COMMERCIAL NUCLEAR POWER PLANT TRAINING PROGRAM EVALUATION FOR NON-LICENSED OPERATORS: A DELPHI APPROACH

By

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PREFACE

This study was concerned with the establishment of detailed qualification criteria on a generic basis for the position of non-licensed operator of a commercial nuclear power plant. The specific objectives included determining general educational requirements and specific technical areas of study necessary or desirable for the non-licensed operator, as well as the type of plant-specific orientation and training that he or she should receive during the first few months of employment. The additional education, training, and experience qualifications necessary for an individual filling the position of a non-licensed operator were also examined. A series of three questionnaires incorporating the Delphi Technique was used to gather data and opinions from commercial nuclear power plant training coordinators (both corporate and site), university educators in the nuclear power area, regulatory agencies auditing training programs for non-licensed operators and management personnel involved with non-licensed operators. Information thus collected was analyzed against majority opinion criteria, and specific qualification elements were identified and ranked in order of importance.

The author wishes to express his appreciation to his major adviser, Dr. Waynne B. James, for her invaluable assistance throughout this study. Appreciation is also expressed to the other committee members, Dr. Craig Anderson and Dr. Clyde Knight, for their assistance in the preparation of the final manuscript. A special note of thanks is given to Ms. Lorely R. McGee for her invaluable assistance in typing the early drafts and final manuscript.

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CHAPTER I

INTRODUCTION

The non-licensed operator at a commercial nuclear plant has long been responsible for ensuring the plant is operated in a safe and efficient manner. This responsibility has encompassed both routine plant operations and potential accident conditions. In the post-Three Mile Island era, the emphasis on non-licensed operator training has increased greatly and engendered a concomitant increase in the demand for higher quality non-licensed operator training programs. During this same period, the preponderance of negative publicity resulting from the accident at Three Mile Island, along with the public's perception of the nuclear industry as a "dead" industry, resulted in declining enrollments in nuclear power degree programs and in the failure of some of these programs (U.S. Department of Energy, 1981). The combination of an increase in demand and a reduction in supply of college educated nuclear power, non-licensed operator candidates resulted in the problem of where the additionally needed personnel would be trained. It also increased the importance of good qualification criterion for the non-licensed operator to ensure that alternate sources of personnel did not dilute the competence that had been present within this position in the past.

Statement of the Problem

Detailed qualification criteria were not available for the non-licensed operator of a commercial nuclear power plant. Such criteria are considered to be critical to the development of adequate training programs and qualification criteria which are necessary to ensure that positions are filled by qualified individuals.

Purpose of the Study

The purpose of this study was to establish a detailed qualification criteria and training program on a generic basis for the position of the non-licensed operator of a commercial nuclear power plant.

Research Questions

The research questions which this study sought to answer were:

1. What general educational requirements are necessary for the non-licensed operator of a commercial nuclear power plant?

2. What specific areas of technical education should be required for an entry level non-licensed operator of a commercial nuclear power plant?

3. What type of plant-specific orientation and training should the entry level non-licensed operator of a commercial nuclear power plant receive within the first few months of employment?

4. What level of experience should be required for a non-licensed operator of a commercial nuclear power plant?

Scope of the Study

This study concentrated on qualification criteria for the non-licensed operator at a commercial reactor site. However, study participants represented all major aspects of the commercial nuclear industry substantially involved in non-licensed operator training programs. These included consultants, regulatory personnel, utility site and corporate training coordinators, university educators in the nuclear power area, and management personnel involved with non-licensed operators.

Limitations

This study was subject to the following limitations:

1. The study addressed only the personnel involved with coordination and presentation of non-licensed operator training programs. The individual non-licensed operators were purposely excluded.

2. The methodology used to conduct this study, the Delphi Technique, did not provide for face-to-face interaction of participants.

Assumptions

The following assumptions were made with respect to this study:

1. It was assumed that a sample of the subject population would yield results consistent with those which would be achieved if the entire population were involved.

2. The assumption was made that the perceived criteria reported by the sample population would be valid indications of the qualification criteria and training programs actually needed.

3. It was assumed that the respondents answered honestly and truthfully.

Definitions

The following definitions are provided to clarify terms used in this study:

ALARA - Health Physics program to maintain dosage to ionizing radiation as low as reasonably achievable (ALARA).

Commercial Nuclear Power Plant - A power plant which utilizes the nuclear process to generate electricity for commercial or private use.

Delphi Technique - A research methodology which employs a series of successive questionnaires with subsequent questionnaires factoring in data from preceding questionnaires. The objective of Delphi is to attain or approximate a consensus opinion on a particular subject (Helmer, 1967).

Education - The conventional formal teaching/learning process which includes high school and college, but excludes specific skills training.

Entry Level - Applies to an individual just starting in his or her first professional position.

HP Procedures - Procedures followed by Health Physics (HP) personnel to ensure minimum risk to exposure to ionizing radiation.

Licensed Operator - An operator of a commercial nuclear power plant who is required to obtain a reactor operator's license from the Nuclear Regulatory Commission.

Non-licensed Operator - An operator of a commercial nuclear power plant who is not required to obtain a reactor operator's license from the Nuclear Regulatory Commission.

Qualification Criteria - The education, training, and experience requirements necessary to fill a position.

Qualifications - The sum of an individual's education, training, and experience.

RAD/CHEM Operations - Operations conducted by Radiological Controls personnel (RAD) and Chemistry personnel (CHEM) to ensure proper Health Physics and Chemistry operations of a commercial nuclear power plant.

Radioactive Material (RAM) Packaging and Transportation - Material which is radioactive and requires special packaging and handling (transportation).

Reactor Operator (RO) Training - Special training required to be granted a license to operate a commercial nuclear power reactor.

Senior Reactor Operator (SRO) Training - Special training required to act in a supervisory capacity over reactor operators.

Training - Performance based instruction of personnel through formal classroom courses, self-study, informal lectures and discussion, and on-the-job experience to achieve a minimum level of proficiency.

Organization of the Study

Chapter I introduces the study, presenting the problem, purpose, limitations, and definition of terms. Chapter II includes a review of related literature concerning relevant regulations, regulatory guidance, industry standards, technical reports, historical evolution, present status and trends for change of qualification standards and criteria as well as training programs for the non-licensed operator. Chapter III reports the procedures utilized in this study, including the population and sample, instrumentation, the Delphi Technique, and the data analysis. The findings of the study are presented in Chapter IV. Chapter V includes a summary of the study, conclusions, and recommendations for qualification standards and criteria for the non-licensed operator of a commercial nuclear power plant.

CHAPTER II

REVIEW OF LITERATURE

The review of literature was conducted to examine the relevant regulations, regulatory guidance, industry standards, technical reports, historical evolution, present status, and trends for change of qualification standards and criteria as well as training programs for the non-licensed operator. This chapter examines the following topics:

1. Background and History of the non-licensed operator of a commercial nuclear power plant,
2. The Three Mile Island Accident,
3. Present Status of Qualification Criteria,
4. Supply and Demand,
5. Summary.

Background and History of Non-Licensed Operators

The non-licensed operator of a commercial nuclear power plant has long been the backbone of an effective and efficiently operated unit (Morgan, 1980). The non-licensed operator has not been recognized in his/her true value in the safe operation of a commercial nuclear power plant. The atomic age was given birth on December 2, 1942 in the metallurgical laboratory at the University of Chicago by non-licensed operators. For the first time, a self-sustaining nuclear chain reaction was achieved by non-licensed operators. Even though the individuals working on the project were experts of their time, they were still non-licensed operators. The Metallurgical Project, which was later a part of the Manhattan Project, uncovered unprecedented training requirements and problems. It was the critical war research which gave birth to specialized non-licensed operators (Morgan, 1980).

With a secure hold in the greatly expanding post-war atomic area, the non-licensed operator (in this case, the health physics technician) grew rapidly (Parker, 1980). Along with the health physics technician came the chemistry technician, the instrumentation and control technicians and finally, the licensed operator candidates which evolved from the non-licensed operators.

A number of professional societies have grown in the atomic area. One such society has been the Health Physics Society for the Health Physics Technicians. The Health Physics Society began in 1955 and was incorporated in 1961. In 1959, the society adopted the following definition of health physics, as quoted from a 1975 pamphlet:

> Health Physics is a profession devoted to the protection of man and his environment from unwarranted radiation exposure. A health physicist is a person engaged in the study of the problems and practices of providing radiation protection. He is concerned with an understanding of the mechanism of radiation damage, with the development and implementation of methods and procedures necessary to evaluate radiation hazards and with providing protection to man and his environment from unwarranted radiation exposure (Health Physics Society, 1975, p. 2).

The Society presently has over 5,400 members in over 40 countries (Health Physics Society Membership Handbook, 1982-1983).

The other non-licensed operator positions previously mentioned have also generated their own professional societies to better the techniques and operations of the non-licensed operators. These societies have recognized and supported the importance of quality training programs and qualification criteria for non-licensed operators in commercial nuclear power plants.

The Three Mile Island Accident

On March 28, 1979, an accident occurred at Metropolitan Edison's Three Mile Island Unit 2 (TMI-2) nuclear plant. Plant operators misread the accident symptoms; the plant's designers failed for a whole day to correct the problem. The Nuclear Regulatory Commission (NRC) regulators had great difficulty in determining what had happened. This all happened before a full load of media representatives. The nuclear industry was summarily stripped of whatever mystique it had left from the old days of the Manhattan Project (U.S. Nuclear Regulatory Commission Special Inquiry Group, 1980).

In the aftermath of Three Mile Island (TMI), investigations were conducted by the Kemeny Commission and numerous other task forces, agencies, and special inquiry groups. The legacy of TMI was a widespread recognition of the need for change. One specific area was targeted for improvement applied directly to this study. That area was training and qualifications (The President's Commission on the Accident at Three Mile Island, The Accident at Three Mile Island, 1979).

In The Accident at Three Mile Island (1980), the Special Inquiry Group made the following finding:

> First of all, it is our conclusion that the training of TMI operators was greatly deficient. While training may have been adequate for the operation of a plant under normal circumstances, insufficient attention was paid to possible serious accidents. And the depth of understanding, even of senior reactor operators, left them unprepared to deal with something as confusing as the circumstances in which they found themselves (The President's Commission on the Accident at Three Mile Island, 1980, p. 10).

The Group recommended that training and qualifications be elevated in importance.

As a result of the TMI investigations, in 1980 the NRC undertook a major effort to evaluate the training and qualification programs at 48 operating commercial nuclear power plants. The program found significant weaknesses in the area of personnel selection, qualification, and training. The most significant weaknesses involved lack of development and use of selection criteria, poorly defined qualification criteria, and inadequate training programs (Cunningham, 1981). The NRC placed increased emphasis on these problem areas and obtained commitments from deficient plants to upgrade their programs (U.S. Nuclear Regulatory Commission, 1981).

Another result of TMI was the establishment of an industry-supported institute dedicated to assisting the nuclear power industry in improving operational safety. The Institute for Nuclear Power Operations (INPO) was created in 1979 as a non-profit independent organization having a stated goal of assisting utilities in achieving a high level of excellence in safety of nuclear power operations. In addition to conducting evaluation and assistance visits to individual plants, INPO was found to be actively involved in establishing performance standards and benchmarks for excellence in the various nuclear operations functional areas. One area of interest in this study was considered of sufficient importance to be established as one of INPO's five major technical divisions: the Training and Education Division. INPO has been successful in having a substantial impact within the industry in these and other areas (Cunningham, 1982).

Present Status of Qualification and Training Criteria

At the time of this study, the most widely recognized qualification criteria for the non-licensed operator were contained in an NRC Regulatory Guide. Regulatory Guide 1.8, "Personnel Selection and Training (1975)," established criteria for the positions of non-licensed operator at a nuclear power plant.

In 1981, the American Nuclear Society (ANS) issued ANS 3.1: Standard for Selection, Qualification and Training of Personnel for Nuclear Power Plants, supporting the criteria from Regulatory Guide 1.8, for non-licensed operators. The criteria listed for the non-licensed operators in ANS 3.1 were:

> 4.4.2 Instrumentation and Control
> a. Education: Associate Degree in Engineering or related science.
> b. Experience: At the time of initial core loading or appointment to the position, whichever is later, the responsible person shall have two years power plant experience in instrumentation and control, of which one year shall be nuclear power plant experience (p. 7).
>
> 4.4.3 Chemistry and Radiochemistry
> a. Education: Bachelor Degree in Chemistry or related science.
> b. Experience: At the time of initial core loading or appointment to the position, whichever is later, the responsible person shall have two years experience in chemistry, of which one year shall be nuclear power plant experience in radiochemistry (p. 7).
>
> 4.4.4 Radiation Protection
> a. Education: Bachelor Degree in a science or engineering subject, including formal training in radiation protection.
> b. Experience: At the time of initial core loading or appointment to the active position, whichever is later, the responsible individual shall have four years of experience in applied radiation protection. At least three years of this experience shall be in applied radiation protection work in a nuclear facility dealing with radiological problems similar to those encountered in nuclear power plants, preferably in a nuclear power plant (p. 7).

In addition to the preceding sources of qualification criteria, it was decided to review the qualifications of the non-licensed operators and comments concerning training from a report titled Utility Management and Technical Resources (Podensky, 1980). The report contained a statement about training and selection of personnel by Hyman G. Rickover, the father of the nuclear power program of the U.S. Navy, before a House Subcommittee.

> Rickover's testimony outlines the philosophy under which he has directed the Naval Propulsion Program. His philosophy includes the following points. The plant design must be highly reliable (i.e., based on sound engineering practice with adequate margin to cover worst-case conditions). If at any point a plant component or system is determined or suspected to be unsatisfactory, it must be redesigned or rebuilt to provide the needed reliability, despite significant costs and delays. Managers must be highly competent in the technical disciplines required to run a nuclear facility, not just good managers in other disciplines. All responsibility must be centralized and clearly delineated. All parts of the nuclear program - design, construction, operation, staff selection and training - must be integrated, since each element depends on all the other elements.
>
> Rickover described in detail the rigorous criteria for personnel selection and the demanding training program for nuclear navy personnel (Podensky, 1980, p. I-4).

The expertise required for an Instrumentation and Control Technician includes the principles of instrument operation and failure; alternate indication and manual control of instruments; actual state versus indicated state of the instruments; and normal levels and transient levels of the instruments. The skill level of an Instrumentation and Control Technician includes the maintenance and calibration of instruments (Podensky, 1980).

The expertise required for Radiation Control and Health Physics Technicians includes dosimetry and radiation monitoring instrumentation;

health effects of radiation exposure; exposure limits; decontamination procedures and techniques; physical and chemical properties of radionuclides; radionuclide transport and detection; shielding and release limits. The skill level for Radiation Control and health Physics Technicians includes the ability to perform required radiation work permit procedures (Podensky, 1980).

The expertise required for Chemistry/Radiochemistry Technicians includes water chemistry for corrosion control; sampling and analytic procedures/techniques under normal and accident conditions; radioactive waste management; and decontamination procedures. The skill level for Chemistry/Radiochemistry Technicians includes the ability to perform required analytical procedures (Podensky, 1980).

The training of reactor power plant personnel has been criticized in almost all investigations of the TMI accident. Weaknesses in content, methodology, and administration of training programs have been documented at length. Since TMI, new standards have been drafted, <u>ANS 3.1, Standards for Qualification and Training of Personnel for Nuclear Power Plants</u>, (1979).

None of the reports, however, dealt systematically with training as an educational process. The results, consequently, represented a patchwork of opinion, not always informed, on the basis of which employees were trained or "qualified" to perform in various levels and types of nuclear power plant jobs. Considering the high-technology that underpins nuclear power, the absence of clear scientific thinking on the subject of training was apparent (Podensky, 1980).

In short, accepted principles of learning have not been applied to nuclear power plant training processes. For example, training or education efforts usually began with precise statements of objectives, behaviorally couched, that a trainee would achieve as a result of training participation. These have been particularized neither by NRC, nor as far as can be determined, by utilities or vendors. Without consensus on objectives, however, no framework existed for curriculum development, for evaluation of trainee learning, or for measurement of the effectiveness of the training program as a total entity.

According to Podensky (1980) in organization for effective training, nothing should go unexplained. For each specific objective (intended consequence of the training), there should be specific statements, in behavioral terms, of the knowledge and skills requisite for reaching this objective, along with its rationale. For each statement of knowledge and skill, the most appropriate hypothesized learning activities, the manner in which trainee performance of that specific knowledge or skill should be assessed, and the level of performance considered to demonstrate possession of that skill or knowledge should be included. The relationship between the training, the employee, and the job function in normal and abnormal (accident) conditions must be clearly explained and fully understood.

As an end result of the TMI accident, utilities have been required to submit to the NRC, prior to operation, and annually after training has commenced, a training plan for initial training and requalification training for those positions in the nuclear power plant that are specified, including (Podensky, 1980):

a. Methods for ascertaining training needs of each employee.

b. Statements of the specific objectives of the training, couched in terms of specific knowledge and skills that trainees would be expected to possess by completion of that particular training.

c. For each objective in (b), the detailed content and method by which the trainee would acquire each desired knowledge or skill.

d. For each objective, the detailed manner in which trainee proficiency and knowledge would be evaluated and a statement of what specific corrective actions would be taken if proficiency was not attained. It would not be sufficient merely to reference the evaluation method, i.e., test, systematic observation, etc. The method would be described in detail. For example, for "systematic observation," the submission should indicate what behavior variables would be observed, how they were to be assessed, how recorded, level of performance considered acceptable, etc.

e. A time-phased plan for development.

f. Projected amount of time devoted to training for this objective.

g. A statement of how the effectiveness of the training processes for this objective would be evaluated (Podensky, 1980).

In addition, an annual report was required to be submitted to the NRC showing, by training program, the number of trainees and their progress; also included would be evidence of the effectiveness of the training, conclusions reached as to needed revisions, and a time-phased plan for making and introducing those revisions. Records of an employee's participation to substantiate this report and success in training were required to be kept in the employee's file (Podensky, 1980).

All training would be ultimately judged in terms of employee effectiveness on the job. Utilities would describe a system for evaluation of the performance of each employee, constituted not around such ambiguous terms as "dependability" or "initiative" but on the basis of behaviors that were determined by job analysis methods as representative "make-or-break" aspects of successful versus unsuccessful job performance. These served as a means of determining employee training needs in the first instance, as well as the assessment of the effectiveness of the training. A time-phased plan for developing this system would be submitted at least one year prior to beginning operations. The annual training report provided by the utility to the NRC would address matters related to performance evaluation and recommend plans for revisions in it, as necessary. To the maximum extent possible, utilities would use unobtrusive measures, such as those derived from computerized performance records or other existing records.

Utilities would be required to view training needs for individual positions, and their related job knowledge and skill objectives, in terms that take into account the broad context of total plant operation. Utilities would show in training plans how cross-specialty training has been conceptualized and how the training for each occupation accommodated the need for cross-skills and knowledge training. Utilities would also show that training programs incorporate a sufficient level of theoretical background so that trainees could apply not only skills of a manipulative kind in operation of controls, but could adapt their knowledge to diagnose situations and select the proper actions to correct impending problems (Podensky, 1980).

Company policy regarding employee attendance at training would be to discourage absenteeism. Employees would not qualify for licensing, requalification, or any other purpose if they do not satisfactorily attend and complete <u>all</u> portions of the training to which they are assigned (Podensky, 1980).

Supply and Demand

The U.S. Department of Energy (1981) recently published a report titled <u>A Study of the Adequacy of Personnel for the U.S. Nuclear Program</u>. The purpose of the study was to determine the adequacy of future nuclear personnel. One complicating factor was that a number of short term personnel requirements have been encountered as the industry began to shift away from plant design and fabrication to plant operation. Another complication was related to the uncertainty in the future evolution of the nuclear industry. Nevertheless, the study concluded that: ". . . the supply infrastructure for special nuclear personnel is barely coping with the present demand and there are a number of trends which indicate a worsening situation" (U.S. Department of Energy, 1981, p. 16).

The study examined nuclear power related field enrollment and degrees granted over a 10 year period (1971-1981). A pattern of declining enrollment was found at the Bachelor's degree and Doctoral degree level (U.S. Department of Energy, 1981). With the exception of the 1980-81 academic years, the decline also appeared in Master's degree enrollment.

Indications were that social attitudes, reflected in peer and parental pressure have had a notable effect in career selection in the nuclear power industry over the last few years. The negative social attitude toward nuclear power and the perception of the nuclear industry as a "dead" industry apparently kept students away in droves, despite high salaries and good advancement potential (U.S. Department of Energy, 1981).

Summary

The review of literature established that the TMI accident had a profound effect on non-licensed operators at nuclear power plants. It established that qualification criteria for the non-licensed operator did exist within the industry, but only in generalized form. Even the changes proposed to existing standards were found to lack detail. The personnel supply and demand situation regarding non-licensed operators indicated a decreasing supply of nuclear trained personnel graduates at all degree levels, in the face of a growing demand.

CHAPTER III

PROCEDURES

The methodology selected for this study was the Delphi Technique. This method was used to approximate a consensus by a panel of individuals involved with non-licensed operators. Procedures were developed to select study participants and to collect and analyze data. This chapter presents the procedures used in this study in the following manner:

1. Delphi Technique,
2. Study Participants,
3. Data Collection,
4. Data Analysis.

Delphi Technique

The Delphi Technique was chosen as the method of obtaining convergent opinion from participants without bringing the participants together physically. The study objective was to reach or approximate an consensus opinion on some topic, the very nature of which did not lend itself to more conventional analysis. The convergent opinion of Delphi participants was accomplished by a series of successive questionnaires each of which built upon the preceding. Each questionnaire provided feedback from the previous questionnaire and gave participants the opportunity to change their opinions. Each round of questions was designed to produce more carefully considered group opinions.

The Delphi Technique was developed by Helmer and his colleagues at the Rand Corporation in the early 1950's to obtain group opinions about urgent defense problems. Delphi has subsequently been used to predict future developments, to obtain expert consensus, and to establish long-range planning priorities. The Delphi Technique:

> . . . eliminates committee activity among the experts all together and replaces it with a carefully designed program of individual interrogations (usually best conducted by a questionnaire) interspersed with information input and opinion feedback (Helmer, 1967, p. 76).

Participants have remained anonymous to each other in past studies, and this anonymity has been proven an essential part of the process. It protected participants' ideas from being submerged due to psychological or hierarchical influences, and afforded each participant the opportunity to evaluate numerous peer opinions and to privately change his or her mind (Helmer, 1967).

Study Participants

The target population for this study consisted of commercial nuclear power plant training coordinators (both corporate and site), university educators in the nuclear power area, regulatory agencies, and management personnel involved with non-licensed operators. These individuals were selected to represent a cross-section of the industry. An attempt was made to obtain a group having a fairly diverse background, as regards both education and pre-commercial nuclear experience, in order to achieve a sample representative of the population as a whole.

Since at least three successive questionnaires were involved, and the results from preceding questionnaires determined questions on succeeding questionnaires, this researcher determined to study a sample rather than the population as a whole. Since the total population of this group was approximately 100, it was randomly determined that a sample of 30 to 40 individuals would prove adequate for this study. To insure this level of participation over the course of the study, 75 individuals were randomly chosen to be included in the study.

Data Collection

Data were collected using a series of three questionnaires designed as a Delphi study. Questionnaire I (Appendix A) incorporated some preliminary qualification and training criteria which were developed from current literature and from phone conversations with a panel of "experts" (Appendix B) in non-licensed operator training. Participants were requested to add to or modify specific areas. Questionnaire I was mailed to the study participants on January 3,1984. Questionnaire II (Appendix C) was mailed to the study participants on January 20, 1984 and consisted of modified qualification and training criteria which participants were asked to rate in importance. Questionnaire III (Appendix D) was mailed to the study participants on February 8, 1984 and consisted of composite qualification and training criteria including a summary of the group's rating of each specific item and an indication of the majority opinion, if any. Majority opinion was arbitrarily established as the single integral of the ratings scale with 50 percent or more of the ratings or, failing that, the two adjacent integrals on the rating scale with 75 percent or more of the ratings. Respondents' choices from Questionnaire II were indicated by a red dot on Questionnaire III. The red dot was placed over each individual respondent's previous rating or choice.

Data Analysis

Questionnaire I consisted of preliminary qualification and training criteria which was developed from current literature with additions or modifications in specific areas by study participants. Questionnaire II utilized the qualification and training criteria established from Questionnaire I which the study participants had rated in importance.

The analysis of Questionnaire III data began with a frequency count to determine items achieving a single integral or adjacent integral majority opinion. Then a group mean was computed for each individual item and the percentage of respondents constituting a majority rating was calculated.

CHAPTER IV

PRESENTATION OF FINDINGS

The purpose of this study was to establish detailed qualification and training program criteria on a generic basis for the position of the non-licensed operator of a commercial nuclear power plant. The study consisted of three successive questionnaires employing the Delphi Technique to achieve or at least approximate an expert consensus opinion on specific qualification criteria. This chapter presents the findings of the study in the following order:

1. Identified Qualification Areas,
2. Respondent Characteristics,
3. Delphi Technique Analysis,
4. General Educational Requirements,
5. Entry Level Technical Areas of Study and Experience Background,
6. Entry Level Orientation and Training,
7. Non-licensed Operator Level of Experience (Entry Level).

Identified Qualification Areas

Through discussions with non-licensed operator training specialists, four general areas were identified as being most relevant to establishing qualification criteria for the non-licensed operators at commercial power reactors. These areas were as follows:

1. General educational requirements.

2. Specific technical areas of study for entry level non-licensed operators.

3. Plant-specific orientation and training for entry level non-licensed operators.

4. Education/training and experience criteria for the non-licensed operators.

Respondent Characteristics

Questionnaire I was sent to individuals representing all aspects of training for non-licensed operators, including utility personnel holding both site and corporate positions, consultants, university educators in the nuclear power area, and regulatory inspection and enforcement personnel. Of the 75 individuals to whom the initial questionnaire was sent, 50 responded (66.7%). Questionnaire II was sent to the individuals who answered the first questionnaire, and 45 responses were received (90.0%). Subsequently, Questionnaire III was sent to the 45 respondents to the second questionnaire, and 31 answers were received (68.9%). The overall response rate, that is, individuals who completed all three questionnaires (31) as compared to the total number of individuals who were sent the first questionnaire (75) was 41.3 percent.

Since the findings presented in this chapter are based upon the data collected from Questionnaire III, the most direct input into the findings was the result of the efforts of the 31 respondents who participated in that questionnaire as well as the preceding two. These 31 individuals had an average of 8.0 years of training experience and 6.0 years of non-licensed operator training experience. With respect to highest academic degree held, one had a Doctoral degree, four held Master's degrees, 18 held Bachelor's degrees, two held Associate degrees, and the remaining six held high school diplomas. Regarding age group, two were under 30 years of age, 26 were in the 30 to 39 age group, and three were between 40 and 49 years of age.

Delphi Technique Analysis

Questionnaire III gave study participants an opportunity to change their responses to Questionnaire II. The questionnaires were identical in organization and scope, the only difference being that Questionnaire III also had information on the results of its predecessor. This was accomplished by indicating the previous choices of all respondents, by percent, under each choice, and by customizing every questionnaire for each individual respondent by placing a red dot over his previous choices.

A total of 506 items required responses on the second and third questionnaires. An analysis of the changes made by individuals on the third questionnaire revealed that the number of changes by individuals ranged from zero to 15 and that the average number of changes for the group was seven. A total of 217 changes made by the entire group, 100 percent were made either by changing from a minority choice to a majority choice, or from a minority choice to a choice <u>closer</u> to a majority choice.

General Educational Requirements

The first research question of this study was "What general educational requirements are necessary for the non-licensed operator of a commercial nuclear power plant?" To clarify and provide a frame of reference for these criteria, it was decided to address the desirability of various degree types and degree levels for a non-licensed operator of a commercial nuclear power plant. The criteria for majority opinion were operationally defined in Chapter III as the single integral of the ratings scale with 50 percent or more of the ratings or, failing that, the next two adjacent integrals on the rating scale with 75 percent or more of the ratings. Results not falling within these criteria were regarded as indetermininant. The mean of the integral ratings scale for each item allowed further refinement of ranking within the categories.

The data in Table I are the responses to the general educational requirements by degree types for Non-Licensed Training for Reactor Operator License Candidates. The responses indicate the perceived importance of seven degree types. The data in Table I, as indicated, show that a degree in Electrical Engineering and Mechanical Engineering was rated as "desirable" by 50 percent and 56 percent. Degrees in Physics (61%), Chemistry (67%), Health Physics - Radiation Science (72%), and other engineering or engineering technology (67%) were rated as "useful".

The data in Table II are the responses to the general educational requirements by degree level for Non-Licensed Training for Reactor Operator License Candidates. The responses indicate the perceived importance of three degree levels. The data in Table II, as indicated,

TABLE I

PERCEIVED IMPORTANCE OF GENERAL EDUCATIONAL REQUIREMENTS FOR NON-LICENSED TRAINING FOR REACTOR OPERATOR LICENSE CANDIDATES BY DEGREE TYPES

Degree Type	Most Desirable x = 4 %	Desirable x = 3 %	Useful x = 2 %	Unsatis-factory x = 1 %	$\bar{x}$
Nuclear Engineering	22	33	28	17	2.50
Electrical Engineering	6	50	28	16	2.44
Mechanical Engineering	6	56	28	10	2.56
Physics	0	28	61	11	2.17
Chemistry	0	17	67	16	2.00
Health Physics (Radiation Science)	0	11	72	17	1.95
Other Engineering or Engineering Technology	0	22	67	11	2.11

N = 31

TABLE II

PERCEIVED IMPORTANCE OF GENERAL EDUCATIONAL REQUIREMENTS FOR NON-LICENSED TRAINING FOR REACTOR OPERATOR LICENSE CANDIDATES BY DEGREE LEVEL

Degree Level	Most Desirable $x = 4$ %	Desirable $x = 3$ %	Useful $x = 2$ %	Unsatis-factory $x = 1$ %	$\bar{x}$
Associate Degree	6	0	83	11	2.06
Bachelor's Degree	6	28	44	22	2.17
Master's Degree	0	11	33	56	1.56

N = 31

show that an Associate's degree was rated as "useful" by 83 percent with a Master's degree rated as "unsatisfactory" by 56 percent.

The data in Table III are the responses to the general educational requirements by degree types for Health Physics Technicians. The responses indicate the perceived importance of six degree types. The data in Table III, as indicated, show that a degree in Health Physics - Radiation Science was rated as "most desirable" by 61 percent. A degree in Chemistry was rated as "desirable" by 67 percent. Degrees in Biology (56%), Nuclear Engineering (61%), Physics (56%), and other engineering or engineering technology (72%) were rated as "useful".

The data in Table IV are the responses to the general educational requirements by degree level for Health Physics Technicians. The responses indicate the perceived importance of three degree levels. The data in Table IV, as indicated, show that an Associate's degree was rated as "useful" by 61 percent with a Master's degree rated as "unsatisfactory" by 62 percent. A Bachelor's degree was rated as "desirable" or "useful" by 44 percent.

The data in Table V are the responses to the general educational requirements by degree types for Chemistry Technicians. The responses indicate the perceived importance of six degree types. The data in Table V, as indicated, show that a degree in Chemistry was rated "most desirable" by 61 percent. A degree in Health Physics - Radiation Science was rated as "desirable" by 61 percent. Degrees in Biology (67%), Nuclear Engineering (67%), Physics (61%), and other engineering or engineering technology (67%) were rated as "useful".

TABLE III

PERCEIVED IMPORTANCE OF GENERAL EDUCATIONAL REQUIREMENTS FOR HEALTH PHYSICS TECHNICIANS BY DEGREE TYPES

Degree Type	Most Desirable $x = 4$ %	Desirable $x = 3$ %	Useful $x = 2$ %	Unsatis-factory $x = 1$ %	$\bar{x}$
Health Physics (Radiation Science)	61	17	22	0	3.39
Chemistry	0	67	28	5	2.61
Biology	0	28	56	16	2.11
Nuclear Engineering	0	22	61	17	2.06
Physics	0	28	56	16	2.17
Other Engineering or Engineering Technology	0	17	72	11	2.56

N = 31

TABLE IV

PERCEIVED IMPORTANCE OF GENERAL EDUCATIONAL REQUIREMENTS FOR HEALTH PHYSICS TECHNICIANS BY DEGREE LEVEL

Degree Level	Most Desirable x = 4 %	Desirable x = 3 %	Useful x = 2 %	Unsatis-factory x = 1 %	$\bar{x}$
Associate Degree	11	22	61	6	2.39
Bachelor's Degree	0	44	33	23	2.22
Master's Degree	0	5	33	62	1.44

N = 31

TABLE V

PERCEIVED IMPORTANCE OF GENERAL EDUCATIONAL REQUIREMENTS FOR CHEMISTRY TECHNICIANS BY DEGREE TYPES

Degree Type	Most Desirable x = 4 %	Desirable x = 3 %	Useful x = 2 %	Unsatis-factory x = 1 %	$\bar{x}$
Chemistry	61	17	22	0	3.39
Health Physics (Radiation Science)	0	61	39	0	2.67
Biology	0	17	67	16	2.00
Nuclear Engineering	0	17	67	16	2.00
Physics	0	17	61	22	1.95
Other Engineering or Engineering Technology	0	11	67	22	1.72

N = 31

The data in Table VI are the responses to the general educational requirements by degree level for Chemistry Technicians. The responses indicate the perceived importance of the three degree levels. The data in Table VI, as indicated, show that an Associate's degree and a Master's degree were rated as "useful" by 72 percent and 50 percent.

The data in Table VII are the responses to the general educational requirements by degree types for Instrumentation Control Technicians. The responses indicate the perceived importance of five degree types. The data in Table VII, as indicated, show that degrees in Physics (50%), Nuclear Engineering (56%), and other engineering or engineering technology (67%) were rated as "useful".

The data in Table VIII are the responses to the general educational requirements by degree level for Instrumentation Control Technicians. The responses indicate the perceived importance of the three degree levels. The data in Table VIII, as indicated, show that an Associate's degree and a Bachelor's degree was rated as "useful" by 61 percent and 50 percent. A Master's degree was rated as "unsatisfactory" by 56 percent.

Entry Level Technical Areas of Study and Experience Background

The second research question of this study was "What specific technical areas of study and experience background should be required for an entry level non-licensed operator?" The frame of reference for the questionnaires was established at an entry level non-licensed operator of a commercial nuclear power plant first entering the job market in 1984.

TABLE VI

PERCEIVED IMPORTANCE OF GENERAL EDUCATIONAL REQUIREMENTS FOR CHEMISTRY TECHNICIANS BY DEGREE LEVEL

Degree Level	Most Desirable x = 4 %	Desirable x = 3 %	Useful x = 2 %	Unsatis-factory x = 1 %	$\bar{X}$
Associate Degree	17	5	72	6	2.33
Bachelor's Degree	11	44	28	17	2.50
Master's Degree	0	5	50	45	1.61

N = 31

TABLE VII

PERCEIVED IMPORTANCE OF GENERAL EDUCATIONAL REQUIREMENTS FOR INSTRUMENTATION CONTROL TECHNICIANS BY DEGREE TYPES

Degree Type	Most Desirable x = 4 %	Desirable x = 3 %	Useful x = 2 %	Unsatis-factory x = 1 %	$\bar{x}$
Electrical Engineering	33	22	39	6	2.83
Mechanical Engineering	0	44	28	28	2.17
Physics	0	28	50	22	2.06
Nuclear Engineering	0	28	56	16	2.11
Other Engineering or Engineering Technology	5	17	67	11	2.17

N = 31

TABLE VIII

PERCEIVED IMPORTANCE OF GENERAL EDUCATIONAL REQUIREMENTS FOR INSTRUMENTATION CONTROL TECHNICIANS BY DEGREE LEVEL

Degree Level	Most Desirable x = 4 %	Desirable x = 3 %	Useful x = 2 %	Unsatis-factory x = 1 %	$\bar{x}$
Associate Degree	22	11	61	6	2.50
Bachelor's Degree	11	17	50	22	2.17
Master's Degree	0	11	33	56	1.56

N = 31

The data in Table IX, Perceived Importance of Specific Technical Areas of Entry Level Study for Non-Licensed Training for Reactor Operator License Candidates, indicate the responses to the degree of importance of 24 technical areas of study. According to the established criteria for majority opinion (50% or more of the ratings; 75% or more of next two adjacent integrals), the areas of study were rated as follows:

1. Essential:
    a. Atomic/Nuclear Physics
2. Essential - Important:
    a. Health Physics
    b. Radiological Emergencies
3. Important:
    a. Mechanical Engineering
    b. Waste Disposal
    c. ALARA
4. Important - Useful:
    a. Electrical Engineering
    b. Radiation Shielding
    c. Radiation Detection and Measurement
5. Useful:
    a. Radiochemistry
    b. Radiation Biology
    c. Computer Science/Technology
    d. Statistics
    e. Risk Analysis

f. Technical Writing/Communications

g. Supervision

6. Unimportant:

a. Epidemiology

7. Indeterminant:

a. Regulations

b. Systems Engineering

c. Environmental Health Physics

d. Meteorology.

The data in Table X, Perceived Importance of Experience Background for Non-Licensed Training for Reactor Operator License Candidates, indicate the responses to the four types of experience. According to the established criteria for majority opinion (50% or more of the ratings; 75% or more of next two adjacent integrals), the experience backgrounds were rated as follows:

1. Useful:

a. Research Reactor Operation

b. University Reactor Operation

c. U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)

2. Useful - Unimportant:

a. U.S. Navy Nuclear Power Qualified Engineering Laboratory Technician.

TABLE IX

PERCEIVED IMPORTANCE OF SPECIFIC TECHNICAL AREAS OF ENTRY LEVEL STUDY FOR NON-LICENSED TRAINING FOR REACTOR OPERATOR LICENSE CANDIDATES

Area of Study	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unimportant x = 1 %	$\overline{x}$
Atomic/Nuclear Physics	61	39	0	0	3.78
Nuclear Reactor Engineering	28	44	22	6	2.95
Electrical Engineering	5	39	39	17	2.33
Mechanical Engineering	0	56	28	16	2.39
Health Physics	33	44	23	0	3.17
Chemistry	28	33	39	0	3.00
Radiochemistry	11	33	50	6	2.50
Radiation Dosimetry	28	39	28	5	2.89
Radiation Shielding	17	44	39	0	3.00
Radiation Detection and Measurement	28	44	28	0	3.00
Waste Disposal	11	50	28	11	2.61
Radiation Biology	5	28	50	17	2.22
Computer Science/ Technology	0	22	50	28	1.95
Statistics	0	5	56	39	1.67
Risk Analysis	0	0	67	33	1.67
ALARA	33	50	0	17	3.00
Technical Writing/ Communications	22	11	56	11	2.33
Supervision	11	17	61	11	2.22
Regulations	39	33	28	0	3.11

TABLE IX (Continued)

Area of Study	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unim-portant x = 1 %	$\overline{X}$
Systems Engineering	33	39	28	0	3.06
Radiological Emergencies	39	39	11	11	3.06
Environmental Health Physics	22	33	17	28	2.50
Meteorology	5	22	39	34	2.00
Epidemiology	0	5	33	62	1.33

N = 31

TABLE X

PERCEIVED IMPORTANCE OF EXPERIENCE BACKGROUND FOR NON-LICENSED TRAINING FOR REACTOR OPERATOR LICENSE CANDIDATES

Experience Background	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unim-portant x = 1 %	$\overline{X}$
Research Reactor Operation	0	11	61	28	1.78
University Reactor Operation	0	11	56	33	1.72
U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)	0	33	67	0	2.22
U.S. Navy Nuclear Power Qualified Engineering Laboratory Technician	0	22	44	34	1.83

N = 31

The data in Table XI, Perceived Importance of Areas of Entry Level Study for Health Physics Technicians, indicate the responses to the degree of importance of 24 technical areas of study. According to the established criteria for majority opinion (50% or more of the ratings; 75% or more of next two adjacent integrals), the areas of study were rated as follows:

1. Essential:
   a. Health Physics
   b. Radiation Dosimetry
   c. Radiation Shielding
   d. Radiation Detection and Measurement
   e. ALARA
   f. Radiological Emergencies
2. Essential - Important:
   a. Atomic/Nuclear Physics
   b. Radiation Biology
   c. Regulations
3. Important:
   a. Waste Disposal
4. Useful:
   a. Nuclear Reactor Engineering
   b. Electrical Engineering
   c. Technical Writing/communications
   d. Supervision
5. Useful - Unimportant:
   a. Risk Analysis
   b. Epidemiology

6. Unimportant:

   a. Mechanical Engineering

7. Indeterminant:

   a. Chemistry

   b. Radiochemistry

   c. Computer Science/Technology

   d. Statistics

   e. Environmental Health Physics

   f. Meteorology.

The data in Table XII, Perceived Importance of Type of Experience Background for Health Physics Technicians, indicate the responses to the four types of experience. According to the established criteria for majority opinion (50% or more of the ratings; 75% or more of next two adjacent integrals), the experience backgrounds were rated as follows:

1. Important:

   a. U.S. Navy Nuclear Power Qualified Engineering Laboratory Technician

2. Useful:

   a. Research Reactor Operation

   b. University Reactor Operation

   c. U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical).

TABLE XI

PERCEIVED IMPORTANCE OF SPECIFIC AREAS OF ENTRY LEVEL STUDY FOR HEALTH PHYSICS TECHNICIANS

Area of Study	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unim-portant x = 1 %	$\overline{x}$
Atomic/Nuclear Physics	39	39	22	0	2.94
Nuclear Reactor Engineering	0	28	50	22	1.94
Electrical Engineering	0	5	50	45	1.61
Mechanical Engineering	0	5	39	56	1.33
Health Physics	72	28	0	0	3.39
Chemistry	28	33	39	0	2.67
Radiochemistry	33	28	39	0	2.72
Radiation Dosimetry	78	11	11	0	3.39
Radiation Shielding	78	11	11	0	3.39
Radiation Detection and Measurement	78	11	11	0	3.39
Waste Disposal	28	50	22	0	2.83
Radiation Biology	44	39	17	0	3.06
Computer Science/ Technology	0	28	44	28	1.89
Statistics	5	28	44	23	2.06
Risk Analysis	0	22	33	45	1.67
ALARA	50	22	28	0	2.78
Technical Writing/ Communications	22	17	50	11	2.44
Supervision	5	11	56	28	1.83
Regulations	39	39	22	0	2.94

TABLE XI (Continued)

Area of Study	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unimportant x = 1 %	$\bar{x}$
Systems Engineering	11	28	28	0	2.94
Radiological Emergencies	72	11	17	0	3.56
Environmental Health Physics	44	28	28	0	2.94
Meteorology	17	22	44	17	2.28
Epidemiology	0	11	44	45	1.61

N = 31

TABLE XII

PERCEIVED IMPORTANCE OF TYPE OF EXPERIENCE BACKGROUND FOR HEALTH PHYSICS TECHNICIANS

Experience Background	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unimportant x = 1 %	$\bar{x}$
Research Reactor Operation	0	5	56	39	1.56
University Reactor Operation	0	0	61	39	1.61
U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)	0	17	56	27	1.83
U.S. Navy Nuclear Power Qualified Engineering Laboratory Technician	0	56	28	16	2.28

N = 31

The data in Table XIII, Perceived Importance of Specific Areas of Entry Level Study for Chemistry Technicians, indicate the responses to the degree of importance of 24 technical areas of study. According to the established criteria for majority opinion (50% more of the ratings; 75% more of next two adjacent integrals), the areas of study were rated as follows:

1. Essential:
   a. Chemistry
   b. Radiochemistry
2. Important - Useful:
   a. Radiation Detection and Measurement
3. Useful:
   a. Nuclear Reactor Engineering
   b. Electrical Engineering
   c. Radiation Dosimetry
   d. Radiation Shielding
   e. Computer Science/Technology
   f. Technical Writing/Communications
   g. Supervision
   h. Meteorology
4. Useful - Unimportant:
   a. Mechanical Engineering
   b. Epidemiology
6. Unimportant:
   a. Risk Analysis

7. Indeterminant:

    a. Atomic/Nuclear Physics

    b. Health Physics

    c. Waste Disposal

    d. Radiation Biology

    e. ALARA

    f. Regulations

    g. Systems Engineering

    h. Radiological Emergencies

    i. Environmental Health Physics

    j. Statistics.

The data in Table XIV, Perceived Importance of Type of Experience Background for Chemistry Technicians, indicate the responses to the four types of experience. According to the established criteria for majority opinion (50% or more of the ratings; 75% or more of next two adjacent integrals), the experience backgrounds were rated as follows:

1. Useful:

    a. U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)

    b. U.S. Navy Nuclear Power Qualified Engineering Laboratory Technician

2. Useful - Unimportant:

    a. University Reactor Operation

3. Unimportant:

    a. Research Reactor Operation.

TABLE XIII

PERCEIVED IMPORTANCE OF SPECIFIC AREAS OF ENTRY LEVEL STUDY FOR CHEMISTRY TECHNICIANS

Area of Study	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unimportant x = 1 %	$\bar{x}$
Atomic/Nuclear Physics	33	33	34	0	2.78
Nuclear Reactor Engineering	5	11	61	23	1.89
Electrical Engineering	0	0	56	44	1.44
Mechanical Engineering	0	0	50	50	1.50
Health Physics	28	33	28	11	2.78
Chemistry	78	22	0	0	3.44
Radiochemistry	72	28	0	0	3.39
Radiation Dosimetry	11	33	56	0	2.33
Radiation Shielding	11	28	61	0	2.28
Radiation Detection and Measurement	22	33	45	0	2.56
Waste Disposal	11	44	28	17	2.39
Radiation Biology	5	33	39	23	2.11
Computer Science/ Technology	0	22	50	28	1.83
Statistics	5	22	44	29	1.94
Risk Analysis	0	11	39	50	1.50
ALARA	33	33	34	0	2.67
Technical Writing/ Communications	11	17	50	22	2.06
Supervision	0	11	67	22	1.78
Regulations	33	33	34	0	2.67

TABLE XIII (Continued)

Area of Study	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unimportant x = 1 %	$\bar{x}$
Systems Engineering	5	22	39	34	1.89
Radiological Emergencies	33	39	28	0	2.83
Environmental Health Physics	5	39	33	23	2.17
Meteorology	5	0	56	39	1.61
Epidemiology	0	0	50	50	1.50

N = 31

TABLE XIV

PERCEIVED IMPORTANCE OF TYPE OF EXPERIENCE BACKGROUND FOR CHEMISTRY TECHNICIANS

Experience Background	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unimportant x = 1 %	$\bar{X}$
Research Reactor Operation	0	5	44	51	1.44
University Reactor Operation	0	0	50	50	1.50
U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)	0	17	56	27	1.78
U.S. Navy Nuclear Power Qualified Engineering Laboratory Technician	0	28	56	16	2.00

N = 31

The data in Table XV, Perceived Importance of Specific Areas of Entry Level Study for Instrumentation Control Technicians, indicate the responses to the degree of importance of 24 technical areas of study. According to the established criteria for majority opinion (50% or more of ratings, 75% or more of next two adjacent integrals), the areas of study were rated as follows:

1. Important:
   a. Computer Science/Technology
   b. Systems Engineering
2. Useful:
   a. Chemistry
   b. Statistics
   c. Supervision
   d. Environmental Health Physics
3. Useful - Unimportant:
   a. Radiochemistry
   b. Waste Disposal
4. Unimportant:
   a. Risk Analysis
   b. Meteorology
   c. Epidemiology
   d. Radiation Biology
5. Indeterminant:
   a. Atomic/Nuclear Physics
   b. Nuclear Reactor Engineering
   c. Electrical Engineering
   d. Mechanical Engineering

e. Health Physics

f. Radiation Dosimetry

g. Radiation Shielding

h. Radiation Detection and Measurement

i. ALARA

j. Technical Writing/Communications

k. Regulations

l. Radiological Emergencies.

The data in Table XVI, Perceived Importance of Type of Experience Background for Instrumentation Control Technicians, indicate the responses to the four types of experience. According to the established criteria for majority opinion (50% or more of the ratings; 75% or more of next two adjacent integrals), the experience backgrounds were rated as follows:

1. Useful:

   a. U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)

   b. U.S. Navy Nuclear Power Qualified Engineering Laboratory Technician

2. Unimportant:

   a. Research Reactor Operation

   b. University Reactor Operation.

TABLE XV

PERCEIVED IMPORTANCE OF SPECIFIC AREAS OF ENTRY LEVEL STUDY FOR INSTRUMENTATION CONTROL TECHNICIANS

Area of Study	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unimportant x = 1 %	$\overline{X}$
Atomic/Nuclear Physics	5	39	28	28	2.06
Nuclear Reactor Engineering	5	39	33	23	2.11
Electrical Engineering	17	39	28	16	2.44
Mechanical Engineering	5	28	33	34	1.94
Health Physics	0	33	39	28	2.19
Chemistry	0	5	61	34	1.61
Radiochemistry	0	0	50	50	1.50
Radiation Dosimetry	5	33	33	29	2.05
Radiation Shielding	5	28	33	34	1.83
Radiation Detection and Measurement	17	39	22	22	2.69
Waste Disposal	0	0	50	50	1.50
Radiation Biology	0	5	44	51	1.63
Computer Science/ Technology	5	67	17	11	2.67
Statistics	0	11	61	28	1.94
Risk Analysis	0	5	44	51	1.63
ALARA	28	17	33	22	2.69
Technical Writing/ Communications	11	22	44	23	2.38
Supervision	0	5	67	28	1.88
Regulations	28	33	22	17	2.72

TABLE XV (Continued)

Area of Study	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unim-portant x = 1 %	$\bar{x}$
Systems Engineering	5	56	17	22	2.75
Radiological Emergencies	5	22	44	29	2.12
Environmental Health Physics	0	0	56	44	1.63
Meteorology	0	5	44	51	1.63
Epidemiology	0	0	28	72	1.31

N = 31

TABLE XVI

PERCEIVED IMPORTANCE OF EXPERIENCE BACKGROUND
FOR INSTRUMENTATION CONTROL TECHNICIANS

Experience Background	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unimportant x = 1 %	$\bar{x}$
Research Reactor Operation	0	5	44	51	1.63
University Reactor Operation	0	5	44	51	1.63
U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)	0	17	67	16	2.13
U.S. Navy Nuclear Power Qualified Engineering Laboratory Technician	0	22	50	28	2.06

N = 31

Entry Level Orientation and Training

The third research question of this study was "What type of plant-specific orientation and training should the entry level non-licensed operator receive within the first few months of employment at a plant site?" The data in Table XVII, Perceived Importance of Orientation and Training for Non-Licensed Operators-Reactor Operator License Candidates, provide indications of the responses to the degree of importance of 20 orientation/training topics. In accordance with the previously discussed criteria for majority opinion (50% or more of the ratings; 75% or more of next two adjacent integrals), the orientation/training topics were rated as follows:

1. <u>Essential</u>:
   a. Nuclear Plant Technology
   b. Plant System Training
   c. ALARA
   d. General Employee Training
   e. Plant Layout
   f. Administrative Controls and Procedures
   g. Personnel Safety
2. <u>Essential - Important</u>:
   a. Emergency Preparedness Training
   b. Radiological Controls
3. <u>Important - Useful</u>:
   a. Rad/Chem Operations

TABLE XVII

PERCEIVED IMPORTANCE OF ORIENTATION AND TRAINING FOR NON-LICENSED OPERATORS - REACTOR OPERATOR LICENSE CANDIDATES

Orientation and Training Area	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unimportant x = 1 %	$\bar{x}$
Nuclear Plant Technology	50	33	17	0	3.33
Plant System Training	78	22	0	0	3.78
Emergency Preparedness Training	44	33	23	0	3.17
ALARA	56	28	16	0	3.33
Process Effluent Data Acquisition and Analysis	11	17	28	44	1.94
General Employee Training	56	22	11	11	3.22
Plant Layout	72	22	6	0	3.67
Rad/Chem Operations	11	33	44	12	2.44
HP Procedures	17	44	28	11	2.67
Regulations/Site Experience	39	17	22	22	2.72
RAM Packaging and Transportation	0	17	56	27	1.89
Administrative Control and Procedures	50	39	6	5	3.33
Radiological Controls	39	44	11	6	3.17
Radioactive Waste Practices	5	33	56	6	2.39
RO Training	44	17	17	22	2.83
SRO Training	33	17	28	22	2.61

TABLE XVII (Continued)

Orientation and Training Area	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unimportant x = 1 %	$\bar{x}$
Public Relations	0	5	50	45	1.11
Reactor Physics	39	28	22	11	2.94
Surveys and Protection	5	44	28	23	2.33
Personnel Safety	67	28	5	0	3.61

N = 31

4. Useful:

   a. RAM Packaging and Transportation

   b. Radioactive Waste Practices

   c. Public Relations

5. Indeterminant:

   a. Process/Effluent Data Acquisition and Analysis

   b. HP Procedures

   c. RO Training

   d. SRO Training

   e. Reactor Physics

   f. Surveys and Protection

   g. Regulations/Site Experience.

The data in Table XVIII, Perceived Importance of Orientation and Training for Health Physics Technicians, provide indications of the responses to the degree of importance of 20 orientation/training topics. In accordance with the previously discussed criteria for majority opinion (50% or more of the ratings; 75% or more of next two adjacent integrals), the orientation/training topics were rated as follows:

1. Essential:

   a. Emergency Preparedness Training

   b. ALARA

   c. General Employee Training

   d. Plant Layout

   e. Rad/Chem Operations

   f. HP Procedures

   g. RAM Packaging and Transportation

   h. Radiological Controls

i. Radioactive Waste Practices

j. Surveys and Protection

k. Personnel Safety

2. Essential - Important:

a. Administrative Control and Procedures

3. Important:

a. Nuclear Plant Technology

b. Plant System Training

4. Useful:

a. Process/Effluent Data Acquisition and Analysis

b. Reactor Physics

5. Useful - Unimportant:

a. Public Relations

6. Unimportant:

a. RO Training

b. SRO Training

7. Indeterminant:

a. Regulation/Site Experience.

The data in Table XIX, Perceived Importance of Orientation and Training for Chemistry Technicians, provide indications of the responses of the degree of importance of 20 orientation/training topics. In accordance with the previously discussed criteria for majority opinion (50% or more of the ratings; 75% or more of next two adjacent integrals), the orientation/training topics were rated as follows:

1. Essential:

a. Process/Effluent Data Acquisition and Analysis

b. General Employee Training

c. Rad/Chem Operations

d. Public Relations

e. Personnel Safety

2. Essential - Important:

a. Emergency Preparedness Training

b. Plant Layout

3. Important:

a. Nuclear Plant Technology

b. ALARA

c. HP Procedures

4. Unimportant:

a. RO Training

b. SRO Training

c. Reactor Physics

5. Indeterminant:

a. Plant System Training

b. Regulation Site Experience

c. RAM Packaging and Transportation

d. Administrative Control and Procedures

e. Radiological Controls

f. Radioactive Waste Practices

f. Surveys and Protection.

The data in Table XX, Perceived Importance of Orientation and Training for Instrumentation Control Technicians, provide indications of the responses of the degree of importance of 20 orientation/training topics. In accordance with the previously discussed criteria for majority opinion (50% or more of the ratings; 75% or more of next two adjacent integrals), the orientation/training topics were rated as follows:

1. Essential:
   a. General Employee Training
   b. Personnel Safety
2. Essential - Important:
   a. Plant System Training
   b. Plant Layout
3. Important:
   a. Nuclear Plant Technology
   b. Radiological Controls
4. Useful:
   a. Public Relations
   b. Reactor Physics
5. Useful - Unimportant:
   a. Process/Effluent Data Acquisition and Analysis
   b. Rad/Chem Operations
   c. HP Procedures
   d. Radioactive Waste Practices
6. Unimportant:
   a. RAM Packaging and Transportation
   b. RO Training
   c. SRO Training

TABLE XVIII

PERCEIVED IMPORTANCE OF ORIENTATION AND TRAINING FOR HEALTH PHYSICS TECHNICIANS

Orientation and Training Area	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unimportant x = 1 %	$\bar{x}$
Nuclear Plant Technology	5	61	22	12	2.71
Plant System Training	11	56	22	11	2.76
Emergency Preparedness Training	50	28	22	0	3.65
ALARA	78	17	5	0	3.94
Process Effluent Data Acquisition and Analysis	11	39	50	0	2.59
General Employee Training	67	11	22	0	3.59
Plant Layout	61	28	11	0	3.59
Rad/Chem Operations	61	39	0	0	3.69
HP Procedures	78	22	0	0	3.82
Regulations/Site Experience	33	39	23	5	3.06
RAM Packaging and Transportation	56	22	11	11	3.35
Administrative Control and Procedures	44	39	17	0	3.29
Radiological Controls	72	17	11	0	3.71
Radioactive Waste Practices	61	22	17	0	3.53
RO Training	0	0	44	56	1.47
SRO Training	0	0	39	61	1.41

TABLE XVIII (Continued)

Orientation and Training Area	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unimportant x = 1 %	$\bar{x}$
Public Relations	0	17	44	39	1.88
Reactor Physics	5	0	50	45	1.71
Surveys and Protection	61	22	17	0	3.47
Personnel Safety	72	22	6	0	3.88

N = 31

TABLE XIX

PERCEIVED IMPORTANCE OF ORIENTATION AND TRAINING FOR CHEMISTRY TECHNICIANS

Orientation and Training Area	Essential $x = 4$ %	Important $x = 3$ %	Useful $x = 2$ %	Unimportant $x = 1$ %	$\bar{x}$
Nuclear Plant Technology	11	56	22	11	2.77
Plant System Training	22	44	22	12	2.88
Emergency Preparedness Training	39	39	22	0	3.24
ALARA	39	50	11	0	3.35
Process Effluent Data Acquisition and Analysis	50	28	22	0	3.35
General Employee Training	67	5	28	0	3.47
Plant Layout	44	39	17	0	3.35
Rad/Chem Operations	72	28	0	0	3.77
HP Procedures	17	56	27	0	2.94
Regulations/Site Experience	28	39	33	0	2.88
RAM Packaging and Transportation	22	11	39	0	2.59
Administrative Control and Procedures	39	33	11	17	3.24
Radiological Controls	33	39	28	0	3.18
Radioactive Waste Practices	22	44	17	17	2.82
RO Training	0	0	44	56	1.47
SRO Training	0	0	44	56	1.47
Public Relations	72	17	11	0	3.82

TABLE XIX (Continued)

Orientation and Training Area	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unimportant x = 1 %	$\bar{x}$
Reactor Physics	0	5	44	51	1.59
Surveys and Protection	17	39	28	16	2.65
Personnel Safety	72	17	11	0	3.82

N = 31

TABLE XX

PERCEIVED IMPORTANCE OF ORIENTATION AND TRAINING FOR INSTRUMENTATION CONTROL TECHNICIANS

Orientation and Training Area	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unimportant x = 1 %	$\bar{x}$
Nuclear Plant Technology	22	50	14	14	2.71
Plant System Training	39	44	17	0	3.24
Emergency Preparedness Training	28	44	28	0	3.00
ALARA	28	33	39	0	2.82
Process Effluent Data Acquisition and Analysis	17	5	44	34	2.12
General Employee Training	50	17	33	0	3.24
Plant Layout	44	33	11	12	3.11
Rad/Chem Operations	0	17	44	39	1.82
HP Procedures	5	11	44	40	1.88
Regulations/Site Experience	28	22	28	22	2.65
RAM Packaging and Transportation	0	11	33	56	1.59
Administrative Control and Procedures	33	39	11	17	3.05
Radiological Controls	0	56	28	16	2.47
Radioactive Waste Practices	0	0	50	50	1.50
RO Training	0	0	44	56	1.47
SRO Training	0	0	44	56	1.47
Public Relations	0	5	50	45	1.69

TABLE XX (Continued)

Orientation and Training Area	Essential x = 4 %	Important x = 3 %	Useful x = 2 %	Unim- portant x = 1 %	$\overline{x}$
Reactor Physics	0	0	56	44	1.60
Surveys and Protection	0	28	39	33	1.94
Personnel Safety	67	28	5	0	3.61

N = 31

7. <u>Indeterminant</u>:

   a. Emergency Preparedness Training

   b. ALARA

   c. Regulation/Site Experience

   d. Administrative Control and Procedures

   e. Surveys and Protection.

Non-Licensed Operator Level of Experience

The fourth research question of this study was "What level of experience should be required for a non-licensed operator of a commercial nuclear power plant?" Again, the frame of reference was established at an entry level non-licensed operator of a commercial nuclear power plant first entering the job market in 1984 for the questionnaires. The data in Table XXI, Perceived Importance of Minimum Years of Nuclear Power Experience for Entry Level Non-Licensed Operator Training Programs, indicate the responses for the number of years of experience required for entry into the non-licensed operator training programs. The average minimum number of years experience for entry into the Non-Licensed Operator Training Program for Reactor Operator License Candidates was 2.75 years; the Health Physics Technician Training Program was 2.31 years; the Chemistry Technician Training Program was 2.06 years for Chemistry experience and Nuclear Chemistry experience; the Instrumentation Control Technician Training Program was 2.80 years of instrumentation control experience with 1.75 years of nuclear instrumentation control experience.

TABLE XXI

PERCEIVED IMPORTANCE OF MINIMUM YEARS OF NUCLEAR POWER EXPERIENCE FOR ENTRY LEVEL NON-LICENSED OPERATOR TRAINING PROGRAMS

Training Programs	Years Experience 1 x = 4 %	2 x = 3 %	3 x = 2 %	4 x = 1 %	$\overline{x}$
Non-Licensed Training for Reactor Operator License Candidate Experience of Any Type	11	22	45	22	2.75
Health Physics Technician Total Radiation Experience	17	50	22	11	2.31
Chemistry Technician Total Chemistry Experience	22	50	28	0	2.06
Chemistry Technician Total Nuclear Chemistry Experience	45	22	22	11	2.06
Instrumentation Control Technician Total Instrumentation Control Experience	17	11	36	36	2.80
Instrumentation Control Technician Total Nuclear Instrumentation Control Experience	33	56	11	0	1.75

N = 31

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to establish a detailed qualification criteria and training program on a generic basis for the position of the non-licensed operator. This Chapter summarizes the study and presents the conclusions reached. Recommendations for practice and further study were also addressed.

Summary

The specific problem with which this study dealt was the lack of detailed qualification criteria for the non-licensed operators of commercial nuclear power plants. The Delphi Technique was chosen as the method of obtaining convergent opinions from participants without bringing the participants together physically. This methodology was employed to achieve or at least approximate a consensus opinion on specific qualification criteria. The study consisted of a series of three questionnaires each of which built upon the preceding. Each questionnaire provided feedback from the previous questionnaire and gave participants the opportunity to modify their opinions. Several general areas were identified as being most relevant to establishing qualificatechnical areas of study for entry level non-licensed operators, as well as plant-specific orientation and training for such individuals. This study also addressed the minimum number of years of nuclear experience that should be required for entry into the non-licensed operator training programs as well as the types of experience background for entry into the non-licensed operator training programs.

The first of the three questionnaires was mailed to 75 individuals concerned with non-licensed operator training programs, and successive questionnaires were mailed only to respondents of the preceding questionnaire. The overall response rate, that is, the number of individuals who completed all three questionnaires (31) as compared to the total number of individuals who were sent the first questionnaire was 41.3 percent. When participants were given the opportunity to modify their opinions on the third questionnaire, responses were changed an average of 9.8 percent of the time. Of the changes that were made, 100 percent were made either by changing from a minority choice to a majority choice, or from a minority choice to a choice <u>closer</u> to a majority choice. The results were that a majority opinion was attained in 167 out of 250 specific items, a rate of 66.8 percent.

The findings of this study rated each element examined for the non-licensed operator under the categories of General Education Requirements of Degree Types and Degree Level, Specific Technical Areas of Entry Level Study, Type of Experience Background, Orientation and Training, and Minimum Years of Nuclear Power Experience. For a Reactor Operator License Candidate, it was found that a degree in Electrical Engineering and Mechanical Engineering was rated as "desirable" by 50 to 56 percent. Degrees in Physics (61%), Chemistry (67%), and Health Physics -

Radiation Science (72%), and other engineering or engineering technology (67%) were rated as "useful." An Associate's degree was rated as "useful" by 83 percent with a Master's degree rated as "unsatisfactory" by 56 percent. For a Health Physics Technician, it was found that a degree in Health Physics - Radiation Science was rated as "most desirable" by 61 percent. A degree in Chemistry was rated as "desirable" by 67 percent. Degrees in Biology (56%), Nuclear Engineering (61%), Physics (56%), and other engineering or engineering technology (72%) were rated as "useful." An Associate's degree was rated as "useful" by 61 percent with a Master's degree rated as "unsatisfactory" by 62 percent. A Bachelor's degree was rated as "desirable" or "useful" by 44 percent and 33 percent. For a Chemistry Technician, a degree in Chemistry was rated "most desirable" by 61 percent. A degree in Health Physics - Radiation Science was rated as "desirable" by 61 percent. Degrees in Biology (67%), Nuclear Engineering (67%), Physics (61%), and other engineering or engineering technology (67%) were rated as "useful." An Associate's degree and a Master's degree was rated as "useful" by 72 percent and 50 percent. For an Instrumentation Control Technician, degrees in Physics (50%), Nuclear Engineering (56%), and other engineering or engineering technology (67%) were rated as "useful." An Associate's degree and a Bachelor's degree were rated as "useful" by 61 percent and 50 percent. A Master's degree was rated as "unsatisfactory" by 56 percent.

Conclusions

The conclusions drawn from this study were as follows:

1. A majority opinion was achieved on most of the items rated regarding generic qualification criteria for the Non-Licensed Operator of a commercial nuclear power plant.

2. The generic qualification criteria set forth in Appendix E were developed from the findings as a basis for detailed qualification criteria for Non-Licensed Operator of a commercial nuclear power plant.

3. The plant-specific orientation and training for the Non-Licensed Operators set forth in Appendix F were developed from the findings as a basis for detailed training for the Non-Licensed Operator.

4. The Delphi Technique appeared to be a sound methodology for studying qualification criteria for Non-Licensed Operators of a commercial nuclear power plant.

Recommendations

The recommendations developed from this study were as follows:

1. The generic qualification criteria set forth in Appendix E be utilized as resource information for individuals charged with developing qualification criteria for non-licensed operators of a commercial nuclear power plant. Such generic qualification criteria provide a basis for development of detailed criteria meeting the specific needs of individual organizations employing non-licensed operators.

2. Individuals responsible for establishing training and orientation programs for non-licensed operators should consider the training and orientation topics set forth in Appendix F for potential inclusion in their programs. A program with these topics would provide a firm foundation upon which the non-licensed operator could develop and grow.

3. Academic institutions supplying graduates for the nuclear industry should consider the areas of study listed in the curriculum section of Appendix E for inclusion in their curriculums for areas which are not presently offered. Such institutions should also consider periodically using the Delphi Technique as a method of obtaining feedback as to the relevancy of their academic curriculum with respect to the needs of the profession to which they supply graduates.

4. Commercial nuclear power plants should consider utilizing the Delphi Technique as a method of determining the relevance of their Non-Licensed Operator Training Programs with the nuclear industry.

5. Future studies should consider including the opinions of the actual non-licensed operators. The inclusion of non-licensed operator's opinions would provide valuable input into a solid non-licensed operator training program.

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APPENDIXES

APPENDIX A

DELPHI QUESTIONNAIRE I

COMMERCIAL NUCLEAR POWER PLANT TRAINING PROGRAMS EVALUATION FOR NON-LICENSED OPERATORS -- A DELPHI APPROACH

Introduction

This is the first in a series of three (possibly four) questionnaires submitted to you as part of a Delphi study for the evaluation of the training programs at commercial nuclear power plants for non-licensed operators. The Delphi technique has been selected for this study because it provides an intuitive methodology of securing convergent opinion from participants without bringing the participants together physically. This convergent opinion is accomplished through a series of successive questionnaires, each of which builds upon the preceding. The second and each subsequent questionnaire provides feedback from the previous questionnaire and gives participants the opportunity to modify their opinions. Each round of questions is designed to produce more carefully considered group opinions. Participants remain anonymous to each other and this anonymity is an essential part of the process. It protects participant's ideas from being submerged due to psychological or hierarchichal influences, and affords each participant the opportunity to evaluate numerous peer opinions and to privately change his or her mind.

Scope

This study addresses only non-licensed training programs at commercial nuclear power plants. Please do not consider any licensed training programs when answering this or succeeding questionnaires. The evaluation criteria will be considered for individuals involved in the non-licensed training at a commercial nuclear power plant. The study considers only those positions at a commercial nuclear power plant; however, study participants represent all major aspects of the commercial nuclear industry involved in training programs for the non-licensed operator, including consultants, regulatory personnel, and utility site and corporate training managers and coordinators.

DELPHI QUESTIONNAIRE I

Respondent Characteristics

Please answer the following questions, they are to be used only to characterize the sample population in this study:

1. Circle the number that corresponds to your age group:

   (1) Under 30 (2) 30-39 (3) 40-49 (4) 50 plus

2. Indicate your sex by circling the appropriate number:

   (1) Male (2) Female

3. Indicate your highest level of educational attainment by circling the appropriate year (e.g. 0 - high school; 1 - freshman; 2 - sophomore; 5 - graduate study)

   0 1 2 3 4 5 6 over 6

4. Please circle the number that corresponds to the highest degree held.

   (1) H.S. Diploma (2) Associate Degree (3) Bachelors Degree

   (4) Masters Degree (5) Doctoral Degree

5. Number of years experience in training: ____________________

6. Number of years experience in nuclear power non-licensed training:

   ____

Instructions

Please provide your input on the next few pages. Do not concern yourself with the relative importance of individual criteria at this time. You will have opportunities to rate the importance of specific items on subsequent questionnaires. A stamped and addressed envelope has been included for your convenience. A prompt reply would be appreciated and would ensure inclusion of your input into the study.

DELPHI QUESTIONNAIRE I

Respondent's Name: ______________________________ Date: ________

I. GENERAL EDUCATIONAL AND EXPERIENCE REQUIREMENTS (ENTRY LEVEL)

Please enter general educational requirements which you deem necessary or highly desirable for an individual entering non-licensed training in a commercial nuclear power in 1983. Include both degree level(s) (A.S./B.S./M.S.) and degree type(s); also include the experience requirements for the program to be entered (i.e. Health Physics Technician Training, Instrumentation Control Technician Training, Chemistry Technician Training and Non-licensed Training for Reactor Operator License Candidates.) (Engineering/Chemistry/Health Physics/Math/etc.)

Degree level(s): ____

____

Degree type(s): ____

____

Experience Background: __________________________________

____

DELPHI QUESTIONNAIRE I

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY LEVEL)

A listing of potential areas of study and experience are given below. These areas should be considered as educational study at the entry level for non-licensed operators. Please enter additional specific technical areas of study, by topic, which you deem to be either essential, important, or useful (do not rate importance at this time). In addition, please enter the specific experience which you deem to be either essential, important, or useful for non-licensed operators in the various areas of operation of a commercial nuclear power plant.

Areas of Study

Reactor Theory

Health Physics

Atomic/Nuclear Physics

Electrical Engineering

Mechanical Engineering

Radiochemistry

Nuclear Instrumentation

____

____

____

DELPHI QUESTIONNAIRE I

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY LEVEL) (Continued)

Specific Experience

Research Reactor Operation

University Reactor operation

U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical or Mechanical)

U.S. Navy Nuclear Power Qualified Engineering Laboratory Technician

____

____

____

DELPHI QUESTIONNAIRE I

III. PLANT-SPECIFIC ORIENTATION AND TRAINING (ENTRY LEVEL)

A short listing of topics for plant-specific orientation and training are listed below. Please enter additional topics/areas which you deem to be either essential, important, or useful (do not rate importance at this time) for an individual during the first few months of his or her assignment to a commercial nuclear power plant.

Nuclear Power Plant Technology

Plant Systems Training

*On-The-Job Training (OJT)

____

____

____

____

*Please cite specific areas for OJT.

DELPHI QUESTIONNAIRE I

IV. SPECIFIC CRITERIA PRESENTLY UTILIZED FOR INDIVIDUALS ENTERING NON-LICENSED OPERATOR TRAINING PROGRAMS

Please enter the specific criteria presently utilized in your non-licensed training programs for accepting individuals into the various programs.

Non-Licensed Training for Reactor Operator License Candidates:

____

____

Health Physics Technicians:

____

____

Chemistry Technicians:

____

____

DELPHI QUESTIONNAIRE I

IV. SPECIFIC CRITERIA PRESENTLY UTILIZED FOR INDIVIDUALS ENTERING NON-LICENSED OPERATOR TRAINING PROGRAMS (Continued)

Instrumentation Control Technicians:

____

____

DELPHI QUESTIONNAIRE I

V. PRESENT METHOD OF NON-LICENSED OPERATOR TRAINING

Please enter the present method of providing non-licensed operator training at your facility. Please include the strength and weakness of your present method and any future plans for improvement of your programs.

Non-Licensed Training for Reactor Operator License Candidates:

Health Physics Technicians:

Chemistry Technicians:

DELPHI QUESTIONNAIRE I

V. PRESENT METHOD OF NON-LICENSED OPERATOR TRAINING (Continued)

Instrumentation Control Technicians:

____

____

APPENDIX B

NON-LICENSED OPERATOR TRAINING
PANEL OF EXPERTS

Mr. Gene Alden	- Manager, Training Services - Babcock and Wilcox, Nuclear Power Generation Division
Mr. Jim Bates	- Senior Evaluator - Chemistry and Health Physics - Institute of Nuclear Power Operations (INPO)
Mr. Lee Lacey	- Manager of Projects - Quadrex Corporation
Mr. Art Mah	- Training Supervisor - Kansas Gas and Electric - Wolf Creek Generating Station
Mr. Mike Nichols	- Radiation Protection Manager - Kansas Gas and Electric - Wolf Creek Generating Station
Mr. Mike Penovich	- Nuclear Non-Licensed Training Supervisor - Florida Power Corporation - Crystal River Power Station
Mr. C. L. Turner	- Director of Nuclear Training - Texas Utilities Generating Company - Comanche Peak Steam Electric Station

APPENDIX C

DELPHI QUESTIONNAIRE II

Respondent's Name: ______________________________ Date: ________

I. GENERAL EDUCATIONAL REQUIREMENTS (ENTRY-LEVEL)

This section of the questionnaire is concerned with the general educational requirements for the various non-licensed operator training programs. Please rate the desirability of the various degree types and levels as indicated for the various non-licensed operator training programs listed below.

DELPHI QUESTIONNAIRE II

Non-Licensed Training For Reactor Operator License Candidates

1. Please rate the desirability of the degree types listed below by circling the appropriate number to the right of the degree type listed:

	Most Desirable	Desirable	Useful	Unsatis-factory
Nuclear Engineering	4	3	2	1
Electrical Engineering	4	3	2	1
Mechanical Engineering	4	3	2	1
Physics	4	3	2	1
Chemistry	4	3	2	1
Health Physics (Radiation Sciences)	4	3	2	1
Other Engineering or Engineering Technology	4	3	2	1

2. Based on the assumption that the degree types are satisfactory, please rate the importance of the listed below degree levels by circling the appropriate number to the right of the degree level listed:

	Essential	Important	Useful	Unim-portant
Associate Degree	4	3	2	1
Bachelors Degree	4	3	2	1
Masters Degree	4	3	2	1

DELPHI QUESTIONNAIRE II

I. GENERAL EDUCATIONAL REQUIREMENTS (ENTRY-LEVEL)

Health Physics Technician

1. Please rate the desirability of the degree types listed below by circling the appropriate number to the right of the degree type listed:

	Most Desirable	Desirable	Useful	Unsatis-factory
Health Physics (Radiation Sciences)	4	3	2	1
Chemistry	4	3	2	1
Biology	4	3	2	1
Nuclear Engineering	4	3	2	1
Physics	4	3	2	1
Other Engineering or Engineering Technology	4	3	2	1

2. Based on the assumption that the degree types are satisfactory, please rate the importance of the degree levels listed below by circling the appropriate number to the right of the degree level listed:

	Essential	Important	Useful	Unim-portant
Associate Degree	4	3	2	1
Bachelors Degree	4	3	2	1
Masters Degree	4	3	2	1

DELPHI QUESTIONNAIRE II

I. GENERAL EDUCATIONAL REQUIREMENTS (ENTRY-LEVEL)

Chemistry Technician

1. Please rate the desirability of the degree types listed below by circling the appropriate number to the right of the degree type listed:

	Most Desirable	Desirable	Useful	Unsatis-factory
Chemistry	4	3	2	1
Health Physics (Radiation Sciences)	4	3	2	1
Biology	4	3	2	1
Nuclear Engineering	4	3	2	1
Physics	4	3	2	1
Other Engineering or Engineering Technology	4	3	2	1

2. Based on the assumption that the degree types are satisfactory, please rate the importance of the degree levels listed below by circling the appropriate number to the right of the degree level listed:

	Essential	Important	Useful	Unim-portant
Associate Degree	4	3	2	1
Bachelors Degree	4	3	2	1
Masters Degree	4	3	2	1

DELPHI QUESTIONNAIRE II

I. GENERAL EDUCATIONAL REQUIREMENTS (ENTRY-LEVEL)

Instrumentation Control Technician

1. Please rate the desirability of the degree types listed below by circling the appropriate number to the right of the degree type listed:

	Most Desirable	Desirable	Useful	Unsatis- factory
Electrical Engineering	4	3	2	1
Mechanical Engineering	4	3	2	1
Physics	4	3	2	1
Nuclear Engineering	4	3	2	1
Other Engineering or Engineering Technology	4	3	2	1

2. Based on the assumption that the degree types are satisfactory, please rate the importance of the degree levels listed below by circling the appropriate number to the right of the degree level listed:

	Essential	Important	Useful	Unim- portant
Associate Degree	4	3	2	1
Bachelors Degree	4	3	2	1
Masters Degree	4	3	2	1

DELPHI QUESTIONNAIRE II

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

This section of the questionnaire is concerned with the specific technical areas of study and experience for the areas of non-licensed training listed below. Please rate the importance of these areas as indicated below:

Please rate the importance of the listed below plant-specific orientation and training topics by circling the appropriate number to the right of each topic:

Non-Licensed Training for Reactor
Operator License Candidate
Area of Study

	Essential	Important	Useful	Unimportant
Atomic/Nuclear Physics	4	3	2	1
Nuclear Reactor Engineering	4	3	2	1
Electrical Engineering	4	3	2	1
Mechanical Engineering	4	3	2	1
Health Physics	4	3	2	1
Chemistry	4	3	2	1
Radiochemistry	4	3	2	1
Radiation Dosimetry	4	3	2	1
Radiation Shielding	4	3	2	1
Radiation Detection and Measurement	4	3	2	1
Waste Disposal	4	3	2	1
Radiation Biology	4	3	2	1
Computer Science/ Technology	4	3	2	1

(Continued on next page)

DELPHI QUESTIONNAIRE II

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Non-Licensed Training for Reactor Operator License Candidate Area of Study (Continued)

Statistics	4	3	2	1
Risk Analysis	4	3	2	1
ALARA	4	3	2	1
Technical Writing/ Communications	4	3	2	1
Supervision	4	3	2	1
Regulations	4	3	2	1
Systems Engineering	4	3	2	1
Radiological Emergencies	4	3	2	1
Environ. Health Physics	4	3	2	1
Meteorology	4	3	2	1
Epidemiology	4	3	2	1

Non-Licensed Training for Reactor Operator License Candidate Experience Background

	Essential	Important	Useful	Unimportant
Research Reactor Operation	4	3	2	1
University Reactor Operation	4	3	2	1
U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)	4	3	2	1
U.S. Navy Nuclear Power Qualified Engineering Laboratory Technician	4	3	2	1

DELPHI QUESTIONNAIRE II

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Health Physics Technician Area of Study	Essential	Important	Useful	Unim-portant
Atomic/Nuclear Physics	4	3	2	1
Nuclear Reactor Engineering	4	3	2	1
Electrical Engineering	4	3	2	1
Mechanical Engineering	4	3	2	1
Health Physics	4	3	2	1
Chemistry	4	3	2	1
Radiochemistry	4	3	2	1
Radiation Dosimetry	4	3	2	1
Radiation Shielding	4	3	2	1
Radiation Detection and Measurement	4	3	2	1
Waste Disposal	4	3	2	1
Radiation Biology	4	3	2	1
Computer Science/ Technology	4	3	2	1
Statistics	4	3	2	1
Risk Analysis	4	3	2	1
ALARA	4	3	2	1
Technical Writing/ Communications	4	3	2	1
Supervision	4	3	2	1
Regulations	4	3	2	1
Systems Engineering	4	3	2	1

(Continued on next page)

DELPHI QUESTIONNAIRE II

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Health Physics Technician Area of Study (Continued)

Radiological Emergencies	4	3	2	1
Environ. Health Physics	4	3	2	1
Meteorology	4	3	2	1
Epidemiology	4	3	2	1

Health Physics Technician Experience Background

	Essential	Important	Useful	Unim- portant
Research Reactor Operation	4	3	2	1
University Reactor Operation	4	3	2	1
U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)	4	3	2	1
U. S. Navy Nuclear Power Qualified Engineering Laboratory Technician	4	3	2	1

Chemistry Technician Area of Study

	Essential	Important	Useful	Unim- portant
Atomic/Nuclear Physics	4	3	2	1
Nuclear Reactor Engineering	4	3	2	1
Electrical Engineering	4	3	2	1
Mechanical Engineering	4	3	2	1

(Continued on next page)

DELPHI QUESTIONNAIRE II

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Chemistry Technician Area of Study (Continued)

Health Physics	4	3	2	1
Chemistry	4	3	2	1
Radiochemistry	4	3	2	1
Radiation Dosimetry	4	3	2	1
Radiation Shielding	4	3	2	1
Radiation Detection and Measurement	4	3	2	1
Waste Disposal	4	3	2	1
Radiation Biology	4	3	2	1
Computer Science/ Technology	4	3	2	1
Statistics	4	3	2	1
Risk Analysis	4	3	2	1
ALARA	4	3	2	1
Technical Writing/ Communications	4	3	2	1
Supervision	4	3	2	1
Regulations	4	3	2	1
Systems Engineering	4	3	2	1
Radiological Emergencies	4	3	2	1
Environ. Health Physics	4	3	2	1
Meteorology	4	3	2	1
Epidemiology	4	3	2	1

DELPHI QUESTIONNAIRE II

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Chemistry Technician Experience Background

	Essential	Important	Useful	Unim-portant
Research Reactor Operation	4	3	2	1
University Reactor Operation	4	3	2	1
U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)	4	3	2	1
U. S. Navy Nuclear Power Qualified Engineering	4	3	2	1

Instrumentation Control Technician Area of Study

	Essential	Important	Useful	Unim-portant
Atomic/Nuclear Physics	4	3	2	1
Nuclear Reactor Engineering	4	3	2	1
Electrical Engineering	4	3	2	1
Mechanical Engineering	4	3	2	1
Health Physics	4	3	2	1
Chemistry	4	3	2	1
Radiochemistry	4	3	2	1
Radiation Dosimetry	4	3	2	1
Radiation Shielding	4	3	2	1
Radiation Detection and Measurement	4	3	2	1
Waste Disposal	4	3	2	1

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DELPHI QUESTIONNAIRE II

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Instrumentation Control Technician Area of Study (Continued)

Radiation Biology	4	3	2	1
Computer Science/ Technology	4	3	2	1
Statistics	4	3	2	1
Risk Analysis	4	3	2	1
ALARA	4	3	2	1
Technical Writing/ Communications	4	3	2	1
Supervision	4	3	2	1
Regulations	4	3	2	1
Systems Engineering	4	3	2	1
Radiological Emergencies	4	3	2	1
Environ. Health Physics	4	3	2	1
Meteorology	4	3	2	1
Epidemiology	4	3	2	1

Instrumentation Control Technician Experience Background

	Essential	Important	Useful	Unimportant
Research Reactor Operation	4	3	2	1
University Reactor Operation	4	3	2	1
U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)	4	3	2	1
U. S. Navy Nuclear Power Qualified Engineering	4	3	2	1

DELPHI QUESTIONNAIRE II

III. NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY LEVEL)

This section of the Questionnaire is concerned with the nuclear power plant experience, orientation and training for non-licensed operators of a commercial nuclear power plant during the first few months of his or her placement in the following training programs. Please rate the importance of these experience orientation and training topics as listed below:

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1. Please rate the importance of the nuclear power plant orientation and training topics listed below by circling the appropriate number to the right of each topic:

Non-Licensed Training For Reactor Operator License Candidates

	Essential	Important	Useful	Unimportant
Nuclear Plant Technology	4	3	2	1
Plant System Training	4	3	2	1
Emergency Preparedness Training	4	3	2	1
ALARA	4	3	2	1
Process/Effluent Data Acquisition and Analysis	4	3	2	1
General Employee Training	4	3	2	1
Plant Layout	4	3	2	1
Rad/Chem Operations	4	3	2	1
HP Procedures	4	3	2	1

(Continued on next page)

DELPHI QUESTIONNAIRE II

III. NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY-LEVEL)

Non-Licensed Training For Reactor Operator License Candidates (Continued)

Regulation/Site Experience	4	3	2	1
RAM Packaging and Transportation	4	3	2	1
Admin. Control and Procedures	4	3	2	1
Radiological Controls	4	3	2	1
Radioactive Waste Practices	4	3	2	1
RO Training	4	3	2	1
SRO Training	4	3	2	1
Public Relations	4	3	2	1
Reactor Physics	4	3	2	1
Surveys and Protection	4	3	2	1
Personnel Safety	4	3	2	1

Health Physics Technician

	Essential	Important	Useful	Unimportant
Nuclear Plant Technology	4	3	2	1
Plant System Training	4	3	2	1
Emergency Preparedness Training	4	3	2	1
ALARA	4	3	2	1
Process/Effluent Data Acquisition and Analysis	4	3	2	1
General Employee Training	4	3	2	1

(Continued on next page)

DELPHI QUESTIONNAIRE II

III. NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY-LEVEL)

Health Physics Technician (Continued)

Plant Layout	4	3	2	1
Rad/Chem Operations	4	3	2	1
HP Procedures	4	3	2	1
Regulation/Site Experience	4	3	2	1
RAM Packaging and Transportation	4	3	2	1
Admin. Control and Procedures	4	3	2	1
Radiological Controls	4	3	2	1
Radioactive Waste Practices	4	3	2	1
RO Training	4	3	2	1
SRO Training	4	3	2	1
Public Relations	4	3	2	1
Reactor Physics	4	3	2	1
Surveys and Protection	4	3	2	1
Personnel Safety	4	3	2	1

Chemistry Technician

	Essential	Important	Useful	Unimportant
Nuclear Plant Technology	4	3	2	1
Plant System Training	4	3	2	1
Emergency Preparedness Training	4	3	2	1

(Continued on next page)

DELPHI QUESTIONNAIRE II

III. NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY-LEVEL)

Chemistry Technician (Continued)

ALARA	4	3	2	1
Process/Effluent Data Acquisition and Analysis	4	3	2	1
General Employee Training	4	3	2	1
Plant Layout	4	3	2	1
Rad/Chem Operations	4	3	2	1
HP Procedures	4	3	2	1
Regulation/Site Experience	4	3	2	1
RAM Packaging and Transportation	4	3	2	1
Admin. Control and Procedures	4	3	2	1
Radiological Controls	4	3	2	1
Radioactive Waste Practices	4	3	2	1
RO Training	4	3	2	1
SRO Training	4	3	2	1
Public Relations	4	3	2	1
Reactor Physics	4	3	2	1
Surveys and Protection	4	3	2	1
Personnel Safety	4	3	2	1

DELPHI QUESTIONNAIRE II

III. NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY-LEVEL)

Instrumentation Control Technician

	Essential	Important	Useful	Unimportant
Nuclear Plant Technology	4	3	2	1
Plant System Training	4	3	2	1
Emergency Preparedness Training	4	3	2	1
ALARA	4	3	2	1
Process/Effluent Data Acquisition and Analysis	4	3	2	1
General Employee Training	4	3	2	1
Plant Layout	4	3	2	1
Rad/Chem Operations	4	3	2	1
HP Procedures	4	3	2	1
Regulation/Site Experience	4	3	2	1
RAM Packaging and Transportation	4	3	2	1
Admin. Control and Procedures	4	3	2	1
Radiological Controls	4	3	2	1
Radioactive Waste Practices	4	3	2	1
RO Training	4	3	2	1
SRO Training	4	3	2	1
Public Relations	4	3	2	1
Reactor Physics	4	3	2	1
Surveys and Protection	4	3	2	1
Personnel Safety	4	3	2	1

DELPHI QUESTIONNAIRE II

III. NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY-LEVEL)

2. Please circle the number representing the minimum years of nuclear power plant experience that should be required for each listed non-licensed operator training program.

Non-Licensed Training for Reactor Operator License Candidates

Total nuclear reactor operator experience of any type (in years):

1 2 3 4 5

Health Physics Technician

Total radiation protection experience (in years):

1 2 3 4 5

Chemistry Technician

Total chemistry experience (in years):

1 2 3 4 5

Total nuclear chemistry experience (in years):

1 2 3 4 5

Instrumentation Control Technician

Total Instrumentation Control experience (in years):

1 2 3 4 5

Total Nuclear Instrumentation Control experience (in years):

1 2 3 4 5

DELPHI QUESTIONNAIRE II

IV. PRESENT NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY LEVEL)

This section concerns the present nuclear plant experience, orientation and training at your facility. Please rate your present method of training and course content as indicated for the various non-licensed operator training programs listed below. Include in your rating, a brief summation of the direction you have outlined for your training programs and method of attainment.

DELPHI QUESTIONNAIRE II

IV. PRESENT NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY LEVEL)

Non-Licensed Training For Reactor Operator License Candidates

1. Please rate your satisfaction with your training method and course content by circling the number to the right of the topic:

	Highly Satisfactory	Satisfactory	Functional	Unsatisfactory
Training Method	4	3	2	1
Course Content	4	3	2	1
Experience Level	4	3	2	1

2. Please provide a brief summation of your present method of training, course content and experience level of your non-licensed operators.

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3. Please provide a brief summation of the direction you have outlined for your training programs and methods of attainment.

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DELPHI QUESTIONNAIRE II

IV. PRESENT NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION, AND TRAINING (ENTRY-LEVEL)

Health Physics Technician

1. Please rate your satisfaction with your training method and course content by circling the number to the right of the topic:

	Highly Satisfactory	Satisfactory	Func-tional	Unsatis-factory
Training Method	4	3	2	1
Course Content	4	3	2	1
Experience Level	4	3	2	1

2. Please provide a brief summation of your present method of training, course content and experience level of your non-licensed operators.

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3. Please provide a brief summation of the direction you have outlined for your training programs and methods of attainment.

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DELPHI QUESTIONNAIRE II

IV. PRESENT NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION, AND TRAINING (ENTRY-LEVEL)

Chemistry Technician

1. Please rate your satisfaction with your training method and course content by circling the number to the right of the topic:

	Highly Satisfactory	Satisfactory	Func-tional	Unsatis-factory
Training Method	4	3	2	1
Course Content	4	3	2	1
Experience Level	4	3	2	1

2. Please provide a brief summation of your present method of training, course content and experience level of your non-licensed operators.

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3. Please provide a brief summation of the direction you have outlined for your training programs and methods of attainment.

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DELPHI QUESTIONNAIRE II

IV. PRESENT NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION, AND TRAINING (ENTRY-LEVEL)

Instrumentation Control Technician

1. Please rate your satisfaction with your training method and course content by circling the number to the right of the topic:

	Highly Satisfactory	Satisfactory	Functional	Unsatisfactory
Training Method	4	3	2	1
Course Content	4	3	2	1
Experience Level	4	3	2	1

2. Please provide a brief summation of your present method of training, course content and experience level of your non-licensed operators.

3. Please provide a brief summation of the direction you have outlined for your training programs and methods of attainment.

Thank you for your cooperation.

APPENDIX D

COMMERCIAL NUCLEAR POWER PLANT TRAINING PROGRAMS
EVALUATION FOR NON-LICENSED OPERATORS
-- A DELPHI APPROACH

Dear Study Participant:

Response to the second questionnaire was excellent. This will be the last questionnaire in this study. All persons responding to the second and third questionnaires will be informed of the results of the study.

This questionnaire is very similar to the second questionnaire. All questions and categories are essentially the same except that information is provided as to how study participants answered the second questionnaire. Specifically, most questions have four choices, and under each choice you will find the percent of respondents who picked that choice on the second questionnaire. I have indicated the choice you picked on the second questionnaire by placing a red dot over it. In each case, please consider your response on the second questionnaire in light of the responses of your collegues. You may elect to change your choice or not, balancing your own professional judgement with that of your anonymous colleagues.

Instructions

Please carefully consider the next few pages. A stamped and addressed envelope has been included for your convenience. Please try to have your reply in the mail by February 20, 1984. Responses received after February 29, 1984 cannot be considered.

Thank you,

Chuck Kesinger

DELPHI QUESTIONNAIRE III

Respondent's Name: ________________________________ Date: _________

I. GENERAL EDUCATIONAL REQUIREMENTS (ENTRY-LEVEL)

This section of the questionnaire is concerned with the general educational requirements for the various non-licensed operator training programs. Please rate the desirability of the various degree types and levels as indicated for the various non-licensed operator training programs listed below. (Your previous choice is indicated by a red dot over it. The previous choices of all respondents are indicated by percentages under them).

DELPHI QUESTIONNAIRE III

Non-Licensed Training For Reactor Operator License Candidates

1. Please rate the desirability of the degree types listed below by circling the appropriate number to the right of the degree type listed:

	Most Desirable	Desirable	Useful	Unsatis-factory
Nuclear Engineering	4 22%	3 33%	2 28%	1 17%
Electrical Engineering	4 6%	3 50%	2 28%	1 16%
Mechanical Engineering	4 6%	3 56%	2 28%	1 10%
Physics	4 0%	3 28%	2 61%	1 11%
Chemistry	4 0%	3 17%	2 67%	1 16%
Health Physics (Radiation Sciences)	4 0%	3 11%	2 72%	1 17%
Other Engineering or Engineering Technology	4 0%	3 22%	2 67%	1 11%

2. Based on the assumption that the degree types are satisfactory, please rate the importance of the degree levels listed below by circling the appropriate number to the right of the degree level listed:

	Essential	Important	Useful	Unim-portant
Associate Degree	4 6%	3 0%	2 83%	1 11%
Bachelors Degree	4 6%	3 28%	2 44%	1 22%
Masters Degree	4 0%	3 11%	2 33%	1 56%

DELPHI QUESTIONNAIRE III

I. GENERAL EDUCATIONAL REQUIREMENTS (ENTRY-LEVEL)

Health Physics Technician

1. Please rate the desirability of the degree types listed below by circling the appropriate number to the right of the degree type listed:

	Most Desirable	Desirable	Useful	Unsatis-factory
Health Physics (Radiation Sciences)	4 61%	3 17%	2 22%	1 0%
Chemistry	4 0%	3 67%	2 28%	1 5%
Biology	4 0%	3 28%	2 56%	1 16%
Nuclear Engineering	4 0%	3 22%	2 61%	1 17%
Physics	4 0%	3 28%	2 56%	1 16%
Other Engineering or Engineering Technology	4 0%	3 17%	2 72%	1 11%

2. Based on the assumption that the degree types are satisfactory, please rate the importance of the degree levels listed below by circling the appropriate number to the right of the degree level listed:

	Essential	Important	Useful	Unim-portant
Associate Degree	4 11%	3 22%	2 61%	1 6%
Bachelors Degree	4 0%	3 44%	2 33%	1 23%
Masters Degree	4 0%	3 5%	2 33%	1 62%

DELPHI QUESTIONNAIRE III

I. GENERAL EDUCATIONAL REQUIREMENTS (ENTRY-LEVEL)

Chemistry Technician

1. Please rate the desirability of the degree types listed below by circling the appropriate number to the right of the degree type listed:

	Most Desirable	Desirable	Useful	Unsatis-factory
Chemistry	4 61%	3 17%	2 22%	1 0%
Health Physics (Radiation Sciences)	4 0%	3 61%	2 39%	1 0%
Biology	4 0%	3 17%	2 67%	1 16%
Nuclear Engineering	4 0%	3 17%	2 67%	1 16%
Physics	4 0%	3 17%	2 61%	1 22%
Other Engineering or Engineering Technology	4 0%	3 11%	2 67%	1 22%

2. Based on the assumption that the degree types are satisfactory, please rate the importance of the degree levels listed below by circling the appropriate number to the right of the degree level listed:

	Essential	Important	Useful	Unim-portant
Associate Degree	4 17%	3 5%	2 72%	1 6%
Bachelors Degree	4 11%	3 44%	2 28%	1 17%
Masters Degree	4 0%	3 5%	2 50%	1 45%

DELPHI QUESTIONNAIRE III

I. GENERAL EDUCATIONAL REQUIREMENTS (ENTRY-LEVEL)

Instrumentation Control Technician

1. Please rate the desirability of the degree types listed below by circling the appropriate number to the right of the degree type listed:

	Most Desirable	Desirable	Useful	Unsatis-factory
Electrical Engineering	4 33%	3 22%	2 39%	1 6%
Mechanical Engineering	4 0%	3 44%	2 28%	1 28%
Physics	4 0%	3 28%	2 50%	1 22%
Nuclear Engineering	4 0%	3 28%	2 56%	1 16%
Other Engineering or Engineering Technology	4 5%	3 17%	2 67%	1 11%

2. Based on the assumption that the degree types are satisfactory, please rate the importance of the degree levels listed below by circling the appropriate number to the right of the degree level listed:

	Essential	Important	Useful	Unim-portant
Associate Degree	4 22%	3 11%	2 61%	1 6%
Bachelors Degree	4 11%	3 17%	2 50%	1 22%
Masters Degree	4 0%	3 11%	2 33%	1 56%

DELPHI QUESTIONNAIRE III

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

This section of the questionnaire is concerned with the specific technical areas of study and experience for the areas of non-licensed training listed below. Please rate the importance of these areas as indicated below. (Your previous choice is indicated by a red dot over it. The previous choices of all respondents are indicated by percentages under them):

Please rate the importance of the listed below plant-specific orientation and training topics by circling the appropriate number to the right of each topic:

Non-Licensed Training for Reactor Operator License Candidate
Area of Study

	Essential	Important	Useful	Unimportant
Atomic/Nuclear Physics	4 61%	3 39%	2 0%	1 0%
Nuclear Reactor Engineering	4 28%	3 44%	2 22%	1 6%
Electrical Engineering	4 5%	3 39%	2 39%	1 17%
Mechanical Engineering	4 0%	3 56%	2 28%	1 16%
Health Physics	4 33%	3 44%	2 23%	1 0%
Chemistry	4 28%	3 33%	2 39%	1 0%
Radiochemistry	4 11%	3 33%	2 50%	1 6%
Radiation Dosimetry	4 28%	3 39%	2 28%	1 5%

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DELPHI QUESTIONNAIRE III

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Non-Licensed Training for Reactor Operator License Candidate Area of Study (Continued)

Radiation Shielding	4 17%	3 44%	2 39%	1 0%
Radiation Detection and Measurement	4 28%	3 44%	2 28%	1 0%
Waste Disposal	4 11%	3 50%	2 28%	1 11%
Radiation Biology	4 5%	3 28%	2 50%	1 17%
Computer Science/ Technology	4 0%	3 22%	2 50%	1 28%
Statistics	4 0%	3 5%	2 56%	1 39%
Risk Analysis	4 0%	3 0%	2 67%	1 33%
ALARA	4 33%	3 50%	2 0%	1 17%
Technical Writing/ Communications	4 22%	3 11%	2 56%	1 11%
Supervision	4 11%	3 17%	2 61%	1 11%
Regulations	4 39%	3 33%	2 28%	1 0%
Systems Engineering	4 33%	3 39%	2 28%	1 0%
Radiological Emergencies	4 39%	3 39%	2 11%	1 11%
Environ. Health Physics	4 22%	3 33%	2 17%	1 28%

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DELPHI QUESTIONNAIRE III

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Non-Licensed Training for Reactor Operator License Candidate Area of Study (Continued)

Meteorology	4 5%	3 22%	2 39%	1 34%
Epidemiology	4 0%	3 5%	2 33%	1 62%

Non-Licensed Training for Reactor Operator License Candidate Experience Background

	Essential	Important	Useful	Unim-portant
Research Reactor Operation	4 0%	3 11%	2 61%	1 28%
University Reactor Operation	4 0%	3 11%	2 56%	1 33%
U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)	4 0%	3 33%	2 67%	1 0%
U.S. Navy Nuclear Power Qualified Engineering Laboratory Technician	4 0%	3 22%	2 44%	1 34%

DELPHI QUESTIONNAIRE III

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Health Physics Technician
Area of Study

	Essential	Important	Useful	Unim-portant
Atomic/Nuclear Physics	4 39%	3 39%	2 22%	1 0%
Nuclear Reactor Engineering	4 0%	3 28%	2 50%	1 22%
Electrical Engineering	4 0%	3 5%	2 50%	1 45%
Mechanical Engineering	4 0%	3 5%	2 39%	1 56%
Health Physics	4 72%	3 28%	2 0%	1 0%
Chemistry	4 28%	3 33%	2 39%	1 0%
Radiochemistry	4 33%	3 28%	2 39%	1 0%
Radiation Dosimetry	4 78%	3 11%	2 11%	1 0%
Radiation Shielding	4 78%	3 11%	2 11%	1 0%
Radiation Detection and Measurement	4 78%	3 11%	2 11%	1 0%
Waste Disposal	4 28%	3 50%	2 22%	1 0%
Radiation Biology	4 44%	3 39%	2 17%	1 0%
Computer Science/ Technology	4 0%	3 28%	2 44%	1 28%
Statistics	4 5%	3 28%	2 44%	1 23%

(Continued on next page)

DELPHI QUESTIONNAIRE III

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Health Physics Technician Area of Study (Continued)

Risk Analysis	4 0%	3 22%	2 33%	1 45%
ALARA	4 50%	3 22%	2 28%	1 0%
Technical Writing/ Communications	4 22%	3 17%	2 50%	1 11%
Supervision	4 5%	3 11%	2 56%	1 28%
Regulations	4 39%	3 39%	2 22%	1 0%
Systems Engineering	4 11%	3 28%	2 33%	1 28%
Radiological Emergencies	4 72%	3 11%	2 17%	1 0%
Environ. Health Physics	4 44%	3 28%	2 28%	1 0%
Meteorology	4 17%	3 22%	2 44%	1 17%
Epidemiology	4 0%	3 11%	2 44%	1 45%

Health Physics Technician Experience Background

	Essential	Important	Useful	Unim- portant
Research Reactor Operation	4 0%	3 5%	2 56%	1 39%
University Reactor Operation	4 0%	3 0%	2 61%	1 39%

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DELPHI QUESTIONNAIRE III

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Health Physics Technician Experience Background (Continued)

U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)	4 0%	3 17%	2 56%	1 27%
U. S. Navy Nuclear Power Qualified Engineering Laboratory Technician	4 0%	3 56%	2 28%	1 16%

Chemistry Technician Area of Study

	Essential	Important	Useful	Unim-portant
Atomic/Nuclear Physics	4 33%	3 33%	2 34%	1 0%
Nuclear Reactor Engineering	4 5%	3 11%	2 61%	1 23%
Electrical Engineering	4 0%	3 0%	2 56%	1 44%
Mechanical Engineering	4 0%	3 0%	2 50%	1 50%
Health Physics	4 28%	3 33%	2 28%	1 11%
Chemistry	4 78%	3 22%	2 0%	1 0%
Radiochemistry	4 72%	3 28%	2 0%	1 0%
Radiation Dosimetry	4 11%	3 33%	2 56%	1 0%
Radiation Shielding	4 11%	3 28%	2 61%	1 0%

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DELPHI QUESTIONNAIRE III

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Chemistry Technician Area of Study (Continued)

Area of Study	4	3	2	1
Radiation Detection and Measurement	22%	33%	45%	0%
Waste Disposal	11%	44%	28%	17%
Radiation Biology	5%	33%	39%	23%
Computer Science/ Technology	0%	22%	50%	28%
Statistics	5%	22%	44%	29%
Risk Analysis	0%	11%	39%	50%
ALARA	33%	33%	34%	0%
Technical Writing/ Communications	11%	17%	50%	22%
Supervision	0%	11%	67%	22%
Regulations	33%	33%	34%	0%
Systems Engineering	5%	22%	39%	34%
Radiological Emergencies	33%	39%	28%	0%
Environ. Health Physics	5%	39%	33%	23%
Meteorology	5%	0%	56%	39%
Epidemiology	0%	0%	50%	50%

DELPHI QUESTIONNAIRE III

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Chemistry Technician Experience Background

	Essential	Important	Useful	Unim-portant
Research Reactor Operation	4 0%	3 5%	2 44%	1 51%
University Reactor Operation	4 0%	3 0%	2 50%	1 50%
U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)	4 0%	3 17%	2 56%	1 27%
U. S. Navy Nuclear Power Qualified Engineering Laboratory Technician	4 0%	3 28%	2 56%	1 16%

Instrumentation Control Technician Area of Study

	Essential	Important	Useful	Unim-portant
Atomic/Nuclear Physics	4 5%	3 39%	2 28%	1 28%
Nuclear Reactor Engineering	4 5%	3 39%	2 33%	1 23%
Electrical Engineering	4 17%	3 39%	2 28%	1 16%
Mechanical Engineering	4 5%	3 28%	2 33%	1 34%
Health Physics	4 0%	3 33%	2 39%	1 28%
Chemistry	4 0%	3 5%	2 61%	1 34%
Radiochemistry	4 0%	3 0%	2 50%	1 50%

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DELPHI QUESTIONNAIRE III

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Instrumentation Control Technician Area of Study (Continued)

Area of Study	4	3	2	1
Radiation Dosimetry	5%	33%	33%	29%
Radiation Shielding	5%	28%	33%	34%
Radiation Detection and Measurement	17%	39%	22%	22%
Waste Disposal	0%	0%	50%	50%
Radiation Biology	0%	5%	44%	51%
Computer Science/ Technology	5%	67%	17%	11%
Statistics	0%	11%	61%	28%
Risk Analysis	0%	5%	44%	51%
ALARA	28%	17%	33%	22%
Technical Writing/ Communications	11%	22%	44%	23%
Supervision	0%	5%	67%	28%
Regulations	28%	33%	22%	17%
Systems Engineering	5%	56%	17%	22%
Radiological Emergencies	5%	22%	44%	29%
Environ. Health Physics	0%	0%	56%	44%

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DELPHI QUESTIONNAIRE III

II. SPECIFIC TECHNICAL AREAS OF STUDY AND EXPERIENCE (ENTRY-LEVEL)

Instrumentation Control Technician Area of Study (Continued)

Meteorology	4 0%	3 5%	2 44%	1 51%
Epidemiology	4 0%	3 0%	2 28%	1 72%

Instrumentation Control Technician Experience Background

	Essential	Important	Useful	Unim-portant
Research Reactor Operation	4 0%	3 5%	2 44%	1 51%
University Reactor Operation	4 0%	3 5%	2 44%	1 51%
U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)	4 0%	3 17%	2 67%	1 16%
U. S. Navy Nuclear Power Qualified Engineering Laboratory Technician	4 0%	3 22%	2 50%	1 28%

DELPHI QUESTIONNAIRE III

III. NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY LEVEL)

This section of the Questionnaire is concerned with the nuclear power plant experience, orientation and training for non-licensed operators of a commercial nuclear power plant during the first few months of his or her placement in the following training programs. Please rate the importance of these experience orientation and training topics as listed below. (Your previous choice is indicated by a red dot over it. The previous choices of all respondents are indicated by percentages under them):

1. Please rate the importance of the nuclear power plant orientation and training topics listed below by circling the appropriate number to the right of each topic:

Non-Licensed Training For Reactor Operator License Candidates

	Essential	Important	Useful	Unim- portant
Nuclear Plant Technology	4 50%	3 33%	2 17%	1 0%
Plant System Training	4 78%	3 22%	2 0%	1 0%
Emergency Preparedness Training	4 44%	3 33%	2 23%	1 0%
ALARA	4 56%	3 28%	2 16%	1 0%
Process/Effluent Data Acquisition and Analysis	4 11%	3 17%	2 28%	1 44%

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DELPHI QUESTIONNAIRE III

III. NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY-LEVEL)

Non-Licensed Training For Reactor Operator License Candidates (Continued)

General Employee Training	4 56%	3 22%	2 11%	1 11%
Plant Layout	4 72%	3 22%	2 6%	1 0%
Rad/Chem Operations	4 11%	3 33%	2 44%	1 12%
HP Procedures	4 17%	3 44%	2 28%	1 11%
Regulation/Site Experience	4 39%	3 17%	2 22%	1 22%
RAM Packaging and Transportation	4 0%	3 17%	2 56%	1 27%
Admin. Control and Procedures	4 50%	3 39%	2 6%	1 5%
Radiological Controls	4 39%	3 44%	2 11%	1 6%
Radioactive Waste Practices	4 5%	3 33%	2 56%	1 6%
RO Training	4 44%	3 17%	2 17%	1 22%
SRO Training	4 33%	3 17%	2 28%	1 22%
Public Relations	4 0%	3 5%	2 50%	1 45%
Reactor Physics	4 39%	3 28%	2 22%	1 11%
Surveys and Protection	4 5%	3 44%	2 28%	1 23%
Personnel Safety	4 67%	3 28%	2 5%	1 0%

DELPHI QUESTIONNAIRE III

III. NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY-LEVEL)

Health Physics Technician

	Essential	Important	Useful	Unimportant
Nuclear Plant Technology	4 5%	3 61%	2 22%	1 12%
Plant System Training	4 11%	3 56%	2 22%	1 11%
Emergency Preparedness Training	4 50%	3 28%	2 22%	1 0%
ALARA	4 78%	3 17%	2 5%	1 0%
Process/Effluent Data Acquisition and Analysis	4 11%	3 39%	2 50%	1 0%
General Employee Training	4 67%	3 11%	2 22%	1 0%
Plant Layout	4 61%	3 28%	2 11%	1 0%
Rad/Chem Operations	4 61%	3 39%	2 0%	1 0%
HP Procedures	4 78%	3 22%	2 0%	1 0%
Regulation/Site Experience	4 33%	3 39%	2 23%	1 5%
RAM Packaging and Transportation	4 56%	3 22%	2 11%	1 11%
Admin. Control and Procedures	4 44%	3 39%	2 17%	1 0%

(Continued on next page)

DELPHI QUESTIONNAIRE III

III. NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY-LEVEL)

Health Physics Technician (Continued)

Radiological Controls	4 72%	3 17%	2 11%	1 0%
Radioactive Waste Practices	4 61%	3 22%	2 17%	1 0%
RO Training	4 0%	3 0%	2 44%	1 56%
SRO Training	4 0%	3 0%	2 39%	1 61%
Public Relations	4 0%	3 17%	2 44%	1 39%
Reactor Physics	4 5%	3 0%	2 50%	1 45%
Surveys and Protection	4 61%	3 22%	2 17%	1 0%
Personnel Safety	4 72%	3 22%	2 6%	1 0%

Chemistry Technician

	Essential	Important	Useful	Unim-portant
Nuclear Plant Technology	4 11%	3 56%	2 22%	1 11%
Plant System Training	4 22%	3 44%	2 22%	1 12%
Emergency Preparedness Training	4 39%	3 39%	2 22%	1 0%

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DELPHI QUESTIONNAIRE III

III. NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY-LEVEL)

Chemistry Technician (Continued)

	4	3	2	1
ALARA	39%	50%	11%	0%
Process/Effluent Data Acquisition and Analysis	50%	28%	22%	0%
General Employee Training	67%	5%	28%	0%
Plant Layout	44%	39%	17%	0%
Rad/Chem Operations	72%	28%	0%	0%
HP Procedures	17%	56%	27%	0%
Regulation/Site Experience	28%	39%	33%	0%
RAM Packaging and Transportation	22%	11%	39%	0%
Admin. Control and Procedures	39%	33%	11%	17%
Radiological Controls	33%	39%	28%	0%
Radioactive Waste Practices	22%	44%	17%	17%
RO Training	0%	0%	44%	56%
SRO Training	0%	0%	44%	56%
Public Relations	72%	17%	11%	0%

(Continued on next page)

DELPHI QUESTIONNAIRE III

III. NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY-LEVEL)

Chemistry Technician (Continued)

Reactor Physics	4 0%	3 5%	2 44%	1 51%
Surveys and Protection	4 17%	3 39%	2 28%	1 16%
Personnel Safety	4 72%	3 17%	2 11%	1 0%

Instrumentation Control Technician

	Essential	Important	Useful	Unimportant
Nuclear Plant Technology	4 22%	3 50%	2 14%	1 14%
Plant System Training	4 39%	3 44%	2 17%	1 0%
Emergency Preparedness Training	4 28%	3 44%	2 28%	1 0%
ALARA	4 28%	3 33%	2 39%	1 0%
Process/Effluent Data Acquisition and Analysis	4 17%	3 5%	2 44%	1 34%
General Employee Training	4 50%	3 17%	2 33%	1 0%
Plant Layout	4 44%	3 33%	2 11%	1 12%
Rad/Chem Operations	4 0%	3 17%	2 44%	1 39%
HP Procedures	4 5%	3 11%	2 44%	1 40%

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DELPHI QUESTIONNAIRE III

III. NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY-LEVEL)

2. Please circle the number representing the minimum years of nuclear power plant experience that should be required for each listed non-licensed operator training program.

Non-Licensed Training for Reactor Operator License Candidates

Total nuclear reactor operator experience of any type (in years):

1	2	3	4	5
11%	22%	45%	22%	0%

Health Physics Technician

Total radiation protection experience (in years):

1	2	3	4	5
17%	50%	22%	11%	0%

Chemistry Technician

Total chemistry experience (in years):

1	2	3	4	5
22%	50%	28%	0%	0%

Total nuclear chemistry experience (in years):

1	2	3	4	5
45%	22%	22%	11%	0%

Instrumentation Control Technician

Total Instrumentation Control experience (in years):

1	2	3	4	5
17%	11%	36%	36%	0%

Total Nuclear Instrumentation Control experience (in years):

1	2	3	4	5
33%	56%	11%	0%	0%

DELPHI QUESTIONNAIRE III

IV. PRESENT NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY LEVEL)

This section concerns the present nuclear plant experience, orientation and training at your facility. Please rate your present method of training and course content as indicated for the various non-licensed operator training programs listed below. Include in your rating, a brief summation of the direction you have outlined for your training programs and method of attainment. (Your previous choice is indicated by a red dot over it. The previous choices of all respondents are indicated by percentages under them).

DELPHI QUESTIONNAIRE III

IV. PRESENT NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY LEVEL)

Non-Licensed Training For Reactor Operator License Candidates

1. Please rate your satisfaction with your training method and course content by circling the number to the right of the topic:

	Highly Satisfactory	Satisfactory	Functional	Unsatisfactory
Training Method	4 33%	3 57%	2 5%	1 5%
Course Content	4 28%	3 62%	2 5%	1 5%
Experience Level	4 11%	3 50%	2 39%	1 0%

Health Physics Technician

1. Please rate your satisfaction with your training method and course content by circling the number to the right of the topic:

	Highly Satisfactory	Satisfactory	Functional	Unsatisfactory
Training Method	4 33%	3 57%	2 5%	1 5%
Course Content	4 22%	3 68%	2 5%	1 5%
Experience Level	4 22%	3 51%	2 22%	1 5%

DELPHI QUESTIONNAIRE III

IV. PRESENT NUCLEAR POWER PLANT EXPERIENCE, ORIENTATION AND TRAINING (ENTRY LEVEL)

Chemistry Technician

1. Please rate your satisfaction with your training method and course content by circling the number to the right of the topic:

	Highly Satisfactory	Satisfactory	Functional	Unsatisfactory
Training Method	4 22%	3 56%	2 11%	1 11%
Course Content	4 5%	3 73%	2 11%	1 11%
Experience Level	4 11%	3 56%	2 28%	1 5%

Instrumentation Control Technician

1. Please rate your satisfaction with your training method and course content by circling the number to the right of the topic:

	Highly Satisfactory	Satisfactory	Functional	Unsatisfactory
Training Method	4 22%	3 73%	2 5%	1 0%
Course Content	4 17%	3 78%	2 5%	1 0%
Experience Level	4 22%	3 50%	2 28%	1 0%

Thank you for your cooperation.

APPENDIX E

GENERIC QUALIFICATION CRITERIA FOR THE NON-LICENSED OPERATOR

The following criteria should be followed in placing personnel in Non-Licensed Operator Training Program/Positions of a commercial nuclear power plant:

1. Degree Criteria - Reactor Operator License Candidates

    1.1 Candidates shall have an Associate's Degree, a Bachelor's Degree or equivalent experience.

    1.2 Degrees in engineering or engineering technology are preferred. Degrees in Physics, Chemistry, and Health Physics - Radiation Science are acceptable.

2. Curriculum Guidelines - Reactor Operator License Candidate

The following technical areas of study are considered to be relevant to the technical competence of a Reactor Operator License Candidate, and most should be in existence on the candidate's transcript. They are presented in order of importance, most important first:

1. Atomic/Nuclear Physics
2. Health Physics
3. Radiological Emergencies
4. Mechanical Engineering
5. Waste Disposal
6. ALARA

7. Electrical Engineering
8. Radiation Shielding
9. Radiation Detection and Measurement
10. Risk Analysis
11. Technical Writing/Communications
12. Supervision.

3. Degree Criteria - Health Physics Technician

3.1 Candidates shall have an Associate's Degree, a Bachelor's Degree or equivalent experience.

3.2 A degree in Health Physics - Radiation Science or Chemistry is preferred. Degrees in Biology, Nuclear Engineering or Physics are acceptable.

4. Curriculum Guidelines - Health Physics Technician

The following technical areas of study are considered to be relevant to the technical competence of a Health Physics Technician, and most should be in existence on the candidate's transcript. They are presented in order of importance, most important first:

1. Health Physics
2. Radiation Dosimetry
3. Radiation Shielding
4. Radiation Detection and Measurement
5. ALARA
6. Radiological Emergencies
7. Atomic/Nuclear Physics
8. Radiation Biology
9. Regulations
10. Waste Disposal
11. Nuclear Reactor Engineering

12. Electrical Engineering
13. Technical Writing/Communications
14. Supervision.

5. Degree Criteria - Chemistry Technician

5.1 Candidates shall have an Associate's Degree, a Bachelor's Degree or equivalent experience. A Master's degree will be given special consideration.

5.2 A degree in Chemistry or Health Physics - Radiation Science is preferred. Degrees in Biology, Nuclear Engineering or Physics are acceptable.

6. Curriculum Guidelines - Chemistry Technician

The following technical areas of study are considered to be relevant to the technical competence of a Chemistry Technician, and most should be in existence on the candidate's transcript. They are presented in order of importance, most important first:

1. Chemistry
2. Radiochemistry
3. Radiation Detection and Measurement
4. Nuclear Reactor Engineering
5. Electrical Engineering
6. Radiation Dosimetry
7. Radiation Shielding
8. Computer Science/Technology
9. Technical Writing/Communications
10. Supervision
11. Meteorology.

7. Degree Criteria - Instrumentation Control Technician

   7.1 Candidates shall have an Associate's Degree or a Bachelor's Degree.

   7.2 Degrees in Physics, Nuclear Engineering or other engineering or engineering technology are acceptable.

8. Curriculum Guidelines - Instrumentation Control Technician

The following technical areas of study are considered to be relevant to the technical competence of a Instrumentation Control Technician, and most should be in existence on the candidate's transcript. They are presented in order of importance, most important first:

1. Computer Science/Technology
2. Systems Engineering
3. Chemistry
4. Statistics
5. Supervision
6. Environmental Health Physics.

9. Experience Background

The experience background for each non-licensed operator position are listed as follows with the most important type of experience background first:

   9.1 Reactor Operator License Candidates

      a. U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)

      b. Research Reactor Operation

      c. University Reactor Operation.

9.2 Health Physics Technician

a. U.S. Nuclear Power Qualified Engineering Laboratory Technician

b. University Reactor Operation

c. Research Reactor Operation/U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical).

9.3 Chemistry Technician

a. U.S. Nuclear Power Qualified Engineering Laboratory Technician/U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical).

9.4 Instrumentation Control Technician

a. U.S. Navy Nuclear Power Qualified Operator (Reactor, Electrical, Mechanical)/U.S. Nuclear Power Qualified Engineering Laboratory Technician.

10. Nuclear Experience Level in Years

10.1 Reactor Operation License Candidates - 2.5 to 3.0 years.

10.2 Health Physics Technicians - 2.0 to 2.5 years.

10.3 Chemistry Technicians - 2.0 to 2.5 years in Chemistry and Nuclear Chemistry.

10.4 Instrumentation Control Technician - 2.5 to 3.0 years in instrumentation control with 1.5 to 2.0 years in nuclear instrumentation control.

APPENDIX F

PLANT-SPECIFIC ORIENTATION AND TRAINING FOR ENTRY LEVEL NON-LICENSED OPERATORS

During the first few months of his or her initial assignment to a commercial nuclear power plant, the entry level non-licensed operator should receive plant-specific orientation and training commensurate with the skill and knowledge factors required. The following orientation/training topics for each non-licensed operator position should be considered for this period. They are listed generally in order of importance for each non-licensed operator position, most important first:

Reactor Operator License Candidates

1. Nuclear Plant Technology
2. Plant System Training
3. ALARA
4. General Employee Training
5. Plant Layout
6. Administrative Controls and Procedures
7. Personnel Safety
8. Emergency Preparedness Training
9. Radiological Controls
10. Rad/Chem Operations
11. RAM Packaging and Transportation
12. Radioactive Waste Practices
13. Public Relations

<u>Health Physics Technician</u>

1. Emergency Preparedness Training
2. ALARA
3. General Employee Training
4. Plant Layout
5. Rad/Chem Operations
6. HP Procedures
7. RAM Packaging and Transportation
8. Radiological Controls
9. Radioactive Waste Practices
10. Surveys and Protection
11. Personnel Safety
12. Administrative Controls and Procedures
13. Nuclear Plant Technology
14. Plant System Training
15. Process/Effluent Data Acquisition and Analysis
16. Reactor Physics

<u>Chemistry Technician</u>

1. Process/Effluent Data Acquisition and Analysis
2. General Employee Training
3. Rad/Chem Operations
4. Public Relations
5. Personnel Safety
6. Emergency Preparedness Training
7. Plant Layout
8. Nuclear Plant Technology
9. ALARA
10. HP Procedures

Instrumentation Control Technician

1. General Employee Training
2. Personnel Safety
3. Plant System Training
4. Plant Layout
5. Nuclear Plant Technology
6. Radiological Controls
7. Public Relations
8. Reactor Physics

VITA 2

Charles Frederick Kesinger, Jr.

Candidate for the Degree of

Master of Science

Thesis: COMMERCIAL NUCLEAR POWER PLANT TRAINING PROGRAMS EVALUATION FOR NON-LICENSED OPERATORS: A DELPHI APPROACH

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Personal Data: Born in Lawrence, Kansas, August 9, 1950, the son of Mr. and Mrs. C. F. Kesinger, Sr. Married Elizabeth A. Forshee on October 18, 1970. Wendy C. Kesinger, a daughter, was born July 10, 1972. Edward S. Kesinger, a son, was born June 16, 1974. Jennifer L. Kesinger, a daughter, was born September 26, 1977.

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