,588 nuclear licensee firms. Positive responses were received from 418 establishments, from which a sample of 17 firms was chosen. A task analysis personal interview instrument was developed by the Southern Interstate Nuclear Board and administered to 53 supervisors reporting for 20 job titles covering 475 technicians. Emphasizing career ladder development within the nuclear industry, and the development of a curriculum guide for nuclear technician training institutes in the region, it was concluded that: (1) The substantially different health-related technician job cluster requires special training, (2) Secondary and post-secondary curriculums should be developed, (3) Task similarities may require common elements in their preparation, (4) Career ladders can be developed, and (5) Further task analyses should be conducted. Tables, term definitions, a brief literature review, discussions of data reliability, and survey forms are provided. (AG)

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NUCLEAR TECHNICIAN MANPOWER

TASK ANALYSIS REPORT

Southern Interstate Nuclear Board
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A TASK ANALYSIS OF SELECTED NUCLEAR TECHNICIAN OCCUPATIONS

A Technical Report Prepared for the
Southern Interstate Nuclear Board
Atlanta, Georgia

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and
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April, 1972

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CHAPTER I

INTRODUCTION, FINDINGS CONCLUSIONS, AND RECOMMENDATIONS

INTRODUCTION

This report is concerned with the second phase of a five-phase research and development project conducted by the Southern Interstate Nuclear Board (hereafter referred to as SINB) leading to a nuclear technician manpower information system for the seventeen states within the SINB Region.

Government and private industry have combined in the past two decades to foster a vital and growing enterprise so complex and expansive that traditional sources of trained manpower supply, such as vocational and technical education institutions, have not been able to meet the demand, either in quantity or quality. Yet, until recently, very little has been done to correct this imbalance between nuclear manpower supply and demand.

One of the efforts to correct this manpower supply and demand imbalance within the Region is presently under development by SINB. The five phases of the SINB project are: (1) assessment of the trained nuclear related technical manpower supply and demand--this phase was completed in June, 1971;[1]

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[1] Work under phase I was completed in June of 1971, and was presented in the report: Braden, Paul V., and Paul, Krishan K., Nuclear Technician Manpower Survey - Approach to an Information System. Atlanta, Georgia: Southern Interstate Nuclear Board, June, 1971.

(2) broad gauged task analysis of selected nuclear technician jobs which is presented in this report; (3) preparation of a nuclear technician curriculum guide; (4) conducting a nuclear technician manpower symposium; (5) testing of the curriculum guide in selected vocational-technical training institutions.

This five-phase program was selected by SINB officials and the Manpower Advisory Committee because they strongly felt that practical tools must be developed for assisting in the resolution of critical manpower problems. This strategy recognizes the high priority data requirements and the corresponding development of an occupational information system as one important step in the emerging concept of manpower policy. This concept utilizes information to foster the development of human potential toward employment opportunities. The overall relationship between manpower policy and this five-phase SINB program seems quite clear, i.e., vast quantities of relevant data must be collected, analyzed, and disseminated as a tool (means) for decision-makers in their attempt to harmonize the efforts of a vast number of people, in diverse settings in order to achieve worthwhile goals (ends). Of course, SINB recognizes that the data must be combined with the necessary socio-political involvements in order to be fully utilized.

The overall purpose of this study (phase II) was to conduct a task analysis of nuclear technician occupations in selected employing organizations in the SINB Region in an attempt to provide the required data to answer the following questions:

1. What are the primary activities of nuclear technicians in the various job clusters?

2. What type of educational backgrounds are characteristic of technicians presently employed in the job clusters?

3. What are the major tasks performed by nuclear technicians by job and job cluster?

4. What percentage of working time and with what frequency are the nuclear technicians performing specific tasks by job and job cluster?

5. What importance is placed on the performance of specific tasks relative to "job entry", "routine job performance" or for "job promotion"?

6. What job functions are associated with specific tasks and at what levels are these tasks performed?

7. What levels of general educational development are associated with specific tasks?

8. What task commonalities exist among nuclear technician jobs and/or job clusters?

9. What potential career ladders appear to be present within nuclear "job clusters"?

10. What specific equipment is utilized in various nuclear technician jobs?

11. Are the job clusters identified in phase I (the Nuclear Technician Survey) valid or justified on the basis of more detailed information?

Basically, in order to attempt to answer the above research questions, the following overall steps had to be undertaken:

1. Identify a sub-sample of establishments employing nuclear technicians from the Nuclear Technician Survey study (Phase I completed in June, 1971);

2. Design instrumentation for use in task analysis which incorporated selected dimensions of performance related to these jobs;

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3. Conduct the task analysis by arranging personal interviews with supervisors of nuclear technicians; and

4. Analyze the task analysis data with implications for career ladder development within the nuclear industry, and for the development of a nuclear technician curriculum guide.

Other than a section devoted to the definition of selected terms, the remainder of this chapter is devoted to the findings, conclusions, and recommendations resulting from the study. First the findings are presented for each major question under investigation. These are followed by conclusions and recommendations which draw upon the findings for their formulation. It should be pointed out that task analysis, particularly as it relates to curriculum improvement, is yet in early stages of development. This should not dampen our spirit in moving forward with such efforts. Caution, however, should be used in applying the results of the study to specific situations. The authors encourage continued use of good common sense in building nuclear curricula, establishing or modifying nuclear jobs, or calculating the potential source patterns in this important field.

FINDINGS

Findings, as they related to the research questions posed in this study, are presented as follows:

Research Question One

What are the primary activities of nuclear technicians in the various job clusters?

Findings

As seen from Table VII in Chapter Four, the technicians in the health related job cluster tend to perform primarily in the single area of patient care; whereas, reactor operation and production, test and measurement instrumentation, and other related technicians perform in several different areas of activity. For example, of the 75 technicians reported in the reactor operation and production job cluster, 13 or 17.3 percent were performing research and development activities, 15 or 20 percent production activities, and 47 or 62.4 percent were performing maintenance activities. Activities of technicians in other job clusters are also similarly divided.

Research Question Two

What type of educational backgrounds are characteristic of technicians presently employed in the job clusters?

Findings

Table VIII in Chapter Four indicates that 274 or 59.7 percent of the technicians have post-high school training but less than a four year degree. However, almost none of the technicians have less than a high school degree. Specifically, of the 459 nuclear technicians for whom educational background data were reported in this study, four or less than one percent did not have a high school education, 162 or 35.3 percent were high school graduates, 274 or 59.7 percent had received 2-3 years of post-high school training, whereas 19 or 4.1 percent had at least a four year degree.

Research Question Three

What are the major tasks performed by nuclear technicians by job and job cluster?

Findings

Tables IX-XIII in Chapter Four show that there were 284 specific tasks identified in this study. These tasks were obtained from 53 supervisors reporting for 20 job titles covering 475 technicians. One hundred forty-two of these tasks were reported for the health related cluster, while 49, 47, 31, and 15 were reported for the reactor operation and production, testing and measurement, other related, and instrumentation job clusters, respectively. The nature of the tasks identified is described in subsequent research questions.

Research Question Four

What percentages of time and with what frequency are the nuclear technicians performing specific tasks by job and job cluster?

Findings

1. As shown in Chapter Four, Tables IX-XIII, the tasks are ranked within jobs by percentage of time devoted by technicians to each major task identified in the study. The time devoted per task ranges from 100 to as low as one percent.

2. Most of the major tasks take less than 50 percent of the total job time. In the reactor operation and production job cluster, only 10 of the 49 tasks

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or 20.4 percent took more than 50 percent of the workers' time, whereas the test and measurement job cluster amounted to 2.1 percent; the instrumentation cluster 6.7 percent; the health cluster 12 percent; and in the other related job cluster, 19.3 percent of the tasks took more than 50 percent of the job time.

3. The frequency of task performance analysis, although critical information for several purposes, was not discriminating in most instances in that the majority of tasks are performed at least once a week within the nuclear industry. However, there are exceptions to this in the reactor operation and production and the test and measurement job clusters where 33 and 27 percent, respectively, of the tasks were performed only once a month or less.

Research Question Five

What importance is placed on the performance of specific major tasks relative to "job entry", "routine job performance", or for "job promotion"?

Findings

1. All job clusters have a distribution of tasks which must be mastered for "job entry", "routine job performance", and "job promotion". The reactor operator and production technician data in Table IX shows that 18.4 percent of the tasks were reported as being necessary for routine job performance. Again, about 42.9 percent of the tasks were considered necessary for promotion. It should, however, be noted that there were a number of tasks reported to be important both for job entry and routine job performance; and, there were at least two tasks which were reported to be

important for all categories, namely, job entry, routine job performance, and promotion. Tables X-XIII in Chapter Four report similar figures on the test and measurement, instrumentation, health, and other job clusters, respectively, as summarized below.

Percentage Analysis of the Importance of Tasks by Job Cluster Relative to Job Entry, Routine Job Performance, and Promotion

Job Cluster	Job Entry	Routine Performance	Promotion
Reactor Operation and Production	18.4	63.3	42.9
Test and Measurement	8.5	100.0	19.1
Instrumentation	20.0	66.7	26.7
Health Related	46.5	76.1	15.5
Other Related	19.3	83.9	19.3

2. The biggest percentage of tasks are for routine job performance although there is a considerable number of tasks which were reported as important for more than one category. On the other hand, only two tasks in test and measurement and eight in health related job clusters were rated important on all the three categories.

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Research Question Six

What job functions were associated with specific tasks and at what levels are these tasks performed?

Findings

1. As shown in Tables XV-XIX, all tasks were rated as to their relationship to data, people, and things and then presented by rank order within jobs (See Appendix D for the actual scales). All tasks were rated this way. A composite score was assigned for each of the data, people, and things ratings after the three scales were each divided into high, medium, and low (See Appendix D for the scale showing high-medium-low scale and their inter-relationship).

2. The composite scores tended to indicate high level tasks across the data, people, and things scales. As shown in Tables XXII and XXV, although the composite scores tended to distribute themselves across all scale levels, the largest percentage of ratings was concentrated at the "nine" level which indicated high job performance requirements.

Research Question Seven

What levels of general educational development are associated with specific tasks?

Findings

The General Education Development scale points range from a one (low) to a six (high) as can be seen below. The overall mean for reasoning, mathematical development, and language is above the 3.0 level.

The Mean General Education Development Score by Job Cluster

JOB CLUSTER	GENERAL EDUCATION DEVELOPMENT		
	Reasoning	Math Development	Language
1. Reactor Operation and Production	3.7	3.9	3.5
2. Testing and Measurement	4.3	3.5	3.3
3. Instrumentation	3.7	2.9	3.5
4. Health Related	3.5	3.2	3.3
5. Other Related	4.2	3.3	3.7
TOTAL	3.8	3.4	3.4

Research Question Eight

What task commonalities exist among nuclear technician jobs and/or job cluster?

Findings

The principal task commonalities within and among the job clusters are shown below.

List of Task Commonalities among Jobs with Job Clusters

1. Reactor Operation and Production

   Perform experiments
   Calibrate equipment
   Maintain equipment

2. Test and Measurement

   Data reduction
   Perform chemical analysis

3. Health Related

   Position patient
   Maintain equipment
   Calibrate instrument
   Count patients
   Keep records

4. Other Related

   Maintain equipment
   Test materials

Research Question Nine

What potential career ladders appear to be present within nuclear technician "job clusters"?

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Findings

Little discrimination due to the people, data, things composite scores was found between the jobs in each cluster. The following table, however, gives the rank ordered jobs within each cluster by the composite scores.

Career Ladders within Job Clusters

	JOB AND JOB CLUSTERS	COMPOSITE SCORE
	Reactor Operation and Production	
1.01	Test or Research Reactor Operator	9
1.08	Nuclear Facility Equipment Operator	9
1.09	Nuclear Facility Maintenance Technician	9
1.05	Nuclear Power Plant Operator	7
1.07	Hot-Cell Technician	7
	Test and Measurement	
2.02	Nuclear Facility	9
2.03	Non-Destructive Testing Technician	9
2.01	Radiation Control Technician	7
	Instrumentation	
3.01	Instrumentation and Control Technician	9
3.02	X-Ray Calibration Technician	9

JOB AND JOB CLUSTERS		COMPOSITE SCORE
	Health Related	
4.07	Special Procedures Technician	10
4.01	Radiologic Technologist	9
4.02	Radiologic Technologist, Chief	9
4.03	Nuclear Medical Technologist	9
4.08	Radiation Therapy Technician	9
4.10	Radiobiology Technician	7
4.11	Radiopharmacist	4
	Other Related	
5.04	Mechanical and Structural Technician	9
5.06	Electronic and Instrument Technicians	9

Research Question Ten

What specific equipment is utilized in various nuclear technician jobs?

Findings

Table XXX in Chapter Four shows the instruments and equipment that are used at least once a week in all the job clusters surveyed. All the other instruments are utilized less than once a month. The instruments most commonly used are listed below:

List of Instruments and Equipment
Used in All the Job Clusters at Least Once a Week

Electrical

Oscilloscope
Pulse generator
Signal generator
Regulated power supplies
Plotters/Recorders

Fluid

Pressure gauges
Flow meters

Thermal

Thermometers

Nuclear

Geiger counter
Scintillation equipment
X-Ray equipment

2. Reactor operation and production, test and measurement, instrumentation, and other related technicians perform in a wide range of activities and may need broad gauged training.

Research Question Eleven

Are the job clusters identified in phase I (the Nuclear Technician Survey) valid or justified on the basis of more detailed information?

Findings

A visual inspection of the various jobs and their respective major tasks indicated that the initial clustering of the jobs as done for the purpose of this study was valid.

CONCLUSIONS

1. The health related technician job cluster tends to show that characteristics different from those of the other clusters. The health related technicians tend to perform exclusively in health activities. Moreover, the health supervisors tend to supervise only health workers as contrasted to the supervisors in other clusters.

2. Nuclear technician jobs from all job clusters tend to consist of several major tasks involving higher levels of educational development scales. This tends to verify the technician level of the jobs analyzed in that, generally speaking, higher level jobs require higher skill attainment.

3. The detailed listing of major tasks and the associated ratings on data, people, things, and general education development presented in this study can be utilized in expanding or contrasting specific jobs within establishments.

4. A hierarchy of tasks within the jobs and to a lesser extent the entire 20 jobs, within the clusters is implied from the distribution of ratings across the various scales. This means that workers could be shifted within the ladder as a part of a career development program.

5. Although not many common tasks were specifically identifiable due to the lack of an instrument with an exact pre-determined task inventory, there were nevertheless several tasks that were closely related. This

implies that the technicians in the various job clusters are indeed performing many similar tasks and may require some common elements in their preparation.

RECOMMENDATIONS

1. It appears that consideration should be given to the preparation of a dual core training program, i.e., one for the health cluster and one for all the other job clusters identified in the study.

2. The task inventory compiled as a result of this study should be examined by a panel of experts. The panel should be comprised of representatives from nuclear technician occupations, as well as supervisors and employers of nuclear technicians.

3. As routine performance on the job is the most consistent reason for task performance by nuclear technicians, a more vigorous effort should be made to develop and design cooperative programs with participants from the employing community.

4. Though the complexity of tasks and the educational background of technicians indicate that nuclear technician training is essentially at the post-secondary level, the possibility of introductory curriculum at secondary level should be actively explored. This introductory program might be used for orientation purposes.

5. Further task analyses of a more traditional type utilizing the task bank developed in this study should be conducted for selected

occupations on a systematic basis. The results of the study should be made available to training institutions concerned with nuclear technician training throughout the Region.

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DEFINITION OF TERMS

In-House Training — An organized system for providing workers with the manipulative skills and technical or theoretical knowledge needed for fompetent performance. The program involves on-the-job work experiences and the related information in the classroom. May be a cooperative program offered by industry, school, and labor working close together.

Interfacing — The term interfacing will mean matching expected supply of trained manpower from specific sources by program title and description with estimated demand by job title and description. This matching of training output with job requirement will be for a given time period and within a specific geographic region. The interfacing process is characterized by clustering of selected training programs and jobs for matching purposes.

Job Analysis — The process of identifying by observation, interviews, and study, and of reporting the significant worker activities and requirements and the technical and environmental facts of a specific job.

Manpower Demand — Demands are notices of job vacancies that exist in the labor market. These notices are expressed in terms of graduates needed from specific vocational-technical education programs defined in the office of Education Classification System.

Manpower Policy — A manpower policy is the process embracing those principles and programs which aim to assist the individual to become fully employed in productive work of his choosing consonant with his aptitudes, talents, and interests under fair standards; to help sustain and rehabilitate the individual experiencing economic or personal hardship; and, to help maintain the individual in as adaptable, flexible, and responsive a stance as possible to the changing requirements of the world of work.

Manpower Supply — Total number of measured or projected skilled persons available during the time period under consideration, categorized according to specific skill, or "skill cluster".

Nuclear Medicine — Nuclear Medicine is that clinical and scientific discipline concerned with diagnostic, therapeutic (exclusive of sealed sources) and investigative use of radionuclides.

Nuclear Related Industry — An industry involved in producing, processing, utilizing, or transporting radioactive materials. A license issued by the United States Atomic Energy Commission is a prior requirement to venture into any of the industrial activities mentioned above.

Nuclear Technology — A combination of subject matter and laboratory experiences designed for the study of scientific principles, mathematival concepts, and communicative skills which when combined with appropriate laboratory situations, perpare the pupil to be supportive to professionals engaged in developing manufacturing, testing, research, maintaining, storing, and handling materials in the nuclear science and energy field.

Southern Interstate Nuclear Board — Is the Nation's first non-federal, public supported, interstate advisory and development agency in the nuclear and space fields. It was established in 1961 by Southern Governors' Conference to help foster the sound application of nuclear and related technology in the South, in agriculture, industry, medicine, and research. The states included are: Maryland, Virginia, West Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Missouri, Oklahoma, Texas, and the Commonwealth of Puerto Rico.

Task — A task, as used in this study, represents a major element of a specific job.

Task Analysis — Task analysis is a method or a process by which a task is examined and its characteristics, in terms of criteria attributes, are identified.

Technical Institute — A school at the post-high school level which offers technical education in one or more fields to prepare people for employment in positions which lie between the skilled workers and professional scientists or engineers.

Technician — A person who directly or indirectly supports scientists and engineers in designing, developing, producing, and maintaining machines and materials. In general, these technician jobs are technical in nature but more limited in scope than those of the engineer or scientist, and have a practical rather than a theoretical orientation.

Technician, Nuclear — A person who works as a technician in a nuclear related industry. May require a license issued by the United States Atomic Energy Commission.

CHAPTER II

BACKGROUND INFORMATION

One of the most important and pressing problems facing vocational and technical educators today relates to the development and implementation of training curricula which are congruent with the needs of employers. This congruence can be achieved through the mechanism of job classification and analysis.

The following pages report research and literature that have a bearing on manpower training and curriculum development in the nuclear field. The presentation is divided into the following two sections:

1. Manpower implications of Nuclear energy, and
2. Task analysis and curriculum development.

It may, however, be pointed out that the research reported on the following pages is by no means exhaustive in scope or in content. Only a limited number of exemplary studies have been included which emphasize the background and context in which the present study has been conducted.

NUCLEAR ENERGY--MANPOWER IMPLICATIONS

Though nuclear industry is still in its infancy, its potential in fields like agriculture, oil exploration and drilling, and transportation is already being recognized as tremendous. Martin Mann in his book Peacetime Uses of Atomic

Energy, points out that atomic energy is a boon to the farmers and has the potential to feed the hungry billions of this planet. Radioisotopes are being used for research into the process of photosynthesis by which the plants grow. Other radioactive materials help to eradicate plant diseases and control other pests; they help in treating seeds to get bigger and heavier crops; and they help the plants to grow faster than they would under the natural circumstances.[1]

Similar revolutions in production techniques, testing procedures and development of new products are being brought about in many industries. The role of industrial radiography, in this context, is worthy of special attention because this new and emerging field tends to overshadow the old testing techniques used by the industry. According to Mann, "Atomic measuring devices alone were saving American Industry three billion dollars every year."[2]

New and varied uses are being found of nuclear energy almost every day. The most profound impact of this source of energy, however, has been in the fields of power generation and health industries. Of these two, electric power generation has by far the greater implications for manpower than health though they both are equally important for the health of the nation. Thousands of highly trained workmen are required to construct, fuel, operate, maintain, and overhaul the nuclear power plants. A larger number is required to provide these personnel with adequate support

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1 Martin Mann, Peacetime Uses of Atomic Energy, (New York: The Viking Press, 1963), pp. 94-117.

2 Ibid., p. 138.

facilities. The U.S. Atomic Energy Commission in a publication entitled Utility Staffing for Nuclear Power, estimated that technician level manpower requirements of a nuclear power plant consist of 47 highly trained technicians at different levels. These requirements, of course, vary from plant to plant according to capacity and existing activity level.[3]

SINB in its 1971 annual report has projected a tremendous growth in nuclear electric generation in the region. According to this report "...by 1990 electric power generation (in the region) by nuclear means will almost equal power generation by fossil fuels."[4] Also, the SINB region by the year 1985 will generate 41 percent of the national total of nuclear power generation. The report goes on to explain that:

> ...total of 46 additional nuclear plants are presently under construction or on order in eleven Southern States... units will represent more than $9 billion in capital investment and add 43,500 mega watts of power to the region's electrical capacity. These scheduled projects will garner for the South almost half of the total annual expenditure of the nation's expanding nuclear power industry.[5]

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3 United States Atomic Energy Commission, Utility Staffing for Nuclear Power, (Washington: Government Printing Office, Publication 1130, July, 1969), pp. 6-7.

4 Science and Technology in the South, Atlanta, Georgia: Southern Interstate Nuclear Board, 1971, p. 21.

5 Ibid., p. 22.

Needless to say that this expansion in nuclear power generation will increase the demand for suitably trained technicians.

Another important and perhaps the most noticeable effect of nuclear energy is in the health field. The number of X-ray technicians have variously been estimated at between 30,000 and 75,000.[6] The latter estimate, however, includes those working part-time. According to a Department of Labor report, which also listed X-ray technicians as one of the 17 most critical occupations in the health field:

> New techniques are being used widely in the treatment of cancer by various types of radiation devices, providing X-rays and gamma rays; equipment utilizing high speed electrons is used in treating certain skin lesions. Hodgkin's disease, a type of cancer, is being treated with energy from linear accelerations.[7]

Other industries like uranium milling, fuel element fabrication, instrument manufacturing, radioactive waste disposal, etc., between them employed 6,500 technicians.[8] Greater demand for nuclear power and other services will increase employment in these segments of the industry, also.

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6 United States Department of Health, Education, and Welfare, Training Branch. National Conference on X-ray Technician Training (Rocheville, Maryland, September 1966), p. 21.

7 United States Department of Labor, Technology and Manpower in the Health Service 1965-75. (Washington: Government Printing Office, May 1967), p. 43.

8 United States Atomic Energy Commission, Occupational Employment Trends in the Atomic Energy Field 1963-68 (Washington: Government Printing Office, 1969), p. 10.

There have been two studies published in recent months which are of great importance in the analysis of manpower needs of nuclear industry. The first of these was conducted by the U.S. Atomic Energy Commission in cooperation with Bureau of Labor Statistics. Their report published in August, 1970 aims at developing "...supply/demand ratio for nuclear degreed scientists and engineers for the period extending from July, 1969 through December 31, 1973."[9] According to this publication between the years 1969 and 1973, 41,279 degreed scientists, engineers and technicians will be needed for jobs in nuclear fields. This figure mades allowances for attrition. Total employment of technicians alone will reach a figure of 46,025 in 1973 from 34,164 in 1969.[10] It may, however, be remembered that X-ray and other health related technicians are not included in this survey.

The second study conducted under the auspices of Southern Interstate Nuclear Board was completed earlier this year.[11] This comprehensive study is the only one of its nature collecting data from all nuclear related industries within the SINB region. A total of 1,588 licensee establishments were surveyed of which 418 were found to be employing nuclear technicians. Present employment of such workers was set at 8,547 with projected net demand of 1,110 for the year

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9 United States Atomic Energy Commission, Nuclear Manpower Survey, Final Report (Washington: Government Printing Press, 1970), p. XI.

10 Ibid., pp. 220-221.

11 Paul V. Braden, and Krishan K. Paul, Nuclear Technician Manpower Survey: Approach to an Information System, (Atlanta: Southern Interstate Nuclear Board, 1971), pp. 3-10.

1971. Another important feature of this study was a survey of all training institutions within the SINB region. It was found that the training institutions estimated 1,080 graduates from different nuclear training programs by June, 1971. Projections of both manpower demand and supply were available for and up to the year 1974-75. The following are some of the other major findings of the study.

1. There are 99 major institutions which train technicians offering 137 training programs most popular among which were radiologic technology, non-destructive testing, and radiologic health technology.
2. Employing organizations have a large number of in-house training programs. A total of 130 establishments offered 180 different training programs.
3. Training institutions and employment organizations trained a total of 1,880 technicians in 1971.
4. Most of the trainees (71 percent) from these training programs end up working as technicians in the field they were trained.
5. Workers in nuclear industry have, in general, a high school education; they have an average of 15.8 months of training and they have an average of 8.2 years of work experience of which 2.9 years is on the nuclear related jobs.
6. Workers are not very mobile and tend to take jobs near their place of training.
7. On an average a worker has held 3.6 jobs including the present employment.

TASK ANALYSIS AND CURRICULUM DEVELOPMENT

A recent review of research in curriculum development has been published by the Center for Vocational and Technical Education at The Ohio State University. Introducing the subject of curriculum development, Larson, the author, says:

> Curriculum development based on employment needs is the essence of effective payroll education for the youth and adult in today's world. The climate of both society and recent legislation has highlighted the base line essential for solutions to problems relative to the world of work for individuals and the nation. Curriculum development, in the Amendments to the Vocational Education Act of 1963, has been identified as a needed force. The real thrust of building curriculum for vocational instruction is found in analysis of occupations. Requirements of the employers are essential to identifying content for occupational and vocational education. Interpretation of the employer's needs of today for tomorrow's program of vocational education to meet the requirements of the employers is more complex--but highly significant in today's changing technological civilization.[12]

Importance of job and task analysis for curriculum development has been recognized by many other authors. According to a paper presented to the National Society of Programmed Instructions, a technical training program has five basic requirements. They are:

1) job specification,
2) translation of job specification into training objectives,

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[12] Milton E. Larson, Analysis for Curriculum Development in Vocational Education, (Columbus, Ohio: The Center for Vocational and Technical Education, 1969) p. 3.

3) measurement of the individual's aptitude for training,
4) development of a method to achieve the training objectives, and
5) performance control and evaluation.[13]

One authority in the field of task analysis is Sidney Fine. He was involved in the revision of the Dictionary of Occupational Titles, a book of reference extensively used for identification, specification, and delineation of jobs. Fine feels that if manpower specialists are to design viable jobs from the entry level to the professional level of various employee organizations, they need a base of accurate and comparable information describing what these employing organizations do. Such information is essential for day-to-day operations such as recruitment, selection, training, assignment, and supervision in order to effectively support and implement a career opportunity system. According to Fine, to develop such information requires two fundamental techniques:

1) Getting control of the fundamental unit of work and job--the task. The guidelines for writing task statements proposed here follow a specific form and structure and express what workers do and what gets done. The task statements answer specific questions by expressing explicit worker actions and their expected results along with an indication of work aids and instructions.

2) Getting control of the language of description using the Worker Function Scales. The three hierarchies of worker functions which define the simplest to the most complex worker behavior in relation to Data,

[13] Ibid., p. 4.

People, and Things are a common language that makes it possible to reduce misunderstanding and inconsistency of interpretation among the many users of task information. In addition to controlling the language and meaning of what workers do, the Worker Function Scales allow one to compare what all workers do in terms of the level and orientation of their respective tasks. It is then possible to know how one task (or series of tasks) stacks up against other tasks--a vital point of departure for job design.[14]

Worker qualifications and scaling of jobs are two of the most important aspects of jobs. According to Fine:

"The most common means for establishing requirements (which then becomes qualifications) has been to set on the basis of custom, competition, or availability in the labor market, a certain number of school years or a degree which workers must acquire to qualify for a given job. The hope is that an applicant who has completed the specified schooling will thereby be able to meet the job requirements. It is now more or less accepted that an individual's years in school often have little or nothing to do with whether he can perform certain tasks. It is also widely acknowledged that arbitrary diploma or degree qualifications have screened out capable motivate applicants from minority and disadvantaged groups. The question raised by most selection officers has become: What do we substitute for years of school, diplomas, and previous experience as qualifications."[15]

Task analysis, no matter how elaborate the techniques, must be viewed as only a part of a much larger information system upon which

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[14] Sidney A. Fine and Wretha W. Wiley, An Introduction to Functional Job Analysis, (E.E. Upjohn Institute for Employment Research, September, 1971), pp. 17-18.

[15] Ibid., p. 27.

manpower authorities base their planning, decision-making and execution. The Occupational Training Information System (OTIS) utilized in Oklahoma as a tool for manpower decision-making was the basic model for SINB's regional information system efforts.[16]

Another important work as it relates to this task analysis study is the work of Roney and Phillips on the third generation technician.

> The third generation of education will cut across established fields of technology. This generation will provide a new combination of technical skills and knowledge built around a core of the sciences. Applications of the sciences will be drawn from modern industrial activities, and the "specialized" content of the instructional program will be systems oriented, rather than field oriented.[17]

SUMMARY

Available literature in the field, as reviewed here, emphasizes the need for training programs in adequate numbers to match the requirements of a growing nuclear industry. In order to gear the training programs to the employers' specific needs, it is essential that jobs be analyzed and translated into specific performance requirements.

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[16] Paul V. Braden, James L. Harris, and Krishan K. Paul, Occupational Training Information System (Stillwater, Oklahoma, Oklahoma State University, 1970), p. 230.

[17] Maurice W. Roney and Donald S. Phillips, Electromechanical Technology, (Washington, D. C., American Association of Junior Colleges, 1970), pp. 9-10.

CHAPTER III

PROJECT PROCEDURES

INTRODUCTION

The purpose of this chapter is to outline the procedures and tools used in an attempt to answer the research questions posed in this study. The research design, population, sample instrumentation, data collection procedures, data analysis procedures, and summary are presented in that order.

RESEARCH DESIGN

The basic design of this study can be characterized as descriptive survey research. This type of research design is particularly suitable for manpower development problems where projections of manpower needs and supply are necessary to make any planning meaningful. Curriculum development through occupational analysis, being one of the more important aspects of manpower development, is specially suitable for survey research design. Chamberlain states:

> If economists want to be "scientific" and therefore quantitative, they are obliged to a short enough run for the phenomena with which they work to stay relatively fixed--where

changes are so moderate or incremental as not to invalidate logic based on a continuity of circumstance. If economists want to deal with a farther future, which increasingly involves not only change but change which is planned for, they are obliged to work with other standards than efficiency and with methods that are judgmental and strategy oriented rather than scientific.[1]

Van Dalen also advocated a descriptive approach to research where the variables are not yet well defined. According to him:

> Before much progress can be made in solving problems, men must possess description of the phenomena with which they work. Early developments in educational research, therefore, as in other disciplines, have been concerned with making accurate assessments of the incidence, distribution, and relationships of phenomena in the field. But descriptive research is not confined to routine fact gathering. Predicting and identifying relationships among and between variables is the goal of competent investigators.[2]

Survey research, however, has some limitations chief among which are the sacrifice of "depth" for the sake of "scope," time and money being constraints.[3] The investigators are aware of these limitations and due caution will be used in interpretating the results of data analysis presented in the following chapter.

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[1] Neil W. Chamberlain, "Some Second Thoughts on the Concept of Human Capitol," The Development and Use of Manpower, (ed.) Gerald G. Summers, (Madison, 1968), pp. 11-12.

[2] Deobold B. Van Dalen, Understanding Educational Research, (New York, 1966), p. 203.

[3] Fred F. Kerlinger, Foundations of Behavioral Research, (New York, 1966), p. 407.

POPULATION FOR THE STUDY

The sample for this study was selected from a population of 1,588 nuclear licensee firms. Any firm or establishment that manufactures, processes, or utilizes nuclear material or product thereof must obtain a license from the United States Atomic Energy Commission (hereafter referred to as AEC). It may, however, be pointed out that application for an issuance of such a license is indicative of intentions only and does not commit the applicant to the process or the product. In order to carry out phase I of the SINB five phase program, the list of 1,588[4] licensee firms within the SINB Region was acquired through the AEC.

Demand questionnaires (See Appendix A) were mailed to all the 1,588 firms in December, 1970, as described earlier. Different forwarding letters were used for those who did respond to the earlier introductory letter and those who did not. This was done to increase the probability of a high response.

On January 4, 1971, a reminder postcard was sent to all the non-respondents.

Table I shows the results of these efforts and the total returns received.

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[4] The 1,588 firms do not necessarily include those licensed by individual states which hold agreements with AEC.

Table I

Response Analysis of Demand Questionnaire

Questionnaires	Number	Percent
Total Number Mailed	1,588	100.0
Total Number Returned	682	42.9
Number Indicating a Demand	418	26.3
Number Indicating No Demand	264	16.6
Number That Identified Key-Men	378	23.8
Number of Returns from Key-Men	335	21.0

Of the 378 organizations that identified key-men, 335 or 88.6% returned questionnaires.

To check for a possible bias in the returns, a sample of 92 firms was randomly selected and a telephone contact was established with them. The results ot this check are reported in Table II.

Table II

Comparison of Results of the Responses to Questionnaires and Telephone Survey Respectively

	Demand Questionnaire	Telephone Survey
Firms Employing Technicians	418	31
Others*	1,170	61
TOTAL	1,588	92

*Represents those establishments that do not employ technicians and also those which are no longer licensees.

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A calculated Chi Square value of 2.404 was not significant at the 0.05 level of significance with one degree of freedom (Table value 3.841 with 1 d.f.). This shows that no significant differences existed between the population of firms represented by the list supplied by AEC and the non-respondents represented by the bias check sample.

A further analysis of the 31 firms from the bias check sample which did employ technicians, however, showed that 15 or 48.4 percent employed less than 5 technicians and 11 or 35.5 percent employed only one technician. Even so, it was clear that not all of the demand was accounted for by the returned demand questionnaires. However, the 418 employing establishments who responded to the demand questionnaire would represent the population of this study.

SAMPLE FOR THIS STUDY

Out of the 418 employing establishments, a sample of twenty was randomly selected. All of the establishments were listed in alphabetical order by state and each was assigned a distinct numerical code. A table of random numbers was used to initially select the sample. This initial sample was modified to include establishments from all job clusters, to make it more geographically representative, to take advantage of the establishments which had representation on the nuclear manpower steering committee, and to comply with financial constraints. Nevertheless, since the primary

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thrust of this study was scope rather than depth, the sample was considered sufficient. This sample was utilized to administer, by personal interview, the technician task analysis instrument.

There were 475 technicians who were reported to be employed by the 17 establishments in the sample. Total employment in 1970 by different job codes compared with the number of technicians surveyed in the present study can be seen in Table III. However, the percentage distribution of these technicians by the job cluster as reported by the employers compared with the data collected from their supervisors can be seen in Table IV. (It may be pointed that the test and measurement and instrumentation job clusters were combined in the Nuclear Technician Manpower Survey (phase I) to make a bigger cluster of testing, monitoring, and related jobs.)

From the Table IV, it can be seen that health job cluster is over represented and "other related job" cluster is under represented. The reason for the latter is that those jobs surveyed earlier in phase one which had no nuclear content were not covered in this task analysis. Supervisory span of control characteristics of the establishments in the sample which employed technicians in the health related job cluster was responsible for over representation of this cluster.

Each establishment in the sample was written an introductory letter (See Appendix B) by the Deputy Director of SINB. These letters were addressed to the representative already identified as "keyman" through the earlier demand survey. These letters helped in paving the way for smoother conduct of interview schedules.

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TABLE III

A Comparison of Nuclear Technicians Surveyed for Task Analysis with 1970 Employment by Job Code

Job Code	Job Title	Number of Technicians Surveyed for Task Analysis	Number Employed in Nuclear Industry in 1970
actor Operation nd Production			
1.01	Testor Research Reactor Operation	31	84
1.02	Production, Test, or Research Operator - Government Owned	--	118
1.03	Accelerator Operator	--	81
1.04	Radioisotope Production Operator	--	124
1.05	Nuclear Power Plant Operator	8	132
1.06	Nuclear Material Processor	--	349
1.07	Hot-Cell Technician	1	75
1.08	Nuclear Facility Equipment Operator	7	273
1.09	Nuclear Facility Maintenance Technician	47	296
Testing and Measurement			
2.01	Radiation Control Technician	31	323
2.02	Nuclear Facility Chemistry Technician	44	273
2.03	Non-Destructive Testing Technician	4	596
nstrumentation			
3.01	Instrumentation and Control Technician	8	352
3.02	X-Ray Calibration Technician	3	45
3.03	Well Logging Technician	--	493

TABLE III CONTINUED

Job Code	Job Title	Number of Technicians Surveyed for Task Analysis	Number Employed in Nuclear Industry in 1970
ealth Related			
4.01	Radiologic Technologist	110	1108
4.02	Radiologic Technologist, Chief	35	148
4.03	Nuclear Medical Technologist	12	297
4.04	Chest Radiographer	--	24
4.05	Urology X-Ray Technician	7	31
4.06	Orthopedic Radiologic Technician	--	60
4.07	Special Procedures Technician	36	105
4.08	Radiation Therepy Technician	10	132
4.09	Internal Dosimetry Technician	--	15
4.10	Radiobiology Technician	1	111
4.11	Radiopharmacist	1	73
;her Related			
5.01	Soils Evaluation Technician	--	418
5.02	Draftsman	--	482
5.03	Computer Programmer	--	116
5.04	Mechanical Instructural Technician	35	597
5.05	Welding Technician	--	275
5.06	Electronic and Instrument Technician	44	555
5.07	Quality Control Technician	--	336
	TOTAL	475	8547

TABLE IV

PERCENTAGE OF NUCLEAR TECHNICIANS EMPLOYED IN NUCLEAR TECHNICIAN SURVEY (PHASE I) AND THE TASK ANALYSIS (THIS REPORT).

JOB CLUSTER FOR TECHNICIAN SURVEY	% EMPLOYMENT N=8547*	JOB CLUSTER FOR TASK ANALYSIS	% FOR WHICH TASKS WERE REPORTED N=475
Power Production Related Jobs	17.9	Power Product Related jobs	19.8
Testing, Monitoring and Related Jobs	24.4	Testing and Measurement	16.7
		Instrumentation	2.9
Health Related	24.6	Health Related	46.9
Other Related	33.1	Other Related	13.7

* Source: Paul V. Braden and Krishan K. Paul, Nuclear Technician Manpower Survey, Atlanta, Georgia: Atlanta, Georgia: Southern Interstate Nuclear Board, 1971, pp. 42-45

RELIABILITY OF PRIMARY DATA SOURCE

The 53 supervisors of nuclear technicians served as the primary data source for this study. Although there are some advantages in seeking job information directly from workers in specified occupations, this is usually done by using instruments which contain already identified tasks which are then reacted to by the workers. Since no tasks existed in the nuclear industry on such a broad number of jobs and job clusters, it was necessary to utilize supervisors as the resource for identifying major tasks by specific jobs and job clusters. As indicated in the recommendation section of Chapter I, the basis now exists for conducting more traditional occupational analyses on specific jobs or job clusters which may appear to warrant further study.

As shown in Table V, the supervisors have had extensive work experience as technicians and as supervisors, the overall average being 13.36 years. Furthermore, these supervisors on the average have insight into multiple job clusters, as shown in Table VI. Clearly, most supervisors have responsibility for workers in several job cluster areas.

INSTRUMENTATION

One basic instrument was developed for data collection, i.e., the task analysis personal interview form (See Appendix C). This instrument was developed with the help of technical educators, SINB personnel,

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TABLE V

WORK EXPERIENCE OF THE SUPERVISORS BY JOB CLUSTER

JOB CLUSTER	Number of Supervisors Surveyed	AVERAGE WORK EXPERIENCE (YEARS)			TOTAL AVERAGE EXPERIENCE (YEARS)
		As Supervisors	As Nuclear Related Technician	As Technician (Other)	
1. Reactor Operation and Production	11	5.00	4.36	3.09	12.45
2. Testing and Measurement	6	12.83	1.5	--	14.33
3. Instrumentation	3	3.33	12.33	1.0	16.66
4. Health Related	27	5.63	5.48	2.22	13.33
5. Other, Related	6	10.66	0.5	1.33	12.49
TOTAL	53	6.75	4.62	1.98	13.35

TABLE VI

TECHNICIANS' PRIMARY AREA OF ACTIVITY BY JOB CLUSTER

N = 475

JOB CLUSTER	Reactor Operation & Production Nos.	Reactor Operation & Production Percent	Test Measurement Nos.	Test Measurement Percent	Instrumentation Nos.	Instrumentation Percent	Health Nos.	Health Percent	Other Nos.	Other Percent	Total Nos.	Total Percent	Data* Not Available Nos.
1. Reactor Operation and Production	35	37.6	7	7.5	26	27.9	-	0.0	25	26.8	93	100	1
2. Testing and Measurement	-	0.0	42	55.3	-	0.0	27	35.5	7	9.2	76	100	3
3. Instrumentation	-	0.0	3	21.4	8	57.2	-	0.0	3	21.4	14	100	-
4. Health Related	-	0.0	1	0.5	7	3.3	198	92.9	7	3.3	213	100	10
5. Other Related	14	21.9	18	28.1	26	40.6	1	1.6	5	7.8	64	100	1
TOTAL	49	10.7	71	15.4	67	14.6	226	49.1	47	10.2	460	100	15

*Represents those cases where the data was not reported on this question.

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consultants, and employers. The instrument was pretested at employing establishments recommended by the SINB Project Director, and the Steering Committee.

The instrument was specifically designed to gather major task information from direct supervisors of nuclear technicians. These supervisors were identified by completing the first section of the instrument in conference with the "keyman" in the establishment. In addition, the interviewer was instructed to personally observe and/or interview nuclear technicians in order to verify the tasks given by the supervisors.

The instrument contained sections dealing with supervisors' work and educational experience and related data in order to gain insight into the background of the interviewer and their mobility patterns. In addition to the several categories of information concerning each task, the instrument incorporated six (6) scales utilized in the Dictionary of Occupational Titles[5] (See Appendix D). Each task was rated, where applicable on each scale. The scales pertain to job functions as related to data, people, and things, as well as the general education development characteristics of reasoning, mathematics, and language. The basic assumption is that all tasks can be rated on the functions and general education development characteristics.

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[5] Dictionary of Occupational Titles, Volume 1, Definitions of Titles, (Washington, D. C.: U. S. Government Printing Office, 1965).

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DATA COLLECTION

Specific Steps in the Task Analysis:

1. Establishments to be visited were selected and appointments were made with "keyman" in each establishment by utilizing the most appropriate contact person; for example, an SINB official or a Steering Committee member.
2. The "keyman" was requested to identify the supervisors of nuclear technicians within his establishment. The "keyman" was given an opportunity to discuss the general issue of nuclear technician manpower supply and demand. These comments were recorded in general style.
3. The "keyman" then made arrangements for interviews with appropriate supervisors of nuclear technicians.
4. Supervisors were then asked specified questions about their educational and work experience background in order to gain increased knowledge about the environment in which nuclear technicians perform.
5. Each supervisor was requested to list the major tasks which are performed by the technician <u>for each specific job title</u> previously indicated on the establishment demand survey instrument utilized in phase I of the project.
6. Next, the interviewer attempted to elicit a minimum of <u>5 major tasks presently performed for each job title</u>. <u>For each of these tasks for each job title</u>, the interviewer utilized a selected set of scales to

secure ratings. There were some scales which were non-applicable to a given task and were, therefore, marked with the appropriate scale number which indicated "no significant relationship".

DATA ANALYSIS

After several discussions held by the authors with Mr. David Jopling of SINB, who did the actual interviewing, the data were coded on specially designed summary sheets. Percentages and frequency counts were used to determine the distribution of responses to all response categories. As already mentioned earlier in this chapter, this study is concerned with the scope rather than the depth of job task information. Percentage and frequency analysis has been found very useful in this kind of research design.

In addition, each job task was classified as high, medium, or low on the data, people, and things scales (See Appendix D). This was utilized in subsequent analyses to assist in identifying career ladders and any common tasks among the various jobs and job clusters.

CHAPTER IV

ANALYSIS OF DATA

INTRODUCTION

The purpose of this study is to conduct a task analysis as a part of a Nuclear Manpower Information System by attempting to answer the following research questions:

1. What are the primary activities of nuclear technicians in the various job clusters?
2. What type of educational backgrounds are characteristic of technicians presently employed in the job clusters?
3. What are the major tasks performed by nuclear technicians by job and job cluster?
4. What percentage of working time and with what frequency are the nuclear technicians performing specific tasks by job and job cluster?
5. What importance is placed on the performance of specific tasks relative to "job entry", "routine job performance" or for "job promotion".
6. What job functions are associated with specific tasks and at what levels are these tasks performed?
7. What levels of general education development are associated with specific tasks?
8. What task commonalities exist among jobs and/or job clusters?

9. What potential career ladders appear to be present within the "job clusters"?

10. What specific equipment is utilized in various nuclear technician jobs?

11. Are the job clusters identified in phase I (the Nuclear Technician Survey) valid or justified on the basis of more detailed information?

Data pertaining to each of the above research questions is presented by the job clusters identified in phase one. These clusters are as follows:

1. Reactor operation and production,

2. Test and measurement,

3. Instrumentation,

4. Health related, and

5. Other related.

The rationale for analysis by job cluster is primarily related to the fact that a meaningful way had to be employed for handling the hundreds of major tasks identified in the data collection stage.

Research Question #1. What are the primary activities of nuclear technicians in the various job clusters?

The traditional activities of "research and development" and "production" were supplemented with categories more germane to the health related job cluster. As shown in Table VII, the technicians in the health related job cluster tend to perform primarily in only one area of "Patient Care," whereas reactor operation and production; test and measurement; and other related technicians perform in several different areas of activity.

TABLE VII

PRIMARY ACTIVITY OF NUCLEAR TECHNICIANS BY JOB CLUSTER

N = 475

JOB CLUSTER	TYPE OF ACTIVITY											TOTAL		Data not Reported	
	Research & Development		Production		Sales	Maintenance		Patient Care		Radiologic Control					
	Nos.	Percent	Nos.	Percent	Nos.	Nos.	Percent	Nos.	Percent	Nos.	Percent	Nos.	Percent	Nos.	Percent
1. Reactor Operation and Production	13	17.3	15	20.0	--	47	62.7	--	--	--	--	75	100	19	20.2
2. Testing and Measurement	2	2.6	9	11.7	--	1	1.3	--	--	65	84.4	77	100	2	2.5
3. Instrumentation	4	28.6	2	14.3	--	8	57.1	--	--	--	--	14	100	--	--
4. Health Related	2	1.1	--	--	--	--	--	172	98.9	--	--	174	100	49	22.0
5. Other Related	10	24.4	10	24.4	--	21	51.2	--	--	--	--	41	100	24	36.9
PERCENT OF TOTAL	31	8.1	36	9.4	--	77	20.2	172	45.1	65	17.1	381	100	94	19.8

For example, of the 75 technicians for whom data were reported in the reactor operation and production job cluster, 13 or 17.3 percent were performing research and development activities, 15 or 20 percent production activities, and 47 or 62.7 percent performing maintenance activities. These figures may be compared with health job cluster where more than 98 percent technicians were performing in patient care. For all technicians--a total of 381--for whom data were reported, 8.1 percent were performing in research and development, 9.4 percent in production, 20.2 percent in maintenance, 45.1 percent in patient care, and 17.1 percent in radiologic control. Not one technician was reported involved in sales activity. Another feature worth noting was that a majority or 82.3 percent technicians in testing and measurement job cluster were reported performing in radiologic control activity.

Research Question #2. What type of educational backgrounds are characteristic of technicians presently employed in the job clusters?

As can be seen in Table VIII, 274 or 59.7 percent of the 459 technicians for whom data were reported had post-high school training, but less than a four year degree. However, only 0.9 percent of the technicians had less than a high school education. Specifically, of the 459 nuclear technicians reported in this table, four or less than one percent did not have a high school education, 162 or 35.3 percent were high school graduates, 274 or 59.7 percent had a post-high school training but less than a four year degree, and only 19 or 4.1 percent had a four year degree.

TABLE VIII

EDUCATIONAL BACKGROUND OF TECHNICIANS INCLUDED IN THE SURVEY

N = 475

JOB CLUSTERS	Less than High School Education		High School Graduates		Post-High School Training but less than 4 Year Degree		4 Year Degree		TOTAL	
	Nos.	Percent	Nos.	Percent	Nos.	Percent	Nos.	Percent	Nos.	Percent
1. Reactor Operation and Production	--	--	27	28.7	67	71.3	--	--	94	100
2. Testing and Measurement	4	5.1	53	67.1	13	16.4	9	11.4	79	100
3. Instrumentation	--	--	6	42.8	6	42.8	2	14.3	14	100
4. Health Related	--	--	54	26.1	149	72.0	4	1.9	207*	100
5. Other Related	--	--	22	33.8	39	60.0	4	6.2	65	100
TOTAL	4	0.9	162	35.3	274	59.7	19	4.1	459	100

*Educational background on 16 technicians was not reported.

Research Question #3. What are the major tasks performed by nuclear technicians by job and job clusters?

As shown in Tables IX through XIII, the reactor operation and production job cluster accounts for 49 tasks with 47 in test and measurement, 15 in instrumentation, 142 in health related, and 31 in other related job clusters for a total of 284 tasks. These major tasks represent the work performed by the 475 technicians reported in this study, ad are presented in the tables rank-ordered by the percentage of time devoted to each task.*

The tasks, as can be seen, were recorded in the actual words of the supervisors and stated who performed the task (implied from the jobs under study); and what major actions were performed. In addition, the task statements were linked with associated information such as supervisor ratings related to the worker functions of data, people, and things (See Appendix D). These task statements do not contain the reason why the tasks were performed since they were major tasks only and as such data would remain too general for analysis.

Research Question #4. What percentage of time and with what frequency are the nuclear technicians performing specific tasks by job and job cluster?

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*The tasks are listed with their associated job identification numbers so that the reader might refer to the listing of jobs in Table III for relationship between the jobs and the tasks.

As shown in Tables IX through XIII, the tasks are rank-ordered within job clusters by percentage of time devoted to each major task identified in the study. The time spent per task ranges from 100 down to one percent. Even though the supervisor normally had more than one worker per job category in mind when estimating percentage of time devoted to each major task, he was instructed to make the major tasks add to 100 percent. (When percentages by job add to multiples of 100, it merely indicates that more than one supervisory observation was made of that job.)

The percent of time devoted to task performance is one major index of task importance to managers, supervisors, and the educators concerned with curriculum development. Most of the major tasks took less than 50 percent of the total time. In the reactor operation and production job cluster, of the 49 tasks only 10 or 20.4 percent took more than 50 percent of the workers' time, whereas in the test and measurement job cluster, it was 2.1 percent; in the instrument cluster it was 6.7 percent; in the health cluster it was 12 percent; and in the other related job cluster, it was 19.3 percent.

The frequency of reported task performance was not discriminating in most instances in that the majority of tasks were performed at least once a week within the nuclear industry. However, there were exceptions to this in the reactor operation and production, and the test and measurement job clusters, where 33 and 27 percent tasks, respectively, were performed only once a month or less.

TABLE IX

An Analysis of Tasks in the Reactor Operation and Production Job Cluster as to Frequency of Task Performance and Percentage of Time Devoted to Each Task

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Assist in control room operation under direction (1.08)	100	X			E
Monitor and control high pressure auxiliary boiler (1.08)	100	X			E
Check control room instrumentation and controls (1.05)	100	X			R
Controls and monitor power level during operation (1.08)	95	X			E
Nuclear reactor unit operation (1.08)	90	X			R
Calibration and functional test of instrumentation (1.09)	70	X			ERP
Control power level and monitor instruments (1.01)	60	X			E
Perform experiments (1.01)	60	X			R
Perform experiments (1.07)	55	X			RP
Check plant equipment (1.05)	50	X			R
Troubleshoot control systems (1.09)	45	X			P
Perform routine maintenance (1.09)	40	X			P
Maintain proficiency and knowledge of reactor procedure and related instructions (1.01)	25	X			R

TABLE IX CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Monitor and interpret all instruments serving reactor (1.01)	25	X			R
Perform unscheduled repairs (1.09)	20	X			P
Calibrate electronic modules (1.09)	20	X			P
Calibrate test instruments (1.09)	20	X			R
Make work area safe and account for all nuclear materials (1.07)	20	X			RP
Inspect all systems and equipment servicing the reactor and perform routine maintenance when necessary (1.01)	20	X			R
Manipulate primary reactor controls (1.01)	20	X			R
Troubleshoot, repair, and perform routine maintenance (1.09)	15	X			ERP
Instrument inspect and repair instrumentation (1.09)	15			X	P
Inspect and repair boiler (1.09)	15			X	P
Record data from experiments and make necessary calculations (1.07)	15	X			RP
Performs experimental operations (1.01	15	X			RP
Plan experiments (1.01)	15			X	P
Document and record instrument calibrations (1.09)	10	X			RP

TABLE IX CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Refuel reactor (1.09)	10			X	P
Calculate control settings (1.09)	10		X		R
Survey radiation (1.05)	10	X			R
Keep records (1.01)	10	X			RP
Maintain equipment (1.01)	10	X			E
Gather data	10	X			R
Data reduction and reporting (1.01)	10			X	P
Insert and remove experiments from reactor (1.01)	10	X			R
Calibrate pneumatic devices (1.01)	5		X		R
As control room operator, Monitor and control all reactivity during refueling (1.08)	5	X			E
Maintain equipment (1.07)	5		X		RP
Install new equipment (1.07)	5			X	RP
Handle experiment and refuel reactor (1.01)	5	X			E
Specify special equipment needed for experiment (1.01)	5			X	P
Write procedures for instrument calibration (1.09)	3		X		P
Perform operational surveillance (1.08)	3	X			R

TABLE IX CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE Weekly	Monthly	Yearly	JOB IMPORTANCE Entry (E) Routine (R) Promotion (P)
Maintain daily performance calculations and other needs for a Nuclear unit (1.08)	3	X			R
Start up and shut down Nuclear unit (1.08)	2			X	R
Operates Nuclear unit as transient (1.08)	1			X	R
Refuel reactor (1.08)	1			X	R
Calibrate test equipment (1.09)	1		X		R
Specify and write orders for replacement parts (1.09)	1		X		R

TABLE X

An Analysis of Task in the Test and Measurement Job Cluster as to Frequency of Task Performance and Percentage of Time Devoted to Each Task

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Perform varied sample analysis on radio benches, hoods, glove boxes, and related housekeeping tasks (2.02)	60	X			R
Conduct radiation and contamination surveys for reactor operation (2.01)	40	X			RP
Perform radiochemical analysis of liquids and gases (2.01)	40	X			R
Clean up dishes and related materials (2.02)	30	X			R
Perform sample preparation, irradiation, and counting (2.02)	30	X			R
Operate radiation survey and laboratory counting equipment (2.01)	30	X			R
Data reduction (2.02)	25	X			ER
Perform routine chemical analysis (2.02)	25	X			ERP
Data reduction (2.02)	25	X			ER
Perform irradiation and counting (2.02)	20	X			R
Take samples of aurum and water, interpret results and estimate action (2.01)	20	X			RP
Perform routine chemical analysis (2.02)	20	X			ERP

TABLE X CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Maintain film badges and dosimeters for facility personnel and experimentors (2.01)	20	X			RP
Interpret guides and establish protective clothing and respiratory protection requirements (2.01)	20	X			RP
Perform ultrasonic inspections relative to thickness, cracks, weld quality, and standards (2.03)	15	X			R
Maintains laboratory (2.02)	15	X			R
Perform routine sample logging and reporting (2.02)	15	X			R
Operate and calculate results from Alpha and other counting equipment in performing count on Alpha, Beta, and Gamma mounts (2.02)	15	X			R
Prepare and monitor radioactive waste shipments (2.01)	15	X			RP
Perform radiation and contamination control surveys (2.01)	15	X			R
Survey and establish dose rates and working time limits for personnel (2.01)	15	X			R
Perform radiation smear surveys (2.01)	15	X			R
Perform radiation and level surveys (2.01)					
Perform radiation-protection surveillance for work parties (2.01)	15	X			R

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TABLE X CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Read X-ray film (2.03)	10	X			R
Write test specifications and fabricate (2.03)	10	X			R
Perform primary dilutions and analysis by remote operation in shielded facilities (2.02)	10	X			R
Processing materials from reactor for shipment (2.01)	10	X			RP
Provide radiation surveillance for facility laboratories (2.01)	10	X			RP
Perform radiochemical sampling of liquids and gases (2.01)	10	X			R
Perform Magna flux inspections (2.03)	5			X	R
Perform black light inspections (2.03)	5		X		R
Perform dye check inspections (2.03)	5	X			R
Perform X-ray inspections (2.03)	5		X		R
Perform fuel element inspections (2.03)	5		X		R
Overhaul equipment (2.03)	5	X			R
Perform field corrosion tests (2.03)			X		R
Perform borescopes and periscopes (2.03)	5		X		R
Perform spot check for materials (2.03)	5		X		R

TABLE X CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Perform field hardness tests (2.03)	5		X		R
Perform material analysis (2.03)	5		X		R
Perform failure analysis (2.03)	5	X			R
Perform laboratory corrosion tests and programs (2.03)	5			X	R
Preparation of samples (2.02)	5		X		R
Provide assistance in library searches (2.02)	5		X		R
Prepare reports on liquid and solid waste disposal (2.01)	5	X			RP
Provide administrative assistance (2.01)	5	X			R

TABLE XI

An Analysis of Task in the Instrumentation Job Cluster as to Frequency of Task Performance and Percentage of Time Devoted to Each Task

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE Weekly	Monthly	Yearly	JOB IMPORTANCE Entry (E) Routine (R) Promotion (P)
Develop, process, read film, and chart data (3.02)	80	X			P
Data reduction (3.02)	20	X			E
Irradiation and counting (3.02)	15	X			R
X-ray florescence analysis (develop file and make exposure) (3.02)	15	X			RP
Prepare (CO-60 source), insert, irradiate, package and log (3.02)	15	X			RP
Sample preparation (3.02)	10	X			R
Calibrate equipment (3.02)	10	X			E
Prepare specimens (3.02)	10	X			R
Provide technical assistance for logging instruments (3.02)	10	X			R
Prepare samples and develop film (3.02)	10	X			RP
Perform miscellaneous services (library errands, etc.) (3.02)	5	X			R
NOTE: Tasks for which no percent of time was reported:					
Perform routine maintenance on various types of equipment including electronic and pneumatic (3.01)		X			R

TABLE XI CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Routine inspection of equipment (3.01)		X			E
Calibrate equipment after repair (3.01)		X			R
Troubleshoot malfunctioning equipment (3.01)		X			R

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TABLE XII

An Analysis of Task in Health Related Job Cluster as to Frequency of Task Performance and Percentage of Time Devoted to Each Task

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Assist and expose film for Radiologist during arteriographs and special procedures (4.02)	100	X			R
Give radiographic examinations to patients (4.02)	90	X			R
Position patients for therapy treatment (4.02)	80	X			ER
Outline scanning procedures (4.01)	80	X			ERP
Examine patients (4.01)	75	X			ER
Make diagnostic radiographs (4.02)	75	X			R
Set up patients and mark area to be treated (4.08)	75	X			ER
Scan the patients utilizing X-ray equipment (4.03)	66		X		ER
Position patient for treatment (4.08)	60	X			E
Positions and radiograph patients (4.02)	60	X			R
Prepare patients and make diagnostic radiographs (4.01)	60	X			P
Make exposures of film to map organs (4.08)	50	X			R
Follow doctor's prescriptions to treat patients (4.08)	50	X			ER

TABLE XII CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Use scanning instruments (4.03)	50	X			E
Use nuclear medical equipment (4.03)	50	X			RP
Perform diagnostic tests (4.03)	50	X			RP
Assist Radiologist in routine flouroscopy (4.02)	50	X			E
Position patient for radiograph to be made (4.02)	45	X			E
Cut sections of organs or skin (4.01)	40	X			R
Position patient (4.02)	35	X			E
Attend formal classes (4.01)	35	X			P
Record data and assist in administration (4.01)	35	X			ER
Position patient for examination and take films (4.01)	35	X			E
Set up and treat patient using modalties for radiation treatments and for X-ray "check" film (4.08)	30	X			ERP
Assist physician in procedures (4.07)	30	X			P
Perform routine radiologic procedure (4.07)	30	X			R
Give treatment to patients (4.08)	25	X			R
Plan treatment including calculations (4.08)	25	X			ERP

TABLE XII CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Carry patient in ambulance to another hospital and assist in Cobalt 60 prescriptions (4.08)	25	X			ER
Operate high energy equipment (4.07)	25		X		R
Operate highly complex recording machines (4.07)	25	X			R
Assist physicians with minor surgical procedures (4.07)	25		X		R
Write brief patient history (4.05)	25	X			ER
Develop film (4.05)	25	X			ER
Load machine and take photograph (4.05)	25	X			ER
Position patient and position body parts (4.05)	25	X			ER
Write patient's history and records (4.03)	25	X			R
Calibrate machines (4.03)	25	X			E
Take radiological films (4.01)	25	X			E
Assist doctor in doing examination (4.01)	25	X			E
Stain sections of skin and organs (4.10)	20	X			R
Assist in P. Hepatectomy (weighing animals, etc.) (4.10)	20		X		R
Patient care, housekeeping, bookkeeping for treatment of patients (4.08)	20	X			P
Set up rooms for sterile procedures (4.07)	20	X			E

TABLE XII CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Program and operate rapid film changers and cine cameras (4.07)	20	X			E
Operate physiologic monitors and monitor physiological status of patients (4.07)	20	X			E
Assist Surgical Radiologist (4.07)	20	X			E
Preparing materials (soluticns, shots) (4.03)	20		X		RP
Be responsible for care of patients while in department (4.03)	20	X			RP
Assist in Administration (4.02)	20	X			P
Critique film and assure quality control (4.02)	20	X			R
Inject isotopes (4.01)	20	X			ER
Keep all therapy and tumor records (4.08)	15	X			E
Position patients and plan radiologic techniques (4.07	15	X			E
Scrub and assist with catheter introduction and manipulation (4.07)	15	X			R
Prepare more difficult X-ray procedures (4.07)	15	X			R
Assist Radiologist (4.02)	15	X			R
Select technical factors for proper exposure (4.02)	15	X			E

TABLE XII CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE Weekly	Monthly	Yearly	JOB IMPORTANCE Entry (E) Routine (R) Promotion (P)
Supervise student technicians (4.02)	15	X			R
Calculate does (4.01)	15	X			ER
Keep record of prescriptions on patients (4.08)	14	X			ER
Prepare materials to be used (4.10)	10	X			R
Fix embedding of tissue (4.10)	10	X			R
Prepare follow-up schedule (4.08)	10	X			R
Assist doctor in caring for patient (4.08)	10	X			E
Prepare patient for examination (4.08)	10	X			E
Keep books and assist in administration (4.07)	10	X			R
Keep patient records (4.07)	10		X		R
Keep equipment in good working order for procedures (4.07)	10	X			E
Take external counting over the body (4.03)	10		X		ER
Be on call duty (4.03)	10	X			RP
Instruct nuclear medical students (4.03)	10	X			RP
Use radioactive compounds (4.03)	10	X			RP
Instruct student technologists (4.02)	10	X			R

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TABLE XII CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Process films (4.02)	10	X			R
Calculate correct exposure (4.02)	10	X			E
Product radiographic technician calculations (4.02)	10	X			E
Position patients (4.01)	10	X			ER
Setting up equipment (4.01)	10	X			ER
Keep all records and data on patients and isotopes (4.01)	10	X			ER
Prepare room for examination (4.01)	10	X			E
Maintain equipment to operable condition (4.08)	5	X			R
Administer medication for tests (4.08)	5	X			R
Assay radioactive medicine for administration (4.08)	5	X			R
Check for radiation exposure in lab (4.08)	5	X			R
Schedule daily work (4.08)	5	X			R
Perform computerized dosimetery and assist physician (4.08)	5	X			R
Plan dosimetery (4.08)	5	X			R
Instruct medical students (4.08)	5	X			R

TABLE XII CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Provide supplies and do other paperwork (4.08)	5	X			ERP
Prepare and assist doctor in treatment planning (4.08)	5	X			ER
Check blood work before prescription for safe level (4.08)	5	X			ER
Assist in dose calculation (4.08)	5	X			E
Prepare patient under aseptic conditions (4.07)	5	X			E
Prepare equipment under sterile conditions (4.07)	5	X			E
Maintain equipment to operable condition (4.02)	5	X			R
Prepare patient (4.02)	5	X			R
Assist radiologist to instruct student technologist in clinical aspects of training (4.02)	5	X			R
Prepare instruments for "special" radiographic examination (4.02)	5	X			P
Operate the controls for patient's actual treatment time (4.02)	5	X			ER
Mark the patient with marking field (4.02)	5	X			ER
Take film if needed (4.02)	5	X			ER

TABLE XII CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Instruct nuclear medicine and therapy (4.01)	5	X			P
Administer doses (4.01)	5	X			ERP
Calculate doses (4.01)	5	X			ERP
Assay Radioactivity (4.01)	5	X			ERP
Calibrate instruments (4.01)	5	X			ERP
Administer pre-medications (4.01)	5	X			ER
Clean up lab (4.01)	5	X			ER
Assist Radiologist in injecting the patient (4.01)	5	X			ER
Prepare and calculate dose for patient (4.01)	5	X			ER
Prepare patient for injection (4.01)	5	X			ER
Help patient in ingestion of opaque material (4.01)	5	X			E
Keep patient records (4.08)	2	X			ER
Prepare therapy (4.08)	2	X			R
Supervise student appointments for out patients (4.08)	1	X			ER
Calibrate capsule (4.03)	1		X		R
Count patient (4.03)	1		X		R

TABLE XII CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Calibrate machine (4.03)	1	X			R
Count patients (4.03)	1		X		R
Prepare capsules (4.03)	1		X		R
Perform T 3 (4.03)	1	X			R
Calibrate machines (4.03)	1	X			R
Calculate decay on radioactive materials (4.08)			X		ER
Positioning of proper body part (4.07)		X			R
Select technique factor for each body part (4.07)		X			R
Provide assistance with radiography under sterile conditions in operating room (4.07)			X		R
Provide technological support for special procedures including vascular and post operative X-ray procedures (4.07)		X			R
Sterilize instruments for special procedures (4.07)		X			R
Provide on-the-job training for students in X-ray and special procedures (4.07)		X			R
Operate instruments other than X-ray equipment related to vascular radiology such as electrical pressure injectors for vessels (4.07)		X			R

TABLE XII CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Position patients (4.01)		X			R
Select proper technique factors (4.01)		X			R
Assist radiography in operating room under sterile conditions (4.01)		X			E
Inject dye interavenously under supervision of Radiologist (4.01)		X			R
Prepare dye for injection into bladder through catheter (4.01)		X			R
Prepare dye for interavenous injection under sterile technique (4.01)		X			R
Operate Elutes 99m To Generators (4.11)		X			R
Calculate radioisotope doses (4.11)		X			R
Performs quality controls on compounds (4.11)		X			R
Assist in maintaining inventory of isotopes (4.11)		X			R
Perform necessary day-to-day tasks, e.g., running errands, washing glassware, drawing up doses, etc. (4.11)		X			R

TABLE XIII

An Analysis of Task in the Other Related Job Cluster as to Frequency of Task Performance and Percentage of Time Devoted to Each Task

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Performs routine maintenance on all forms of Plant Instrumentation (5.06)	85	X			R
Performs Metallographic examination (5.04)	70	X			R
Performs maintenance, repair, and calibration of reactor instruments and all associated equipment (200 units) (5.06)	60	X			R
Repairs electronic instruments (5.06)	50	X			ER
Manufactures equipment for the reactor (Mechanical) (5.04)	50	X			R
Designs new instruments including package design (5.06)	50		X	X	RP
Maintains mechanical equipment used for instruction or R & D (5.04)	35	X			E
Maintains and calibrates counting and test equipment (250 units) (5.06)	25	X			R
Calibrates instruments (5.06)	25	X			ER
Builds new instrumentation or instrumentation systems (5.06)	25	X			RP
Assists in set up of equipment for educational experiments (5.04)	25	X			E

TABLE XIII CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Maintains and repairs reactor mechanical equipment (5.04)	20	X			R
Performs maching and welding in order to prepare R & D equipment for use (5.04)	20	X			E
Receives and ships equipment and supply items (5.04)	20	X			E
Performs Photography (5.04)	15	X			R
Performs maching and design improvisations (5.06)	15		X	X	RP
Instrument operation including computer (5.06)	15		X	X	RP
Maintenance of nuclear instruments and (electronic modification) and repair (5.06)	15		X	X	RP
Order materials and supplies needed for other tasks (5.04)	10	X			R
As a machinist, assist in design of equipment for the reactor and experimental programs (5.04)	10	X			R
Manufacture equipment designed for experiments (5.04)	10	X			R
Evaluation of process variable and equipment related to control loop (5.06)	10	X			R
Test materials for corrosion (5.04)	5	X			R
Performs mechanical testing (5.04)	5	X			R

TABLE XIII CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Maintains and repairs reactor mechanical equipment (5.04)	20	X			R
Performs maching and welding in order to prepare R & D equipment for use (5.04)	20	X			E
Receives and ships equipment and supply items (5.04)	20	X			E
Performs Photography (5.04)	15	X			R
Performs maching and design improvisations (5.06)	15		X	X	RP
Instrument operation including computer (5.06)	15		X	X	RP
Maintenance of nuclear instruments and (electronic modification) and repair (5.06)	15		X	X	RP
Order materials and supplies needed for other tasks (5.04)	10	X			R
As a machinist, assist in design of equipment for the reactor and experimental programs (5.04)	10	X			R
Manufacture equipment designed for experiments (5.04)	10	X			R
Evaluation of process variable and equipment related to control loop (5.06)	10	X			R
Test materials for corrosion (5.04)	5	X			R
Performs mechanical testing (5.04)	5	X			R

TABLE XIII CONTINUED

TASKS	% OF TIME	FREQUENCY OF PERFORMANCE			JOB IMPORTANCE
		Weekly	Monthly	Yearly	Entry (E) Routine (R) Promotion (P)
Performs heat treating, casting operations (5.04)	3		X		R
Performs X-ray diffraction analysis by utilizing a computer (5.04)	5		X		R
Performs record keeping and reporting writing (5.06)	5	X			R
Purchase parts & equipment and maintaining inventory (5.06)	5	X			R
Design and manufacture experimental electronic equipment (5.06)	5		X		R
General determination of problems with radiation equipment, e.g., standardizing and adjustment of read-out (5.06)	5		X		R
Calibrate and test instruments (5.06)	5		X	X	RP
	100	X			

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Research Question #5. What importance is placed on the performance of specific major tasks relative to "job entry," "routine job performance," or for "job promotion"?

All job clusters have a distribution of tasks which must be mastered for "job entry," "routine job performance," and for "promotion". The reactor operator and production technician data in Table IX shows that 18.4 percent tasks were reported as important for job entry, whereas 63.3 percent tasks were reported necessary for routine performance on jobs, and 42.9 percent tasks were considered necessary for promotion. It should, however, be noted that there are a number of tasks which are important both for job entry and routine performance; and there are at least two tasks which are important on all the three criteria, namely, job entry, routine performance, and promotion.

Tables X, XI, XII, and XIII report similar figures on the test and measurement, instrumentation, health, and other job clusters, respectively. These data, along with those from Table IX, are summarized in Table XIV.

It can be seen from Table XIV that the biggest percentage of tasks are for routine performance and also there are considerable number of jobs which are important for more than one reason. On the other hand, only two tasks in test and measurement and eight in health related job clusters are rated important on all the three criteria.

TABLE XIV

Percentage Analysis of the Relative Importance of Tasks by Job Cluster

Job Cluster	Job Entry	Routine Performance	Promotion
Reactor Operation and Production	18.4	63.3	42.9
Test and Measurement	8.5	100.0	19.1
Instrumentation	20.0	66.7	26.7
Health Related	46.5	76.1	15.5
Other Related	19.3	83.9	19.3
Average for all job clusters (%)	22.5	78.0	24.7

Research Question #6. What job functions are associated with specific tasks and at what levels are these tasks performed?

As shown in Tables XV, XVI, XVII, XVIII, and XIX, each task was rated as to its relationship to data, people, and things (See Appendix D for the actual scales) and presented by rank-order within jobs. All tasks can be rated this way. A composite score was computed for each task based on data, people, things ratings after the scales were divided into high, medium, and low (See Appendix D for derivation of high-medium-low scale).

The composite scores tended to be high across the various scales. Each task was rated by utilizing a composite score derived from the independent ratings for data, people, and things.

TABLE XV

A Rank Ordering of the Reactor Operation and Production Job Cluster By Composite Job Function Score within Jobs with a Listing of Associated General Education Development Ratings

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Perform experiments (1.01)	9	H	M	H	4	4	4
Monitor and interpret all instruments serving reactor (1.01)	9	H	M	H	4	4	3
Inspect all systems and equipment servicing the reactor and perform routine maintenance when necessary (1.01)	9	H	M	H	4	4	4
Manipulate primary reactor controls (1.01)	9	H	M	H	3	4	4
Plan experiments (1.01)	9	H	M	H	4	5	3
Handle experiment and refuel reactor (1.01)	9	H	M	H	3	4	4
Calibrate pneumatic devices (1.01)	8	H	L	H	4	4	3
Control power level and monitor instruments (1.01)	6	H	L	M	4	4	4
Maintain proficiency and knowledge of reactor procedure and related instructions (1.01)	6	H	M	L	4	4	5
Maintain equipment (1.01)	6	H	L	M	4	3	3
Data reduction and reporting (1.01)	6	H	M	L	3	5	4
Insert and remove experiments from reactor (1.01)	6	M	L	H	3	1	2

TABLE CONTINUED XV

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Specify special equipment needed for experiment (1.01)	6	H	M	L	4	4	3
Performs experimental operations (1.01)	4	M	M	M	4	4	4
Gather data (1.01)	2	L	L	M	3	1	3
Keep records (1.01)	1	L	L	L	3	4	4
Check control room instrumentation and controls (1.05)	7	M	M	H	4	5	3
Survey radiation (1.05)	3	M	M	L	4	5	3
Check plant equipment (1.05)	3	M	M	L	4	5	3
Maintain equipment (1.07)	7	H	M	M	4	3	3
Install new equipment (1.07)	7	H	M	M	3	1	3
Perform experiments (1.07)	7	M	M	H	4	3	3
Make work area safe and account for all nuclear materials (1.07)	5	H	L	L	4	3	3
Record data from experiments and make necessary calculations (1.07)	2	L	L	M	4	4	3
As control room operator, Monitor and control all reactivity during refueling (1.08)	9	H	M	H	4	5	3
Assist in control room operation under direction (1.08)	9	H	M	H	4	5	3

TABLE CONTINUED XV

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Monitor and control high pressure auxiliary boiler (1.08)	9	H	M	H	4	5	3
Controls and monitor power level during operation (1.08)	9	H	M	H	4	5	3
Perform operational surveillance (1.08)	9	H	M	H	5	1	4
Start up and shut down Nuclear unit(1.08)	9	H	M	H	3	4	4
Nuclear reactor unit operation (1.08)	7	H	M	M	4	4	4
Operates Nuclear unit as transient (1.08)	7	H	M	M	4	1	1
Refuel reactor (1.08)	7	M	M	H	4	4	4
Maintain daily performance calculations and other needs for a Nuclear unit (1.08)	1	L	L	L	1	3	1
Troubleshoot, repair, and perform routine maintenance (1.09)	9	H	M	H	4	5	4
Troubleshoot control systems (1.09)	9	H	M	H	6	5	5
Calibrate test equipment (1.09)	9	H	M	H	4	5	4
Instrument inspect and repair instrumentation (1.09)	8	H	L	H	4	4	3
Inspect and repair boiler (1.09)	8	H	L	H	4	4	3
Refuel reactor (1.09)	8	H	L	H	3	4	4

TABLE CONTINUED XV

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Calibrate electronic modules (1.09)	8	H	L	H	3	5	4
Calibrate test instruments (1.09)	8	H	L	H	3	5	4
Perform unscheduled repairs (1.09)	7	H	M	M	4	4	4
Calibration and functional test of instrumentation (1.09)	6	H	M	L	4	5	4
Perform routine maintenance (1.09)	6	H	L	M	4	4	3
Write procedures for instrument calibration (1.09)	6	H	M	L	5	5	5
Document and record instrument calibrations (1.09)	2	M	L	L	2	5	3
Calculate control settings (1.09)	2	M	L	L	4	5	4
Specify and write orders for replacement parts (1.09)	1	L	L	L	2	1	2

TABLE XVI

A Rank Ordering of the Test and Measurements Job Cluster By Composite Job Function Score with a Listing of Associated General Education Development Ratings

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Conduct radiation and contamination surveys for reactor operation (2.01)	7	H	M	M	4	4	4
Operate radiation survey and laboratory counting equipment (2.01)	7	H	M	M	5	4	2
Take samples of aurum and water, interpret results and estimate action (2.01)	7	H	M	M	5	5	3
Maintain film badges and dosimeters for facility personnel and experimentors (2.01)	7	H	M	M	4	3	4
Prepare and monitor radioactive waste shipments (2.01)	7	H	M	M	3	5	3
Perform radiation and contamination control surveys (2.01)	7	H	M	M	5	4	3
Survey and establish does rates and working time limits for personnel (2.01)	7	H	M	M	5	4	4
Perform radiation smear surveys (2.01)	7	H	M	M	4	3	3
Perform radiation and level surveys (2.01)	7	H	M	M	4	4	3
Perform radiation-protection surveillance for work parties (2.01)	7	H	M	M	3	4	4
Processing materials from reactor for shipment (2.01)	7	H	M	M	3	5	3
Provide radiation surveillance for facility laboratories (2.01)	7	H	M	M	4	6	4

TABLE CONTINUED XVI

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Perform radiochemical analysis of liquids and gases (2.01)	6	H	L	M	3	4	3
Interpret guides and establish protective clothing and respiratory protection requirements (2.01)	6	H	M	L	5	1	4
Prepare reports on liquid and solid waste disposal (2.01)	6	H	M	L	4	5	4
Perform radiochemical sampling of liquids and gases (2.01)	3	M	L	M	4	3	3
Provide administrative assistance (2.01)	1	L	L	L	2	4	2
Perform sample preparation, irradiation, and counting (2.02)	8	H	L	H	3	4	3
Perform varied sample analysis on radio benches, hoods, glove boxes, and related housekeeping tasks (2.02)	7	M	M	H	3	3	3
Perform routine sample logging and reporting (2.02)	7	M	M	H	4	3	3
Perform primary dilutions and analysis by remote operation in shielded facilities (2.02)	7	M	M	H	5	2	4
Perform routine chemical analysis (2.02)	6	M	L	H	4	4	4
Data reduction (2.02)	6	H	L	M	3	4	2

TABLE CONTINUED XVI

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Perform irradiation and counting (2.02)	6	H	L	M	3	1	3
Perform routine chemical analysis (2.02)	6	M	L	H	4	4	4
Preparation of samples (2.02)	5	L	L	H	3	1	3
Operate and calculate results from Alpha and other counting equipment in performing count on Alpha, Beta, and Gamma mounts (2.02)	4	M	M	M	3	3	3
Data reduction (2.02)	3	M	L	M	3	1	2
Provide assistance in library searches (2.02)	2	M	L	L	4	1	4
Clean up dishes and related materials (2.02)	1	L	L	L	4	1	2
Maintains laboratory (2.02)	1	L	L	L	4	1	2
Perform ultrasonic inspections relative to: Thickness, cracks, weld quality, and standards (2.03)	9	H	M	H	6	4	4
Read X-Ray film (2.03)	9	H	M	H	6	4	4
Write test specifications and fabricate (2.03)	9	H	M	H	3	4	4
Perform Magna flux inspections (2.03)	9	H	M	H	4	4	3

TABLE CONTINUED XVI

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Perform black light inspections (2.03)	9	H	M	H	5	4	3
Perform dye check inspections (2.03)	9	H	M	H	5	4	3
Perform X-Ray inspections (2.03)	9	H	M	H	3	4	3
Perform fuel element inspections (2.03)	9	H	M	H	6	4	3
Overhaul equipment (2.03)	9	H	M	H	6	4	4
Perform field corrosion tests (2.03)	9	H	M	H	6	4	4
Perform borescopes and periscopes (2.03)	9	H	M	H	6	4	3
Perform spot check for materials (2.03)	9	H	M	H	6	9	3
Perform field hardness tests (2.03)	9	H	M	H	6	4	3
Perform material analysis (2.03)	9	H	M	H	6	4	4
Perform failure analysis (2.03)	9	H	M	H	6	4	4
Perform laboratory corrosion tests and progress (2.03)	9	H	M	H	6	4	4

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TABLE XVII

A Rank Ordering of the Instrumentation Job Cluster
By Composite Job Function Score with a Listing of
Associated General Education Development Ratings

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Routine inspection of equipment (3.01)	9	H	M	H	3	5	3
Calibrate equipment after repair (3.01)	9	H	M	H	5	5	4
Troubleshoot malfunctioning equipment (3.01)	9	H	M	H	5	5	4
Develop, process, read film, and chart data (3.02)	9	H	M	H	4	5	3
Prepare specimens (3.02)	9	H	M	H	4	1	3
Perform routine maintenance on various types of equipment including electronic and pneumatic (3.01)	9	H	M	H	3	5	4
Calibrate equipment (3.02)	7	M	M	H	4	1	3
Irradiation and counting (3.02)	6	H	L	M	3	1	3
Prepare samples and develop film (3.02)	6	H	L	M	3	4	4
Prepare sample preparation (3.02)	5	L	L	H	3	1	3
Prepare (CO-60 source), insert, irradiate, package and log (3.02)	3	M	M	L	4	4	5
Data reduction (3.02)	2	M	L	L	3	1	2

TABLE CONTINUED XVII

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
X-ray florescence analysis (develop file and make exposure) (3.02)	2	M	L	L	3	4	4
Provide technical assistance for logging instruments (3.02)	2	M	L	L	4	1	4
Perform miscellaneous services (library errands, etc.) (3.02)	1	L	L	L	4	1	4

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TABLE XVIII

A Rank Ordering of the Health Related Job Cluster By Composite Job Function Score with a Listing of Associate General Education Development Ratings

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Outline scanning procedures (4.01)	9	H	M	H	4	4	4
Instruct nuclear medicine and therapy (4.01)	9	H	M	H	4	4	4
Assay Radioactivity (4.01)	9	H	M	H	4	5	4
Assist doctor in doing examinations (4.01)	9	H	M	H	4	5	4
Setting up equipment (4.01)	8	H	L	H	4	3	2
Calibrate instruments (4.01)	8	H	L	H	4	1	3
Assist radiography in operating room under sterile conditions (4.01)	8	H	L	H	4	4	4
Examine patients (4.01)	7	H	M	M	4	5	4
Prepare patients and make diagnostic radiographs (4.01)	7	H	M	M	4	1	4
Attend formal classes (4.01)	7	H	M	M	4	4	3
Position patient for examination and take films (4.01)	7	M	M	H	4	5	4
Prepare and calculate doses for patient (4.01)	7	H	M	M	3	5	2
Position patients (4.01)	7	H	M	M	3	1	4
Position patients (4.01)	6	H	M	L	4	1	2
Administer doses (4.01)	6	M	H	L	4	5	4

TABLE CONTINUED XVIII

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Administer pre-medications (4.01)	6	H	M	L	4	3	3
Prepare patient for injection (4.01)	6	H	M	L	3	1	4
Inject isotopes (4.01)	6	H	M	L	3	1	3
Select proper technique factors (4.01)	6	M	L	H	3	4	4
Calculate doses (4.01)	5	H	L	L	3	4	2
Calculate doses (4.01)	5	H	L	L	3	5	3
Clean up lab (4.01)	5	H	L	L	4	1	2
Assist Radiologist in injecting the patient (4.01)	5	H	L	L	3	1	5
Inject dye intravenously under supervision of Radiologist (4.01)	4	M	M	M	4	3	4
Prepare dye for injection into bladder through catheter (4.01)	3	M	L	M	4	3	3
Help patient in ingestion of opaque material (4.01)	2	L	M	L	4	1	3
Take radiological films (4.01)	2	L	M	L	3	5	4
Prepare room for examination (4.01)	2	L	L	M	4	1	2
Prepare dye for intravenous injection under sterile technique (4.01)	2	M	L	L	4	3	3
Keep all records and data on patients and isotopes (4.01)	1	L	L	L	2	5	3
Record data and assist in administration (4.01)	1	L	L	L	2	3	2

TABLE CONTINUED XVIII

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Give radiographic examinations to patients (4.02)	9	H	M	H	4	4	2
Supervise student technicians (4.02)	9	H	M	H	4	5	4
Position patient (4.02)	9	H	M	H	3	1	2
Assist Radiologist (4.02)	9	H	M	H	4	5	4
Assist Radiologist to instruct student technologist in clinical aspects of training (4.02)	9	H	M	H	5	4	3
Select technical factors for proper exposure (4.02)	8	H	L	H	3	4	4
Assist and expose film for Radiologist during arteriographs and special procedures (4.02)	7	H	M	M	3	5	5
Make diagnostic radiographs (4.02)	7	H	M	M	4	5	2
Assist Radiologist in routine fluoroscopy (4.02)	7	H	M	M	4	3	5
Instruct student technologists (4.02)	7	H	M	M	4	4	4
Product radiographic technician calculations (4.02)	7	H	M	M	4	5	5
Prepare instruments for "special" radiographic examination (4.02)	7	M	M	H	5	1	1
Maintain equipment to operable condition (4.02)	7	M	M	H	4	5	3

TABLE CONTINUED XVIII

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Prepare patient (4.02)	7	H	M	M	4	1	4
Position patient for radiograph to be made (4.02)	6	H	M	L	4	1	2
Mark the patient with marking field (4.02)	6	H	M	L	3	1	2
Critique film and assure quality control (4.02)	6	H	M	L	5	1	4
Position patients for therapy treatment(4.02)	5	H	L	L	3	1	2
Calculate correct exposure (4.02)	5	H	L	L	3	5	4
Process films (4.02)	3	M	L	M	3	1	2
Operate the controls for patient's actual treatment time (4.02)	3	M	L	M	3	4	2
Position and radiograph patients (4.02)	2	M	L	L	4	4	4
Take film if needed (4.02)	2	M	L	L	3	1	2
Assist in Administration (4.02)	2	M	L	L	1	1	2
Use scanning instruments (4.03)	9	H	M	H	3	5	5
Perform diagnostic tests (4.03)	9	H	M	H	4	5	4
Be on call duty (4.03)	9	H	M	H	6	5	3
Use radioactive compounds (4.03)	9	H	M	H	3	5	4
Write patient's history and records (4.03)	9	H	M	H	3	5	5
Calibrate machines (4.03)	9	H	M	H	3	5	5

TABLE CONTINUED XVIII

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Be responsible for care of patients while in department (4.03)	9	H	M	H	6	1	5
Scan the patients utilizing X-ray equipment (4.03)	7	H	M	M	3	3	3
Use nuclear medical equipment (4.03)	7	H	M	M	6	5	5
Take external counting over the body (4.03)	7	H	M	M	3	3	3
Instruct nuclear medical students (4.03)	7	H	M	M	6	5	5
Preparing materials (solutions, shots)(4.03)	7	H	M	M	3	3	3
Calibrate capsule (4.03)	6	M	L	H	3	3	3
Count patient (4.03)	6	M	L	H	3	3	3
Calibrate machine (4.03)	6	M	L	H	3	3	3
Count patients (4.03)	6	M	L	H	3	3	3
Prepare capsules (4.03)	6	M	L	H	3	3	3
Perform T 3 (4.03)	6	M	L	H	3	3	3
Calibrate machines (4.03)	6	M	L	H	3	3	3
Write brief patient history (4.05)	6	H	M	L	4	4	4
Position patient and position body parts (4.05)	6	H	M	L	4	4	3
Develop film (4.05)	2	L	L	M	3	1	2
Load machine and take photograph (4.05)	2	L	L	M	3	4	4

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TABLE CONTINUED XVIII

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Provide assistance with radiography under sterile conditions in operating room (4.07)	10	H	H	H	4	4	3
Operate high energy equipment (4.07)	9	H	M	H	3	5	4
Operate highly complex recording machines (4.07)	9	H	M	H	3	5	4
Assist physicians with minor surgical procedures (4.07)	9	H	M	H	4	5	4
Set up rooms for sterile procedures (4.07)	9	H	M	H	4	1	4
Program and operate rapid film changers and cine cameras (4.07)	9	H	M	H	6	4	4
Operate physiologic monitors and monitor physiological status of patients (4.07)	9	H	M	H	6	4	4
Position patients and plan radiologic techniques (4.07)	9	H	M	H	6	4	4
Scrub and assist with catheter introduction and manipulation (4.07)	9	H	M	H	4	1	4
Prepare more difficult X-ray procedures (4.07)	9	H	M	H	3	5	4
Provide technological support for special procedures including vascular and post operative X-ray procedures (4.07)	9	H	M	H	5	5	2
Provide on-the-job training for students to X-ray in special procedures (4.07)	9	H	M	H	5	5	2

TABLE CONTINUED XVIII

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Operate instruments other than X-ray equipment related to vascular radiology such as electrical pressure injectors for vessels. (4.07)	9	H	M	H	5	5	2
Perform routine radiologic procedure (4.07)	7	H	M	M	3	4	4
Assist Surgical Radiologist (4.07)	7	H	M	M	4	4	4
Prepare patient under aseptic conditions (4.07)	7	H	M	M	4	4	4
Prepare equipment under sterile conditions (4.07)	7	H	M	M	3	4	4
Positioning of proper body part (4.07)	7	H	M	M	3	1	4
Keep equipment in good working order for procedures (4.07)	6	H	M	L	5	4	4
Select technique factor for each body part (4.07)	6	M	L	H	3	4	4
Keep books and assist in administration (4.07)	4	M	M	M	2	3	2
Assist physician in procedures (4.07)	4	M	M	M	4	4	4
Sterilize instruments for special procedures (4.07)	2	L	L	M	1	1	2
Keep patient records (4.07)	1	L	L	L	2	4	4
Follow doctor's prescriptions to treat patients (4.08)	9	H	M	H	3	4	3
Keep record of prescriptions on patients (4.08)	9	H	M	H	3	1	2

TABLE CONTINUED XVIII

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Assist doctor in caring for patient (4.08)	9	H	M	H	3	4	4
Set up and treat patients using modalties for radiation treatments and for X-ray "check" film (4.08)	9	H	M	H	4	4	3
Plan treatment including calculations (4.08)	9	H	M	H	3	5	3
Carry patient in ambulance to another hospital and assist in Cobalt 60 prescriptions (4.08)	9	H	M	H	3	4	3
Plan dosimetery (4.08)	9	H	M	H	4	5	4
Set up patients and mark area to be treated (4.08)	7	H	M	H	4	5	4
Give treatment to patients (4.08)	7	H	M	M	3	4	4
Patient care, housekeeping, bookkeeping, for treatment of patients (4.08)	7	H	M	M	4	4	4
Administer medication for tests (4.08)	7	H	M	M	3	3	4
Prepare and assist doctor in treatment planning (4.08)	7	H	M	M	4	1	3
Position patient for treatment (4.08)	6	L	M	H	4	4	3
Assay radioactive medicine for administration (4.08)	6	H	L	M	3	5	2
Perform computerized dosimetery and assist physician (4.08)	6	H	M	L	4	5	4

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TABLE CONTINUED XVIII

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Check blood work before prescription for safe level (4.08)	6	H	M	L	3	1	2
Maintain equipment to operable condition (4.08)	4	M	M	M	5	1	3
Check for radiation exposure in lab (4.08)	4	M	M	M	4	3	2
Instruct medical students (4.08)	4	M	M	M	5	5	4
Make exposures of film to map organs (4.08)	3	M	L	M	4	3	1
Prepare follow-up schedule (4.08)	3	M	M	L	1	1	4
Prepare therapy (4.08)	3	M	M	L	4	1	3
Assist in dose calculation (4.08)	3	M	L	M	3	4	2
Calculate decay on radioactive materials (4.08)	2	M	L	L	3	3	2
Keep patient records (4.08)	1	L	L	L	1	1	1
Supervise student appointments for out patients (4.08)	1	L	L	L	1	1	2
Keep all therapy and tumor records (4.08)	1	L	L	L	1	1	2
Schedule daily work (4.08)	1	L	L	L	4	1	1
Provide supplies and do other paperwork (4.08)	1	L	L	L	2	1	2
Prepare patient for examination (4.08)	1	L	L	L	4	1	2

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TABLE CONTINUED XVIII

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Fix embedding of tissue (4.10)	7	M	M	H	4	3	5
Stain sections of skin and organs (4.10)	7	M	M	H	3	3	5
Assist in P. Hepatectomy (weighing animals, etc.) (4.10)	7	M	M	H	3	3	5
Cut sections of organs or skin (4.10)	6	L	M	H	3	1	3
Prepare materials to be used (4.10)	2	L	M	L	2	3	2
Performs quality controls on compounds (4.11)	4	M	M	M	4	3	3
Assist in maintaining inventory of isotopes (4.11)	4	M	M	M	3	3	3
Calculate radioisotope doses (4.11)	3	M	L	M	3	3	3
Operate Elutes 99m Tc Generators (4.11)	2	M	L	L	3	3	3
Perform necessary day-to-day tasks, e.g. running errands, washing glassware, drawing up doses, etc. (4.11)	1	L	L	L	4	1	2

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TABLE XIX

A Rank Ordering of the Other Related Job Cluster By Composite Job Function Score with a Listing of Associated General Education Development Ratings

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Performs Metallographic examination (5.04)	9	H	M	H	5	3	4
Manufactures equipment for the reactor (Mechanical) (5.04)	9	H	M	H	4	3	3
Maintains and repairs reactor mechanical equipment (5.04)	9	H	M	H	4	1	3
Manufacture equipment designed for experiments (5.04)	9	H	M	H	4	4	4
Performs mechanical testing (5.04)	9	H	M	H	4	4	3
Performs Photography (5.04)	8	H	L	H	6	3	3
Test materials for corrosion (5.04)	7	H	M	M	4	4	3
Performs heat treating, casting operations (5.04)	7	M	M	H	3	3	4
As a machinist assist in design of equipment for the reactor and experimental programs (5.04)	6	H	M	L	4	4	4
Maintains mechanical equipment used for instruction or R & D (5.04)	5	L	L	H	4	4	3
Performs maching and welding in order to prepare R & D equipment for use (5.04)	5	L	L	H	4	3	5
Performs X-Ray diffraction analysis by utilizing a computer (5.04)	2	M	L	L	4	3	4

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TABLE CONTINUED XIX

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
Assists in set up of equipment for educational experiments (5.04)	1	L	L	L	4	3	3
Receives and ships equipment and supply items (5.04)	1	L	L	L	4	3	3
Performs routine maintenance on all forms of Plan T instrumentation (5.06)	9	H	M	H	5	4	5
Performs maintenance, repair and calibration of reactor instruments and all associated equipment (200 units) (5.06)	9	H	M	H	5	3	4
Repairs electronic instruments (5.06)	9	H	M	H	4	5	3
Designs new instruments including package design (5.06)	9	H	M	H	4	4	5
Maintains and calibrates counting and test equipment (250 units) (5.06)	9	H	M	H	5	4	4
Builds new instrumentation or instrumentation systems (5.06)	9	H	M	H	4	5	5
Performs machine and design improvisation (5.06)	9	H	M	H	5	4	5
Design and manufacture experimental electronic equipment (5.06)	9	H	M	H	4	4	4

TABLE CONTINUED XIX

TASKS	JOB FREQUENCY				GENERAL EDUCATION DEVELOPMENT		
	Composite Score	Data	People	Things	Reasoning	Math Development	Language
General determination of problems with radiation equipment, e.g., standardizing and adjustment of read-out (5.06)	9	H	M	H	4	4	4
Calibrates instruments (5.06)	7	M	M	H	5	5	4
Evaluation of process variable and equipment related to control loop (5.06)	6	H	M	L	4	3	4
Calibrate and test instruments (5.06)	6	H	M	L	4	4	4
Maintenance of nuclear instruments and (electronic modification) and repair (5.06)	4	M	M	M	5	4	5
Instrument operation including computer (5.06)	3	M	L	M	4	3	4
Purchase parts & equipment and maintaining inventory (5.06)	3	M	M	L	4	1	2
Performs record keeping and reporting writing (5.06)	1	L	L	L	3	1	4

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On the "data" dimension, most of the scores were reported high in all job clusters . the average being 64.3 percent of all tasks. For the five clusters, the percentage of tasks rated high was 71.4, 72.3, 53.3, 59.9, and 64.5 percent, respectively.

On the "people" dimension, on the other hand, only two tasks were rated high, both being in health related job cluster. On this dimension, a majority of the tasks were rated medium (average 65.9 percent). Respective percentages within the job clusters were 63.3, 72.3, 53.3, 66.2, and 74.2 for reactor operation and production, test and measurement, instrumentation, health related, and other job clusters.

On the "thing" dimension, the distribution of ratings between high, medium, and low were more or less evenly divided. On the average, 51.7 percent tasks were rated high, 25.5 percent were rated medium, and 22.1 percent were rated low.

As shown in Tables XX, XXI, XXII, XXIII, XXIV, and XXV, the composite scores tended to distribute themselves across the full range of the scale. The largest percentage of ratings were concentrated at the "nine" level, being 30.3 percent (Table XXV) for all tasks reported in this study. Also, 71.5 percent of all the tasks were rated at better than average composite scores with 28.5 percent rated at composite score of five or less. Similar distribution is apparent in the five job clusters reported in Table XX through XXIV.

TABLE XX

Percentage Distribution of Composite Scores on Tasks Performed in Reactor Operation and Production Job Cluster

TASK RATED BY:	COMPOSITE SCORE 10	9	8	7	6	5	4	3	2	1	TOTAL
Numbers	-	15	6	8	9	1	1	2	4	3	49
Percent	0.0	30.6	12.2	16.3	18.4	2.0	2.0	4.1	8.2	6.2	100.0

TABLE XXI

Percentage Distribution of Composite Scores on Tasks Performed in Test and Measurment Job Cluster

TASK RATED BY:	COMPOSITE SCORE 10	9	8	7	6	5	4	3	2	1	TOTAL
Numbers		16	1	15	7	1	1	2	1	3	47
Percent	0.0	34.1	2.1	31.9	14.9	2.1	2.1	4.3	2.1	6.4	100.1

TABLE XXII

Percentage Distribution of Composite Scores on Tasks Performed in Instrumentation Job Cluster

TASKS RATED BY:	COMPOSITE SCORE										TOTAL
	10	9	8	7	6	5	4	3	2	1	
Numbers	-	6	-	1	2	1	-	1	3	1	15
Percent	-	40.0	-	6.7	13.3	6.7	-	6.7	20.0	6.7	100.1

TABLE XXIII

Percentage Distribution of Composite Scores on Tasks Performed in Health Related Job Cluster

TASKS RATED BY:	COMPOSITE SCORE 10	9	8	7	6	5	4	3	2	1	TOTAL
Numbers	1	35	4	32	25	6	8	8	13	10	142
Percent	0.7	24.7	2.8	22.5	17.6	4.2	5.6	5.6	9.2	7.1	100.0

TABLE XXIV

Percentage Distribution of Composite Scores on Tasks Performed in Other Job Cluster

TASKS RATED BY:	COMPOSITE SCORE										TOTAL
	10	9	8	7	6	5	4	3	2	1	
Numbers	-	14	1	3	3	2	1	3	1	3	31
Percent	-	45.1	3.2	9.7	9.7	6.5	3.2	9.7	3.2	9.7	100.0

TABLE XXV

Percentage Distribution of Composite Scores on Task Performed in all Job Clusters

TASK RATED BY:	COMPOSITE SCORE										TOTAL
	10	9	8	7	6	5	4	3	2	1	
Numbers	1	86	12	59	46	11	11	16	22	20	284
Percent	0.4	30.3	4.2	20.4	16.2	4.0	4.0	5.6	7.9	7.0	100.0

Research Question #7. What levels of general education development are associated with specific tasks?

Each task was rated by the "reasoning," "mathematical development," and "language requirements." As shown in Tables XV, XVI, XVII, XVIII, and XIX, the ratings tended to seek a middle level on a six point scale used to score the tasks. An explanation of the scale can be seen in Appendix D. The mean scores for each job cluster on each of the general educational development scales are shown in Table XXVI.

TABLE XXVI

The Mean General Education Development Score by Job Cluster

JOB CLUSTER	GENERAL EDUCATION DEVELOPMENT		
	Reasoning	Math Development	Language
1. Reactor Operation and Production	3.7	3.9	3.5
2. Testing and Measurement	4.3	3.5	3.3
3. Instrumentation	3.7	2.9	3.5
4. Health Related	3.5	3.2	3.3
5. Other Related	4.2	3.3	3.7
TOTAL	3.8	3.4	3.4

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As can be seen in the Table, the overall mean for reasoning, mathematical development, and language are above the 3.0 level which is the theoretical mean for a six point scale.

Research Question #8. What task commonalities exist among jobs and/or job clusters?

Each task statement in each job cluster was analyzed as to similarity of written word in order to determine common areas of performance even though many of the task ratings on the six scales varied. For a task to be exactly similar to another, the ratings on different scales should also be similar in addition to a similarity of performance objective. No such similarities were found among the tasks reported in this study. However, since it was intended in this initial study to show that a commonly worded task, such as "data reduction," could be identified both within and among the various job clusters, as a means of commonality among tasks, it was decided to bring about commonalities in wording only. Table XXVII shows the principal task commonalities within and among the job clusters.

TABLE XXVII

List of Commonalities among Jobs within Job Clusters

1. Reactor Operation and Production

   Perform experiment
   Calibrate equipment
   Maintain equipment

2. Test and Measurement

   Data reduction
   Perform chemical analysis

3. Health Related

   Position patient
   Maintain equipment
   Calibrate instrument
   Count patients
   Keep records

4. Other Related

   Maintain equipment
   Test materials

Research Question #9. What potential career ladders appear to be present within the "job clusters"?

The jobs were awarded a composite score in order to determine the career ladders within each job cluster. Since there are several tasks listed for each job, the highest scores on data, people, things scales were utilized in determining the job composite score. The scales for rating jobs are similar to those used for rating the tasks. Table XXVIII shows the career ladders for each job cluster.

TABLE XXVIII

CAREER LADDERS WITHIN JOB CLUSTERS

Job and Job Clusters		Composite Score
	Reactor Operation and Production	
1.01	Test or Research Reactor Operator	9
1.08	Nuclear Facility Equipment Operator	9
1.09	Nuclear Facility Maintenance Technician	9
1.05	Nuclear Power Plant Operator	9
1.07	Hot-Cell Technician	7
	Test and Measurement	
2.02	Nuclear Facility	9
2.03	Non-Destructive Testing Technician	9
2.01	Radiation Control Technician	7
	Instrumentation	
3.01	Instrumentation and Control Technician	9
3.02	X-Ray Calibration Technician	9
	Health Related	
4.07	Special Procedures Technician	10
4.01	Radiologic Technologist	9

TABLE XXVIII CONTINUED

Job and Job Clusters	Composite Score
Health Related (continued)	
4.02 Radiologic Technologist, Chief	9
4.03 Nuclear Medical Technologist	9
4.08 Radiation Therapy Technician	9
4.10 Radiology Technician	7
4.11 Radiopharmacist	4
Other Related	
5.04 Mechanical and Structural Technician	9
5.06 Electronic and Instrument Technician	9

The analysis did not discriminate very much because each set of tasks that make up a job contained several high scores on each of the scales. When the highest scores only are used to determine high, medium, and low among the jobs, the distribution tends to be skewed towards the "high" and to that extent the results will be biased.

Research Question #10. What specific equipment is utilized in various nuclear technician jobs?

The frequency of use of instruments and equipment can be seen in Table XXIX. It can be seen in the Table that most of the instruments listed are used at least once a week in one or other of the job clusters. Only one instrument, i.e., the SWR meter, was reported to have never been used on any of the jobs. Some of the instruments, on the other hand, were reported used at least once a month to perform on all the jobs. Such instruments are thermometer and geiger counter. Reactor operator, nuclear facility maintenance technician, mechanical and structural technician, and electronic and instrument technician are the four job titles which seem to use the most of the instruments reported.

Table XXX shows the instruments and equipment that are used at least once a week on all the job clusters surveyed. Table XXXI shows, on the other hand, all the instruments and equipment used at least once a month on all the job clusters except in the health related job cluster. All the other instruments are utilized less than once a month on various other jobs.

TABLE XXIX

FREQUENCY OF INSTRUMENT AND EQUIPMENT USAGE BY JOB NUMBER

W = At least once a Week
M = At least once a Month
Y = At least once a Year

Instrument and Equipment

Job Number	Job Title	VOM-VTVM-TVM	OSCILLOCOPE	IMPEDANCE BRIDGE	SWR METER	PULSE GEN.	SIGNAL GEN.	CURVE TRACER	REG. POWER SUPPLIES	FREQU. METER	PLOTTERS/RECORDERS	TORQUE METER	TACHOMETER	STROBELIGHT	MICROMETER	VERNIER CALIPER	STRAIN GAGES	HARDNESS TESTER	COMPRESSION TESTER	TENSION TESTER	FORCE GAGES	ACCELEROMETERS	SPECTROMETER	LIGHT METER	PRESSURE GAGES	FLOW METERS	VISCOSITY METERS	HYDROMETERS	THERMOCOUPLE INSTR.	THERMOMETER	PYROMETERS	GEIGER COUNTER	CLOUD CHAMBER	SCINTILLATION	SAMPLE CHANGER	X-RAY EQUIP.	ELECTROSCOPE	RADIOMETERS	DOSIMETERS
1.01	TESTOR RESEARCH REACTOR OPERATION	W	W	W		W	W		W	W	W	M	W	Y	W	W	W	W	W	W	M	Y	Y	M	W	W		W	W	W		W		W	W	Y		W	W
1.05	NUCLEAR POWER OPERATOR PLANT											Y	Y							M		M			W	W		M	W	W	W	W		W	W			W	W
1.06	NUCLEAR MATERIAL OPERATOR PROCESSOR																																						
1.07	HOT-CELL TECHNICIAN	M							W		W				W	W					M				W	W			W	M	W	W							W
1.08	NUCLEAR FACILITY-EQUIPMENT OPERATOR			W					W	W	W		Y	Y	W									Y	W	W			W	W		W		W					W
1.09	NUCLEAR FACILITY- MAINTENANCE TECHNICIAN	W	W	M		M	M	Y	W	M	W	M	W	W	M	Y	M			Y	Y	Y	Y	Y	W	W	Y	M	W	W	W	W		W	M				W
2.01	RADIATION CONTROL TECHNICIAN		W			M					W												W		W	W				W		W		W	W	W	W	W	W
2.02	NUCLEAR FACILITY CHEMISTRY TECHNICIAN										W												W							W		W		W					W
2.03	NON-DESTRUCTIVE TESTING TECHNICIAN		W			M	M		W		M	M	M	M	W	M	M	W	M	M	M	M			W	W				M	M	W		M	M	W		M	W
3.01	INSTRUMENTATION & CONTROL TECHNICIAN	W	W	W		W	W	W	W	M	W		Y	Y	M			Y	Y		Y		M		W	W		W	W	W	W	W		W	W	W			
3.02	X-RAY CALIBRATION TECHNICIAN	M	Y			M	W		W	W	W				W	W		M	Y	Y	M		Y	W	Y				W	W	W	M		W		W			
4.01	RADIOLOGIC TECHNOLOGIST		W							W	W												W	M	W	W				W	W	W	M	W	W	W		W	W
4.02	RADIOLOGIC TECHNOLOGIST, CHIEF					W					W														W	W				W		W		W		W	W		
4.03	NUCLEAR MEDICAL TECHNOLOGIST		W			W	W	W	W		W												W	W						W		W		W	W	W		W	
4.07	SPECIAL PROCEDURE TECHNICIAN		W	W		W	W		W	W	W		W				W							W	W					W		M	M	M		W	M	M	W
4.08	RADIATION THERAPY TECHNICIAN										W			Y											W					M		W	M	W		W		W	W
4.10	RADIO BIOLOGY TECHNICIAN																													W		W		M	Y				W
4.11	RADIO PHARMACIST																								W					W		W							W
5.04	MECHANICAL & STRUCTURAL	Y	Y	Y		M	M		W	M	W	M	Y	Y	W	W	Y	W	M	W				W	W	M	M		W	W	M	W		W		W			W
5.06	ELECTRONIC & INSTRUMENT TECHNICIAN	W	W	M		W	W	M	W	W	W		M	M	W	W	M			Y			W		W	W	M	M	W	W	M	W		W	W	M	M	Y	W

Table XXX

List of Instrument and Equipment Used At Least Once a Week in All the Job Clusters

Electrical

Oscilloscope
Pulse generator
Signal generator
Regulated power supplies
Plotters/Recorders

Fluid

Pressure gauges
Flow meters

Thermal

Thermometers

Nuclear

Geiger counter
Scientillation equipment
X-Ray equipment

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TABLE XXXI

List of Instrument and Equipment used At Least Once a Month in all the job clusters other than Health

Electrical

Oscilloscope
Pulse generator
Signal generator
Regulated power supplies
Frequency meter
Plotters/Recorders

Mechanical

Tachometer
Strobe light
Micrometer
Vernier Caliper
Hardness tester
Compression tester

Fluid

Pressure gauges
Flow meters

Thermal

Thermometer
Pyrometer

Nuclear

Geiger Counter
Scintillation Equipment

Research Question #11. Are the job clusters identified in Phase I (the Nuclear Technician Survey) valid or justified on the basis of more detailed information?

A visual inspection of the various jobs and their respective major tasks indicated that, although there is a need for updating selected job definitions, the initial clustering of jobs into clusters was essentially accurate.

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APPENDIX A

Technician Manpower Demand Survey Instrument

1. NAME OF THE ESTABLISHMENT ______________________________

____

(If the establishment is a part of another organization, specify the name of the organization but report only the establishment named above. A separate questionnaire should be completed for each of your establishments within the SINB region. Please make extra copies where necessary.)

2. MAILING ADDRESS OF ESTABLISHMENT ______________________________
Number and Street

____
City or Town   State   County   Zip Code

3. ______________________________
Representative Completing This Form

____
Representative's Title

____
Representative's Address

____
Representative's Phone and Extension

4. TOTAL NUMBER OF EMPLOYEES IN THIS ESTABLISHMENT ______________

Please rank the segment(s) of the nuclear field in which this establishment participates using product or service "mix" activity as a guideline. Please rank them (1) for the most and (2), (3), (4), etc. for the next highest level of activity.

_____ Uranium Milling
_____ Production of Feed Materials
_____ Production of Special Materials for Use in Reactors
_____ Fuel Element Fabrication and Recovery Activities
_____ Reactor and Reactor Component Design and Manufacturing
_____ Design and Engineering of Nuclear Facilities
_____ Power Reactor Operation and Maintenance
_____ Uranium Mining
_____ Radiation Processing
_____ Irradiation Manufacturing or Services
_____ Non-Destructive Testing(NDT)
_____ Transportation of Radioactive Materials

_____ Radiation Preservation of Foods
_____ Radioactive Waste Disposal
_____ Activation Analysis
_____ Nuclear Instrument Manufacturing
_____ Processing and Packaging Radioisotopes
_____ Particle Accelerate Manufacturing
_____ Research Laboratories
_____ Industrial Radiography
_____ Nuclear Medicine
_____ Other Health Related
_____ Nuclear Training for Employment Outside your Organization
_____ Higher Education
_____ Other ______________
(Please Specify)

GENERAL INSTRUCTIONS

■ Please enter your best estimates of the number of workers you will need for the "job titles and descriptions" and "years" listed on the following pages. When estimating manpower requirements only consider "new jobs" and "replacements" (deaths, retirements, and normal turnover) and enter the composite figure in the appropriate column.

■ When estimating your manpower needs, please enter your total anticipated requirements even though you may plan to satisfy a portion and/or all of this through training programs within your own organization.

■ When estimating manpower requirements for more than one calendar year, please enter only the cumulative total requirements for new jobs and replacements. For example, if you estimate your need for a specific job title to be 3 in 1972 and 4 in 1973, enter only the total of 7 in the column headed 1972-73.

■ If you cannot relate the work performed in your establishment to the descriptions contained herein, list your own job title and a description of the work performed on the blank spaces provided for that purpose. If you need more space than provided please use an extra blank sheet.

ASSUMPTIONS--These manpower estimates should be based on the assumptions (1) that the economic growth rates over the past decade of your establishment and/or organization and the state and national economy will continue their trend unless you anticipate changes, (2) that private and government support of nuclear and nuclear related activities will continue at the same fraction of the GNP, and (3) that required manpower will be available.

Job Code	Job Titles and Descriptions for Reactor Operation and Production Technicians	How many technician level workers are presently employed?	Estimated Manpower Requirements for the Calendar Years: 1971	1972-73	1974-75	1976-80
1.01	TEST OR RESEARCH REACTOR OPERATOR--Performs hands-on operation of these facilities and requires AEC Senior Reactor Operator or Reactor Operator License.					
1.02	PRODUCTION, TEST OR RESEARCH REACTOR OPERATOR-GOVERNMENT OWNED--Performs hands-on operation of these facilities and requires certification by the operating agency.					
1.03	ACCELERATOR OPERATOR--Sets up or assists in setting up, coordinates, and monitors the operation of particle accelerates under the supervision of a research scientist.					
1.04	RADIOISOTOPE-PRODUCTION OPERATOR--Prepares radioisotopes and other radioactive materials for use in biological, biochemical, physiological, and industrial research.					
1.05	NUCLEAR POWER PLANT OPERATOR--Performs hands-on operation of the nuclear power plant requiring AEC Senior Reactor Operator of Reactor Operator License.					
1.06	NUCLEAR MATERIAL PROCESSOR, SENIOR--Is responsible for the maintenance and operation of radioactive processing facilities; receiving, transferring, and shipping of nuclear material, and the issuance of reactor fuels for research assemblies.					
1.07	HOT-CELL TECHNICIAN--Operates remote-controlled equipment in cell to perform chemical and metalurgical tests involving radioactive materials.					
1.08	NUCLEAR FACILITY EQUIPMENT OPERATOR--Operates nuclear facility auxiliary equipment and does not require AEC operator license.					

Job Code	Job Titles and Descriptions for Reactor Operation and Production Technicians	How many technician level workers are presently employed?	Estimated Manpower Requirements for the Calendar Years:			
			1971	1972-73	1974-75	1976-80
1.09	NUCLEAR FACILITY MAINTENANCE TECHNICIAN--Performs electrical and mechanical equipment maintenance on nuclear facility.					
Other--Please Describe						
Other--Please Describe						

Job Code	Job Titles and Descriptions for Test and Measurement Technicians	How many technician level workers are presently employed?	Estimated Manpower Requirements for the Calendar Years:			
			1971	1972-73	1974-75	1976-80
2.01	RADIATION CONTROL TECHNICIAN--Monitors personnel, plant facilities, work environment, and plant vicinity to detect and control radioactivity and/or radiation exposure. Performs operation, analysis and calibration of radiation monitoring equipment.					
2.02	NUCLEAR FACILITY CHEMISTRY (RADIOCHEMISTRY) TECHNICIAN--Performs all plant related laboratory chemistry analyses including radiochemistry.					
2.03	NON-DESTRUCTIVE TESTING TECHNICIAN--Performs NDT testing on nuclear facility equipment (includes radiography, ultrasonics, dye penefram, magnetic particle and visual techniques.					
Other--Please Describe						
Other--Please Describe						

Job Code	Job Titles and Descriptions for Instrumentation Technicians	How many technician level workers are presently employed?	Estimated Manpower Requirements for the Calendar Years:			
			1971	1972-73	1974-75	1976-80
3.01	INSTRUMENTATION AND CONTROL TECHNICIAN--Handles facility instrumentation and control system calibration and maintenance. (Includes computer maintenance)					
3.02	X-RAY CALIBRATION TECHNICIAN--Test X-ray calibration, equipment reliability and safety; evaluates field and filter performance.					
3.03	WELL LOGGING TECHNICIAN--Conducts radioactive logging in the underground study of oil fields; maintains source instruments; evaluates data.					
Other--Please Describe						
Other--Please Describe						

Job Code	Job Titles and Descriptions for Health Technicians	How many technician level workers are presently employed?	Estimated Manpower Requirements for the Calendar Years;			
			1971	1972-73	1974-75	1976-80
4.01	RADIOLOGIC TECHNOLOGIST--Applies roentgen and/or gamma rays to patients for diagnostic and therapeutic purposes.					
4.02	RADIOLOGIC TECHNOLOGIST, CHIEF--Coordinates activities of and supervises radiologic technologists engaged in taking and developing X-ray photographs.					
4.03	NUCLEAR MEDICAL TECHNOLOGIST--Prepares, administers and measures radioactive isotopes in therapeutic, diagnostic, and tracer applications, utilizing variety of radioactive equipment.					
4.04	CHEST RADIOGRAPHER--Conducts mass chest X-ray surveys to determine the incidence of pulmonary diseases.					

Job Code	Job Titles and Descriptions for Health Technicians	How many technician level workers are presently employed?	Estimated Manpower Requirements for the Calendar Years: 1971	1972-73	1974-75	1976-80
4.05	UROLOGY X-RAY TECHNICIAN--Assists a urologist by performing radiographic examinations of the urogenital tract to rule out disease in that system.					
4.06	ORTHOPEDIC RADIOLOGIC TECHNICIAN--Works with an orthopedic surgeon in performing radiographic studies of the skeletal system.					
4.07	SPECIAL PROCEDURES TECHNICIAN--Performs radiographic studies of the blood vessels and the nervous system, which requires special skills.					
4.08	RADIATION THERAPY TECHNICIAN--Positions patients and applies X-ray or gamma radiation to predetermined anatomical areas with known malignant disease.					
4.09	INTERNAL DOSIMETRY TECHNICIAN--Conducts whole body counting, bioassay, and wound contamination analysis.					
4.10	RADIOBIOLOGY TECHNICIAN--Conducts tests for external and internal radiation effects in plants and animals.					
4.11	RADIOPHARMACIST--Purchases of pre-prepared radiopharmaceuticals and formulates all locally prepared radiopharmaceutical compounds.					
Other--Please Describe						
Other--Please Describe						
Other--Please Describe						

Job Code	Job Titles and Descriptions for Related Technicians	How many technician level workers are presently employed?	Estimated Manpower Requirements for the Calendar Years: 1971	1972-73	1974-75	1976-80
5.01	SOILS EVALUATION TECHNICIAN--Assesses soil density, radioactivity, and moisture content.					
5.02	DRAFTSMAN--Performs routine tasks in preparing detail engineering drawings, from work outlined by others.					
5.03	COMPUTER PROGRAMMER--Converts scientific, engineering, and other technical problem formulations to a format processed by computer.					
5.04	MECHANICAL AND STRUCTURAL TECHNICIAN--Assists in the design and fabrication of nuclear facility mechanical and structural equipment.					
5.05	WELDING TECHNICIAN--Performs specialized welding operations on nuclear components--requires code certification.					
5.06	ELECTRONIC AND INSTRUMENT TECHNICIAN--Does various operations connected with fabricating, assembling, modifying, maintaining, and installing nuclear electronic equipment.					
5.07	QUALITY CONTROL AND/OR QUALITY ASSURANCE SPECIALIST--Does product evaluation, testing, and monitoring to insure strict adherence to product specifications.					
Other--Please Describe						
Other--Please Describe						

TRAINING PROGRAMS

1. Do you have an in-house or on-the-job training program? YES ____ NO ____ (check one)

2. If yes, please supply the following information.

Job Title(s) for Which You Have Training Programs	Length of Training Program in Hours	Number of Graduates (if any) in the Years:			
		1971	1972-73	1974-75	1976-80

All other things being equal, would you hire graduates from public and private training institutions if they were available for the job titles listed above? YES _____ NO ____ (check one)

If no, please explain: ______________________________

____

____

____

APPENDIX B

Introductory Letter to Establishments
Selected for Task Analysis

ERIC

SOUTHERN INTERSTATE NUCLEAR BOARD

7 Dunwoody Park
Suite 104
Atlanta, Georgia 30341
404/458-9343

September 10, 1971

Dear ________:

In 1970, (Company name) participated in a regional manpower survey to determine the supply and demand of nuclear technicians in the South. Dr. Paul V. Braden of Oklahoma State University conducted this research for the Southern Interstate Nuclear Board (SINB) and published the document, "Nuclear Technician Manpower Survey...Approach to an Information System," which you have received.

The manpower findings of Dr. Braden's work are serving as the first step of a five-phase SINB program leading to a nuclear technician manpower system for the Southern United States. SINB would appreciate an opportunity to include (Company) in the second phase of this follow-on research. The second step of the expanded manpower project is a task analysis and involves direct visitation, observation, and person-to-person interviews with approximately twelve select companies and institutions to gain firsthand knowledge from workers concerning the adequacy of their training in relationship to job performance requirements. This second phase is also under the direction of Dr. Braden, now Director, Comprehensive Data System, The Center for Vocational and Technical Education, Ohio State University.

We would appreciate your assistance in arranging an interview between myself and supervisors who are associated with your office and who manage technicians filling (type of jobs). We will be in touch with you by telephone approximately one week after you receive this letter.

We want to minimize any interference which such an interview might cause in your business operations; however, both Dr. Braden and a number of other manpower consultants believe that the importance of (Company's) operations makes an analysis of the type of subprofessional nuclear technicians employed by your company/institution essential if a comprehensive manpower analysis of the South is to be made. In addition, the geographical location of your office is important to the representativeness of our sample.

The information which this interview will produce will be used in the preparation of a curriculum planning guide. This later phase of the SINB manpower program is proposed under the joint sponsorship of the Technical Education Research Center, Cambridge, Massachusetts, and the National Science Foundation.

An additional phase of our work will take the form of a nuclear technician manpower symposium, supported by the Atomic Energy Commission, and scheduled for the Spring of 1972. In addition to your own office, invited attendees will be vocational-technical school administrators, industrial personnel representatives, hospital training managers, university and junior college officials, and others with active involvement in subprofessional, nuclear technician manpower.

The final phase of this composite program will involve the testing of the curriculum guide at selected training centers throughout the South. The first of these schools identified is the Midlands Technical Education Center in Columbia, South Carolina, Robert L. Grigsby, Director.

I hope that your office will be able to participate in the second phase discussed above.

Thank you for your cooperation in our manpower study activities and the support which you have given SINB.

Sincerely yours,

David G. Jopling
Deputy Director

DGJ:clt

APPENDIX C

Task Analysis Personnel Interview Form

ERIC

I.D. #

NUCLEAR TECHNICIAN MANPOWER

1. Name of Establishment ______________________________

2. Mailing Address ______________________________
   Number and Street

   ____
   City State Zip Code

3. ______________________________
   Representative Completing Demand Questionnaire

   ____
   Representative Title

   ____
   Representative Phone Number and Extension

4. Demand Information -- From Demand Instrument

   Job Code Job Title Reported Present Employment

5. Phone Contact by ______________________________
   SINB Steering Committee Member

6. Details of Phone Contact ______________________________

   ____

   ____

   ____

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I.D. #

NUCLEAR TECHNICIAN MANPOWER

Name of Management Representative ______________________

Title ______________________

Phone ______________________

Interview Schedule -- Supervisor(s)

Name	Department	Date/Time
Name	Department	Date/Time
Name	Department	Date/Time
Name	Department	Date/Time

Management comments about nuclear-related technicians: e.g., formal versus in-house training; promotion and hiring practices, and future technical trends which may have bearing on the technician's performance tasks.

SINB-2 (Task Analysis Project)

I.D. #

NUCLEAR TECHNICIAN MANPOWER

SUPPLEMENTAL INTERVIEW SCHEDULE SHEET

Name	Department	Date/Time

Name	Department	Date/Time

Name	Department	Date/Time

Name	Department	Date/Time

Name	Department	Date/Time

Management comments about nuclear-related technicians: e.g., formal versus in-house training; promotion and hiring practices, and future technical trends which may have a bearing on the technician's performance tasks.

I.D. # ______

NUCLEAR TECHNICIAN MANPOWER

____
Supervisor's Name

____
Title

____
Telephone Number and Extension

YEARS OF WORK EXPERIENCE (indicate the number of years in each category which applies)

______ As Supervisor

______ As Nuclear-Related Technician

______ As Technician (other than Nuclear-Related)

SUPERVISOR'S EDUCATIONAL TRAINING WHICH QUALIFIED HIM FOR ENTRANCE TO THE NUCLEAR FIELD

Number of Months		Degree, diploma or certificate of completion (if any, please specify)
______	On-the-Job Training	______
______	Technical/Vocational Training	______
______	Military Training	______
______	College - Nuclear Related	______
______	College (Academic)	______
______	Other ______ Specify	

NUMBER OF TECHNICIANS SUPERVISED THAT WORK WITH NUCLEAR-RELATED MATERIALS

______
Number

SINB-3 (Task Analysis Project)

____
I.D. #

INDICATE THE NUMBER OF TECHNICIANS WORKING UNDER YOUR SUPERVISION BY THEIR PRIMARY AREA OF ACTIVITY

__________ Reactor Operation & Production
Number

__________ Test and Measurement
Number

__________ Instrumentation
Number

__________ Health
Number

__________ Other __________
Number Specify

INDICATE THE NUMBER OF NUCLEAR-RELATED TECHNICIANS ENGAGED IN THE FOLLOWING CATEGORIES AS THEIR PRIMARY LEVEL OF ACTIVITY UNDER YOUR SUPERVISION

__________ Research and Development
Number

__________ Production
Number

__________ Sales
Number

__________ Maintenance
Number

__________ Other __________
Number Specify

Of the technical workers under your supervision which you listed previously, please specify the number who have the following educational background.

1. Bachelor's degrees __________ Number

2. Two years of specialized post-high school technical training (for example, electronics or Nuclear Technology). __________ Number

3. Specialized post-high school technical training but less than two years. (Include military if appropriate.) __________ Number

4. One to three years of general college education (such as a liberal arts program in a junior college). __________ Number

I.D. #

5. No formal post-high school education. ____________ Number

6. Less than high school completion. ____________ Number

Please make any suggestions for the content of training programs for this job.

ERIC

NUCLEAR TECHNICIAN MANPOWER

I.D. #

Listed below are a number of instruments often used by nuclear technicians. Please review the list and indicate how often the instruments are used by your nuclear technicians by checking the appropriate column; that is, either Weekly, Monthly, Yearly, or Never.

Supervisor's Name: ____________________

INSTRUMENT LIST

	Frequency of Use: Weekly	Monthly	Yearly	Never
ELECTRICAL				
VOM-VTVM-TVM				
Oscilloscope				
Impedance Bridge				
SWR Meter				
Pulse Gen.				
Signal Gen.				
Curve Tracer				
Reg. Power Supplies				
Frequ. Meter				
Plotters/Recorders				
Other:				
MECHANICAL				
Torque Meter				
Tachometer				
Strobelight				
Micrometer				
Vernier Caliper				
Strain Gages				
Hardness Tester				
Compression Tester				
Tension Tester				
Force Gages				
Accelerometers				
Other:				
OPTICAL				
Spectrometer				
Light Meter				
Other:				

	Frequency of Use: Weekly	Monthly	Yearly	Never
FLUID				
Pressure Gages				
Flow Meters				
Viscosity Meters				
Hydrometers				
Other:				
THERMAL				
Thermocouple Instr.				
Thermometer				
Pyrometers				
Other:				
NUCLEAR				
Geiger Counter				
Cloud Chamber				
Scintillation Equip.				
Sample Changer				
X-ray Equip.				
Electroscope				
Radiometers				
Dosimeters				
OTHER:				

NUCLEAR TECHNICIAN MANPOWER

TASK ANALYSIS INTERVIEW FORM

(Ratings by Supervisor with Verification by Interviewer Observations of Technicians)

Major Task(s) Presently Being Performed by Technician	Percent of Time Spent on Major Task(s)	Frequency of Performance			Level of Importance for			Scales: Gen. Educational Development			Scales: Worker Functions			
What does the Worker do? What are his functions?	Must Add to 100% Time Span	Weekly	Monthly	Yearly	Job Entry	Routine Job Performance	Promotion	Reasoning	Math Dev.	Language	Worker Instructions	Data	People	Things

Red Markings Indicate Variations by Technicians from Supervisor Ratings.

Supervisor's Name:________________

I.D. #

APPENDIX D

Explanation of Relationships
within Data, People, Things Hierarchies
and General Education Development Scales

ERIC

Explanation of Relationships Within Data, People, Things Hierarchies

Much of the information in this edition of the Dictionary is based on the premise that every job requires a worker to function in relation to Data, People, and Things, in varying degrees. These relationships are identified and explained below. They appear in the form of three hierarchies arranged in each instance from the relatively simple to the complex in such a manner that each successive relationship includes those that are simpler and excludes the more complex.[1] The identifications attached to these relationships are referred to as worker functions, and provide standard terminology for use in summarizing exactly what a worker does on the job by means of one or more meaningful verbs.

A job's relationship to Data, People, and Things can be expressed in terms of the highest appropriate function in each hierarchy to which the worker has an occupationally significant relationship, and these functions taken together indicate the total level of complexity at which he must perform. The last three digits of the occupational code numbers in the Dictionary reflect significant relationships to Data, People, and Things, respectively.[2] These last three digits express a job's relationship to Data, People, and Things by identifying the highest appropriate function in each hierarchy to which the job requires the worker to have a significant relationship, as reflected by the following table:

DATA (4th digit)	PEOPLE (5th digit)	THINGS (6th digit)
0 Synthesizing	0 Mentoring	0 Setting-Up
1 Coordinating	1 Negotiating	1 Precision Working
2 Analyzing	2 Instructing	2 Operating-Controlling
3 Compiling	3 Supervising	3 Driving-Operating
4 Computing	4 Diverting	4 Manipulating
5 Copying	5 Persuading	5 Tending
6 Comparing	6 Speaking-Signaling	6 Feeding-Offbearing
7 } No significant relationship	7 Serving	7 Handling
8 }	8 No significant relationship	8 No significant relationship

DATA: Information, knowledge, and conceptions, related to data, people, or things, obtained by observation, investigation, interpretation, visualization, mental creation; incapable of being touched; written data take the form of numbers, words, symbols; other data are ideas, concepts, oral verbalization.

0 **Synthesizing:** Integrating analyses of data to discover facts and/or develop knowledge concepts or interpretations.

1 **Coordinating:** Determining time, place, and sequence of operations or action to be taken on the basis of analysis of data; executing determinations and/or reporting on events.

2 **Analyzing:** Examining and evaluating data. Presenting alternative actions in relation to the evaluation is frequently involved.

3 **Compiling:** Gathering, collating, or classifying information about data, people, or things. Reporting and/or carrying out a prescribed action in relation to the information is frequently involved.

4 **Computing:** Performing arithmetic operations and reporting on and/or carrying out a prescribed action in relation to them. Does not include counting.

5 **Copying:** Transcribing, entering, or posting data.

6 **Comparing:** Judging the readily observable functional, structural, or compositional characteristics (whether similar to or divergent from obvious standards) of data, people, or things.

PEOPLE: Human beings; also animals dealt with on an individual basis as if they were human.

0 **Mentoring:** Dealing with individuals in terms of their total personality in order to advise, counsel, and/or guide them with regard to problems that may be resolved by legal, scientific, clinical, spiritual, and/or other professional principles.

---

*Dictionary of Occupational Titles, V.I., 1965

1 **Negotiating:** Exchanging ideas, information, and opinions with others to formulate policies and programs and/or arrive jointly at decisions, conclusions, or solutions.

2 **Instructing:** Teaching subject matter to others, or training others (including animals) through explanation, demonstration, and supervised practice; or making recommendations on the basis of technical disciplines.

3 **Supervising:** Determining or interpreting work procedures for a group of workers, assigning specific duties to them, maintaining harmonious relations among them, and promoting efficiency.

4 **Diverting:** Amusing others.

5 **Persuading:** Influencing others in favor of a product, service, or point of view.

6 **Speaking-Signaling:** Talking with and/or signaling people to convey or exchange information. Includes giving assignments and/or directions to helpers or assistants.

7* **Serving:** Attending to the needs or requests of people or animals or the expressed or implicit wishes of people. Immediate response is involved.

THINGS: Inanimate objects as distinguished from human beings; substances or materials; machines, tools, equipment; products. A thing is tangible and has shape, form, and other physical characteristics.

0 **Setting Up:** Adjusting machines or equipment by replacing or altering tools, jigs, fixtures, and attachments to prepare them to perform their functions, change their performance, or restore their proper functioning if they break down. Workers who set up one or a number of machines for other workers or who set up and personally operate a variety of machines are included here.

1 **Precision Working:** Using body members and/or tools or work aids to work, move, guide, or place objects or materials in situations where ultimate responsibility for the attainment of standards occurs and selection of appropriate tools, objects, or materials, and the adjustment of the tool to the task require exercise of considerable judgment.

2 **Operating-Controlling:** Starting, stopping, controlling, and adjusting the progress of machines or equipment designed to fabricate and/or process objects or materials. Operating machines involves setting up the machine and adjusting the machine or material as the work progresses. Controlling equipment involves observing gages, dials, etc., and turning valves and other devices to control such factors as temperature, pressure, flow of liquids, speed of pumps, and reactions of materials. Setup involves several variables and adjustment is more frequent than in tending.

3 **Driving-Operating:** Starting, stopping, and controlling the actions of machines or equipment for which a course must be steered, or which must be guided, in order to fabricate, process, and/or move things or people. Involves such activities as observing gages and dials; estimating distances and determining speed and direction of other objects; turning cranks and wheels; pushing clutches or brakes; and pushing or pulling gear lifts or levers. Includes such machines as cranes, conveyor systems, tractors, furnace charging machines, paving machines and hoisting machines. Excludes manually powered machines, such as handtrucks and dollies, and power assisted machines, such as electric wheelbarrows and handtrucks.

4 **Manipulating:** Using body members, tools, or special devices to work, move, guide, or place objects or materials. Involves some latitude for judgment with regard to precision attained and selecting appropriate tool, object, or material, although this is readily manifest.

5 **Tending:** Starting, stopping, and observing the functioning of machines and equipment. Involves adjusting materials or controls of the machine, such as changing guides, adjusting timers and temperature gages, turning valves, to allow flow of materials, and flipping switches in response to lights. Little judgment is involved in making these adjustments.

6 **Feeding-Offbearing:** Inserting, throwing, dumping, or placing materials in or removing them from machines or equipment which are automatic or tended or operated by other workers.

7 **Handling:** Using body members, handtools, and/or special devices to work, move, or carry objects or materials. Involves little or no latitude for judgment with regard to attainment of standards or in selecting appropriate tool, object, or material.

NOTE: Included in the concept of Feeding-Offbearing, Tending, Operating-Controlling, and Setting Up, is the situation in which the worker is actually part of the setup of the machine, either as the holder and guider of the material or holder and guider of the tool.

The scales described above were arranged in three groups according to their place in hierarchies of data, people, and things. This was done primarily to arrive at a composite score on the complexity of tasks. The three groups were as follows:

1. High, (Scores 0 - 2)
2. Medium, and (Scores 3 - 5)
3. Low. (Scores 6 - 9)

The composite scores were assigned to the combinations of scales on data, people, and things in the following manner:

Combination	LLL	LLM	LMM	MMM	LHL	LHM	MHM	LHH	MHH	HHH
Composite Score	1	2	3	4	5	6	7	8	9	10

Within a specific group all arrangements were assigned the same composite score. For example, LHM, LMH, HML, HLM, MLH, or MHL all were assigned a composite score of 6. This scheme of arriving at a composite score is a modification of a similar scheme outlined by Fine et. al. in their manual Functional Job Analysis Task Bank Manual, (Washington, D.C.: W.E. Upjohn Institute for Employment Research, (1971), p. 80.

GENERAL EDUCATIONAL DEVELOPMENT

Level	Reasoning Development	Mathematical Development	Language Development
6	Apply principles of logical or scientific thinking to a wide range of intellectual and practical problems. Deal with nonverbal symbolism (formulas, scientific equations, graphs, musical notes, etc.) in its most difficult phases. Deal with a variety of abstract and concrete variables. Apprehend the most abstruse classes of concepts.	Apply knowledge of advanced mathematical and statistical techniques such as differential and integral calculus, factor analysis, and probability determination, or work with a wide variety of theoretical mathematical concepts and make original applications of mathematical procedures, as in empirical and differential equations.	Comprehension and expression of a level to— —Report, write, or edit articles for such publications as newspapers, magazines, and technical or scientific journals. Prepare and draw up deeds, leases, wills, mortgages, and contracts. —Prepare and deliver lectures on politics, economics, education, or science. —Interview, counsel, or advise such people as students, clients, or patients, in such matters as welfare eligibility, vocational rehabilitation, mental hygiene, or marital relations. —Evaluate engineering technical data to design buildings and bridges.
5	Apply principles of logical or scientific thinking to define problems, collect data, establish facts, and draw valid conclusions. Interpret an extensive variety of technical instructions, in books, manuals, and mathematical or diagrammatic form. Deal with several abstract and concrete variables.		
4	Apply principles of rational systems [1] to solve practical problems and deal with a variety of concrete variables in situations where only limited standardization exists. Interpret a variety of instructions furnished in written, oral, diagrammatic, or schedule form.	Perform ordinary arithmetic, algebraic, and geometric procedures in standard, practical applications.	Comprehension and expression of a level to— —Transcribe dictation, make appointments for executive and handle his personal mail, interview and screen people wishing to speak to him, and write routine correspondence on own initiative. —Interview job applicants to determine work best suited for their abilities and experience, and contact employers to interest them in services of agency. —Interpret technical manuals as well as drawings and specifications, such as layouts, blueprints, and schematics.
3	Apply common sense understanding to carry out instructions furnished in written, oral, or diagrammatic form. Deal with problems involving several concrete variables in or from standardized situations.	Make arithmetic calculations involving fractions, decimals, and percentages.	Comprehension and expression of a level to— —File, post, and mail such material as forms, checks, receipts, and bills. —Copy data from one record to another, fill in report forms, and type all work from rough draft or corrected copy. —Interview members of household to obtain such information as age, occupation, and number of children, to be used as data for surveys or economic studies. —Guide people on tours through historical or public buildings, describing such features as size, value, and points of interest.
2	Apply common sense understanding to carry out detailed but uninvolved written or oral instructions. Deal with problems involving a few concrete variables in or from standardized situations.	Use arithmetic to add, subtract, multiply, and divide whole numbers.	
1	Apply common sense understanding to carry out simple one- or two-step instructions. Deal with standardized situations with occasional or no variables in or from these situations encountered on the job.	Perform simple addition and subtraction, reading and copying of figures, or counting and recording.	Comprehension and expression of a level to— —Learn job duties from oral instructions or demonstration. —Write identifying information, such as name and address of customer, weight, number, or type of product, on tags or slips. —Request orally, or in writing, such supplies as linen, soap, or work materials.

[1] Examples of "principles of rational systems" are: Bookkeeping, internal combustion engines, electric wiring systems, house building, nursing, farm management, ship sailing.