QUALIFICATION CRITERIA FOR THE POWER REACTOR HEALTH PHYSICIST: A DELPHI APPROACH

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QUALIFICATION CRITERIA FOR THE POWER

REACTOR HEALTH PHYSICIST:

A DELPHI APPROACH

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PREFACE

This study is concerned with the establishment of detailed qualification criteria on a generic basis for the position of power reactor health physicist. The specific objectives include determining general educational requirements and specific technical areas of study necessary or desirable for the entry level power reactor health physicist, 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 Radiation Protection Manager are also examined. Finally, the question of licensing or formal certification of power reactor health physicists is studied. A series of three questionnaires incorporating the Delphi Technique is used to gather data and opinions from practicing power reactor health physicists. Information thus collected is analyzed against majority opinion criteria, and specific qualification elements are identified and ranked in order of importance.

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CHAPTER I

INTRODUCTION

The power reactor health physicist at a commercial nuclear plant has long been responsible for protecting the health and safety of plant workers and members of the off-site public from the harmful effects of ionizing radiation. This responsibility has encompassed both routine plant operations and potential accident conditions. In the post-Three Mile Island era, the emphasis on radiation protection in the nuclear power industry escalated dramatically and engendered a concomitant increase in the demand for health physics professionals. During this same period, the preponderance of negative publicity resulting from the accident at Three Mile Island, coupled with the public's perception of the nuclear industry as a "dead" industry, resulted in declining enrollments in health physics degree programs and in the failure of some of these programs (U.S. Department of Energy, 1981). The combination of an increase in demand for college-educated health physics professionals and a reduction in their supply brought up the problem of where the additionally needed professionals would come from. If some were to come from non-traditional sources, what would be the potential for dilution of the level of professional competence that has been inherent in this population in the past?

Statement of the Problem

Detailed qualification criteria were not available for the power reactor health physicist. Such criteria were considered to be critical to the development of adequate position descriptions, 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 on a generic basis for the position of power reactor health physicist.

Objectives of the Study

The specific objectives which this study was intended to achieve were:

1. A determination of the general educational requirements involved for any professional power reactor health physicist.
2. A determination of the specific areas of technical education that should be required for an entry level power reactor health physicist.
3. A determination of the type of plant-specific orientation and training that the entry level power reactor health physicist should receive within the first few months of employment.
4. A determination of any additional areas of study (education and training) that should be required for a power reactor

health physicist filling the position of Radiation Protection Manager.

5. A determination of the level of experience that should be required for a power reactor health physicist filling the position of Radiation Protection Manager.
6. A determination of whether licensing and/or certification should be required or encouraged for power reactor health physicists.

Scope of the Study

The study concentrated on qualification criteria for entry level professionals and on the senior health physics position (Radiation Protection Manager or RPM) at a commercial reactor site. However, study participants represented all major aspects of the commercial nuclear industry substantially involved in plant radiation protection programs, including consultants, regulatory personnel, and utility site and corporate health physicists.

Limitations

This study was subject to the following limitations:

1. The study addressed only the professional level power reactor health physicist. Technician and foreman level personnel were purposely excluded.
2. The methodology used to conduct this study, the Delphi Technique, did not provide for face-to-face interaction of

participants. This undoubtedly resulted in the loss of the synergistic effects of a committee format.

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 indices of the qualification criteria actually needed.

Definitions

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

1. Certification - The formal written recognition by an appropriate body or official that an individual's qualifications meet or exceed job requirements. The process of receiving certification may require examination or testing.
2. 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, p. 2).

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

4. <u>Entry Level</u> - Applies to an individual just starting in his or her first professional position.

5. <u>Health Physicist</u> - A practitioner of health physics.

6. <u>Health Physics</u> - The science of protecting man and his environment from the harmful effects of radiation.

7. <u>Qualification Criteria</u> - The education, training, and experience requirements necessary to fill a position.

8. <u>Qualifications</u> - The sum of an individual's education, training, and experience.

9. <u>Power Reactor Health Physicist</u> - A practitioner of health physics specializing in radiation protection at a power reactor site.

10. <u>Radiation Protection</u> - Synonymous with health physics.

11. <u>Radiation Protection Manager (RPM)</u> - The senior health physicist at a commercial power reactor site who is responsible for implementing the Radiation Protection Program.

12. <u>Training</u> - 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.

CHAPTER II

REVIEW OF LITERATURE

The review of literature was conducted to examine the historical evolution, present status, and trends for change of qualification standards and criteria for the health physicist in general and the power reactor health physicist in particular. This chapter examines the following topics:

1. Background and History of Health Physics
2. The Three Mile Island Accident
3. Present Status of Qualification Criteria
4. Supply and Demand
5. Summary

Background and History of Health Physics

Shortly after the discovery of X-rays and radium, the first harmful effects of penetrating radiation were observed. In fact, Morgan (1980) observed that a man in Chicago was attempting to find a cure for his X-ray burns only a month after Roentgen announced the discovery of X-rays in November, 1895. Radiation produced damage so insidiously and inconspicuously that early researchers were seldom aware of receiving excessive radiation until radiation burns were incurred, or until years later they were stricken by cancer. During the early history of the use of penetrating radiation, steps were taken to organize work practices in such a manner as to prevent recurrence of observed injuries. In most of these instances, radiation protection was a corrective response following a series of misadventures. In some cases a situation approximating a public scandal occurred before suitable remedial measures were established. This unfortunate state of affairs persisted into the 1920s; however, from that time until the present, the science of radiation protection has steadily improved.

The atomic age was really born into this world on December 2, 1942, in the Metallurgical Laboratory at the University of Chicago. For the first time ever, a self-sustaining nuclear chain reaction was achieved. It was recognized early in the Metallurgical Project, which later became a part of the Manhattan Project, that unprecedented health hazards would be encountered. The first health physics department was created, and the descriptive title "Health Physics" was employed to obscure the nature of the work undertaken in this highly secret project. Actually, the pre-war title, "Radiation Protection" is much more functionally descriptive. It was this critical war research which established health physics as a budding professional discipline (Morgan, 1980).

With a firmly established foothold in the rapidly expanding post-war atomic era, the health physics profession grew rapidly (Parker, 1980). The Health Physics Society was organized in 1955 and 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 forty countries (Health Physics Society Membership Handbook, 1982-1983).

The U.S. Department of Labor provided a very generalized description of the professional health physicist in its Dictionary of Occupational Titles:

> Devises and directs research, training, and monitoring programs to protect plant and laboratory personnel from radiation hazards. Conducts research to develop inspection standards, radiation exposure limits for personnel, safe work methods, and decontamination procedures, and tests surrounding areas to insure that radiation is not in excess of permissible standards. Develops criteria for design and modification of health physics equipment, such as detectors and counters, to improve radiation protection. Assists in developing standards of permissible concentrations of radioisotopes in liquids and gases. Directs testing and monitoring of equipment and recording of personnel and plant area radiation exposure data. Requests bioassay samples from individuals believed to be exposed. Consults with scientific personnel regarding new experiments to determine that equipment or plant design conforms to health physics standards for protection of personnel. Conducts research pertaining to potential environmental impact of proposed atomic energy related industrial development to determine qualifications for licensing. Requisitions and maintains inventory of instruments. Instructs personnel in principles and regulations related to radiation hazards. Assigns film badges and dosimeters to personnel, and recommends changes in assignment for health reasons. Advises public authorities on methods of dealing with radiation hazards, and procedures to be followed in radiation incidents, and assists in civil defense planning (U.S. Department of Labor, 1977, p. 63).

As practiced in industry, health physics was not found to be a pure science, but rather a hybrid discipline combining various aspects of physics, biology, and engineering. As might be expected with any profession, health physics has subdivided into more than 20 specialties, including such areas as dosimetry, instrumentation, radiation, biology, medical physics, and reactor health physics. Health Physicists are employed by the government, research laboratories, universities, hospitals, and industry (Parker, 1980).

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 diagnosis; the Nuclear Regulatory Commission (NRC) regulators floundered around trying to discover what had happened. And it all took place before a packed house 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. Two specific areas that were targeted for improvement applied directly to this study. Those areas were training and qualifications, and radiation protection (The President's Commission on the Accident at Three Mile Island, 1979).

In Three Mile Island - A Report to the Commissioners and the Public (1980), the Nuclear Regulatory Commission Special Inquiry Group made the following finding:

> Our investigation found deficiencies in the radiation protection program at Three Mile Island that were both pervasive and serious. The utility had identified these deficiencies itself prior to the accident, but its efforts to improve the program before March 28 were slow and weak. NRC also was or should have been aware of the deficiencies and should have taken meaningful action to remedy the problems (U.S. Nuclear Regulatory Commission Special Inquiry Group, 1980, p. 155).

The Group recommended that the radiation protection function be elevated in importance and be made independent of the operations function at all commercial nuclear plants.

As a result of the TMI investigations, in 1980 the NRC undertook a major effort to evaluate the radiation protection programs at 48 operating commercial nuclear power plants. This effort was called the Health Physics Appraisal Program. 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 and other problem areas in radiation protection 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. Two areas of interest in this study were considered of sufficient importance to be established as two of INPO's five major technical divisions: the Radiological Protection and Emergency Preparedness Division and 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 Criteria

At the time of this study, the most widely recognized qualification criteria for the power reactor health physicist were contained in an NRC Regulatory Guide. Regulatory Guide 1.8, "Personnel Selection and Training (1975)," established criteria for the position of Supervisor-Radiation Protection at a nuclear power plant. The document referred to the position generically as the Radiation Protection Manager.

> The Radiation Protection Manager (RPM) should be an experienced professional in applied radiation protection at nuclear facilities dealing with radiation protection problems and programs similar to those at nuclear power stations. The RPM should be familiar with the design features and operations of nuclear power stations that affect the potential for exposures of persons to radiation. The RPM should have the technical competence to establish radiation protection programs and the supervisory capability to direct the work of professionals, technicians, and journeymen required to implement the radiation protection programs.
>
> The RPM should have a bachelor's degree or the equivalent in a science or engineering subject, including some formal training in radiation protection. The RPM should have at least five years of professional experience in applied radiation protection. (A master's degree may be considered equivalent to one year of professional experience, and a doctor's degree may be considered equivalent to two years of professional experience where course work related to radiation protection is involved.) At least three years of this professional experience should be in applied radiation protection work in a nuclear facility dealing with radiological problems similar to those encountered in nuclear power stations, preferably in an actual nuclear power station (U.S. Nuclear Regulatory Commission, 1980, p. 1).

The "American National Standard for Selection and Training of Nuclear Power Plant Personnel" issued in 1978 by the American Nuclear Society essentially echoed the previously cited criteria from Regulatory

Guide 1.8, but added the following provision for a division of responsibilities between on-site and off-site managers:

> The individual may be located either on-site or off-site. If this individual is located off-site, he shall be responsible for the preparation of the site radiation protection program and the issuance of program revisions. In addition, he shall provide technical direction and conduct appropriate audits to ensure that the site program is implemented.
>
> If the individual is located off-site, the individual responsible on-site shall have a minimum of five years of experience in radiation protection at a nuclear reactor facility. Two years of this five years experience should be related technical training. A maximum of four years of this five years experience may be fulfilled by related technical or academic training (American Nuclear Society, 1978, p. 5).

It was possible to infer yet a third set of generalized qualification criteria by examining the American Board of Health Physics (ABHP) requirements to attain certification as a power reactor health physicist. The ABHP was formally established by the Health Physics Society in 1958 to develop standards and procedures, to examine candidates, and to issue written proof of certification to the Board. For the first 20 years of its existence, the ABHP issued only a comprehensive certification in health physics. However, in 1979, a Power Reactor Specialty Certification was initiated. The general requirements for Power Reactor Specialty Certification include a Bachelor's degree in a physical science or in a biological science with a minor in a physical science, at least six years of professional experience in health physics, and a passing grade on a two-part, seven-hour written examination. Although many power reactor health physicists meet the academic and experience requirements, the examination is sufficiently difficult that only 19 individuals were certified in the Power Reactor Specialty by the end of 1982, and of those, probably less than one-third achieved certification by passing the examination. The remaining two-thirds were practicing power reactor health physicists holding comprehensive certification who were "grandfathered" into Power Reactor Specialty Certification.

In addition to the preceding sources of qualification criteria, it was decided to look at the qualifications of individuals who were filling the RPM position at various nuclear plants. A report titled Utility Management and Technical Resources (Podensky, 1980) compiled data on the education and experience of individuals holding key management and technical positions at nuclear power plants. Upon examining the qualifications of individuals filling the RPM position at 45 plants, it was found that the average individual had 9.4 years of nuclear experience. The highest educational attainment of individuals were reviewed and it was discovered that 2 percent held Doctoral degrees, another 48 percent held Master's degrees, 31 percent held only Bachelor's degrees, and 18 percent had less than a Bachelor's degree. Individuals having less than a Bachelor's degree averaged 12.4 years of experience, four years more than the population as a whole.

It was found that graduate degrees predominate in the health physics offerings of colleges and universities in the United States. However, some baccalaureate degree programs also exist. Table I serves as an example of an undergraduate health physics curriculum, while Table II represents a Master's degree program (Georgia Institute of Technology, 1982).

Several changes had been proposed recently that had some impact on the power reactor health physicist. One of the more substantive was a draft revision to the "American National Standard for Selection,

TABLE I

SAMPLE BACCALAUREATE DEGREE HEALTH PHYSICS CURRICULUM

	Quarter Hour Credits
Freshman and Sophomore Years	
General Chemistry	10
Physics	15
Calculus and Differential Equations	30
Biology	13
Introduction to Engineering Design	3
Computer Programming and Graphics	3
Introduction to Health Physics	3
Physical Training	3
Electives	24
Junior and Senior Years	
Atomic and Nuclear Physics	5
Electronics	10
Radiation Detection	4
Health Physics	14
Radiation Biology	4
Nuclear Reactor Engineering	9
Non-ionizing Radiation	3
Radiation Shielding	3
Nuclear Technology and the Environment	3
Nuclear Chemistry	4
Special Problem in Health Physics	3
Electives	36
Total	202

TABLE II

SAMPLE MASTERS DEGREE HEALTH PHYSICS CURRICULUM

	Quarter Hour Credits
Core Courses	
Radiological Health Physics	3
Radiation Detection	4
Nuclear Physics	4
Industrial Health Protection Survey	3
Radiation Dosimetry	3
Fund. of Nuclear Engineering	3
Health Physics Practice	3
Env. Surveillance & Waste Disposal	3
Biological Effects of Radiation	4
Electives	
Advanced Radiation Detection	3
Rad. Technology Laboratory	3
Rad. Prot. at Nuclear Facilities	3
Environmental Impact of Nuclear Power	3
Applied Health Physics Lab	3
Radioisotopes Engineering I, II	3
Radiation Attenuation	4
Rad. Effects on Materials	3
Applied Radiation Physics	3
Radiation Dosimetry Systems	3
Physical Principles in Industrial Health Protection	3
Total	64

Qualification, and Training of Personnel for Nuclear Power Plants" dated 4/10/81. This draft addressed RPM qualifications as follows:

> EDUCATION: Bachelor Degree in a science or engineering subject, including formal training in radiation protection.
>
> EXPERIENCE: At the time of initial core loading or appointment to the active position, whichever is later, the responsible individual shall have four (4) years of experience in applied radiation protection. At least three (3) 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. During the three years, the individual shall participate in the radiation protection section of an operating nuclear power plant during the following periods.
>
> (1) Routine refueling outage (1 to 2 months)
> (2) Two (2) months operations above 20% power.
>
> Six (6) months experience shall be on-site (American Nuclear Society, 1981, p. 18).

The draft standard also addressed training for professional technical personnel, including the RPM.

> Training shall be provided to compensate for deficiencies identified by comparing the individuals experience and knowledge to the task analysis. The required training of these professional-technical personnel can be implemented by involvement in related training programs. These training programs may include assignment at operating reactors and/or simulators, and at vendor facilities. The training shall be for periods of time sufficient to develop the proficiency required, for safe and competent supervision (American Nuclear Society, 1981, p. 35).

Supply and Demand

The U.S. Department of Energy (1981) recently published a report titled "A Study of the Adequacy of Personnel for the U.S. Nuclear Program." 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. In the health physics area in particular the supply is currently inadequate, the demand is growing, and the number of graduates, if not the number of programs, must be increased (U.S. Department of Energy, 1981, p. 3).

The study examined health physics enrollment and degrees granted over a ten year period. Figure 1 graphically displayed the results of that examination. A pattern of declining enrollment was found at the Bachelor's degree and Doctoral degree level (U.S. Department of Energy, 1981, p. 33). With the exception of the 1980-81 academic years, the decline also appeared in Master's degree enrollment. This decline has been exacerbated by an increase in demand for health physics professionals caused by the increased emphasis on radiation protection after TMI and by the large number of plants becoming operational over the next five years.

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.

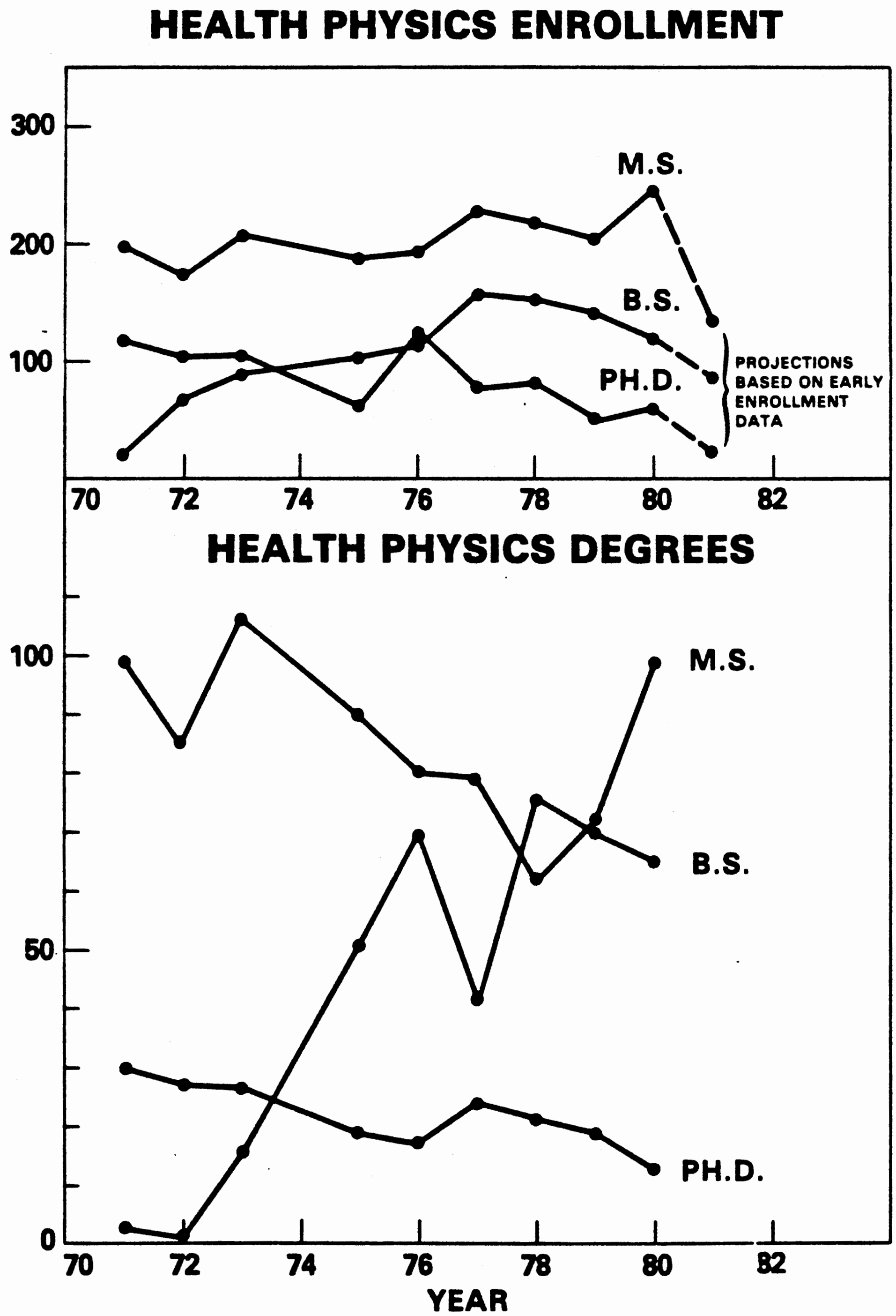

Figure 1. Health Physics Enrollment and Health Physics Degrees

Summary

The review of literature established that the TMI accident had a profound effect on radiation protection at nuclear power plants. It established that qualification criteria for the power reactor health physicist 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 power reactor health physicists indicated a decreasing supply of health physics graduates at all degree levels, in the face of a growing demand.

CHAPTER III

PROCEDURES

The methodology selected to implement this study included employment of the Delphi technique as a means of approximating a consensus by a panel of experts. 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 selected as a method of securing convergent opinion from participants without bringing the participants together physically. Typically, past study participants have been experts and the study objective was to reach or approximate an expert consensus opinion on some topic, the very nature of which did not lend itself to more conventional analysis. The objective may have involved predicting future trends or developing competency criteria. The convergent opinion of past Delphi participants had been 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 modify 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 altogether 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.

Study Participants

The target population for this study consisted of practicing power reactor health physicists in upper level technical positions or mid-to-upper-level management positions. These individuals were selected to represent a cross-section of the industry, including consultants, regulators, and both site and corporate utility personnel. 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. Some participants were certified by the American Board of Health Physics.

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 probably not much greater than two hundred, it was determined that a sample of 10 to 15 individuals would prove adequate for this study. To insure this level of participation over the course of the study, 27 individuals were originally included in the study.

Data Collection

Data were collected using a series of three questionnaires designed as a Delphi study. Questionnaire I incorporated some preliminary qualification criteria which were developed from current literature. Participants were requested to add to or modify specific areas. Questionnaire II consisted of modified qualification criteria which participants were asked to rate in importance. Questionnaire III consisted of composite qualification 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. Questionnaires were customized for the individual respondent by indicating his or her previous rating.

Data Analysis

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 criteria for the position of power reactor health physicist. 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. Entry Level General Educational Requirements
5. Entry Level Technical Areas of Study
6. Entry Level Orientation and Training
7. Radiation Protection Manager Education/Training
8. Radiation Protection Manager Experience
9. Licensing/Certification

Identified Qualification Areas

Through discussions with power reactor health physicists, five general areas were identified as being most relevant to establishing qualification criteria for professional health physics positions at commercial power reactors. These areas were as follows:

1. General educational requirements for entry level professionals.
2. Specific technical areas of study for entry level professionals.
3. Plant-specific orientation and training for entry level professionals.
4. Education/training and experience criteria for the position of Radiation Protection Manager.
5. Licensing/certification for power reactor health physics positions.

Respondent Characteristics

Questionnaire I was sent to individuals representing all aspects of the power reactor health physics profession, including utility personnel holding both site and corporate positions, consultants, and regulatory inspection and enforcement personnel. Of the 27 individuals to whom the initial questionnaire was sent, 18 responded (66.7%). Questionnaire II was sent to the individuals who answered the first questionnaire, and 15 responses were received (83.3%). Subsequently, Questionnaire III was sent to the 15 respondents to the second questionnaire, and 11 answers were received (73.3%). The overall response rate, that is, individuals who completed all three questionnaires (11) as compared to the total number of individuals who were sent the first questionnaire (27) was 40.7%.

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 11 respondents who participated in that questionnaire as well as the preceding two. These 11 individuals had an average of 11.2 years of total health physics experience and 8.9 years of power reactor health physics experience. With respect to highest academic degree held, two had Doctoral degrees, five held Master's degrees, and the remaining four all had Bachelor's degrees. Regarding age group, two were under 30 years of age, five were in the 30 to 39 age group, and four were between 40 and 49 years of age. Two of the respondents were females and five were certified by the American Board of Health Physics.

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 done 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 or her previous choices.

A total of 66 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 12 and that the average number of changes for the group was six. An even more relevant statistic was that of the total of

66 changes made by the entire group, 100% were made either by changing from a minority choice to a majority choice, or from a minority choice to a choice closer to a majority choice. This indicated that a strong correlation existed between the direction of changes in Questionnaire III and the majority responses of the group to Questionnaire II.

Entry Level Educational Requirements

The first objective of this study was to make a determination of the general educational requirements that should apply to the professional power reactor health physicist. 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 professional power reactor health physicist first entering the job market in 1983.

The data shown in Table III indicate the responses to the desirability of five degree types and the data in Table IV show the responses to three degree levels. 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 two adjacent integrals on the rating scale with 75 percent or more of the ratings. Results not falling within these criteria were regarded as indeterminant. Based on these criteria, the data in Table III indicate that a degree in Health Physics (Radiation Sciences) was rated "most desirable," and a degree in Nuclear Engineering was rated "desirable." Other engineering and engineering technologies were rated "useful," as were degrees in Physics and Biology. Table IV data show that a Bachelor's degree was rated "essential," a Master's degree as "important," and a Doctoral degree as "important." The mean ($\overline{x}$) of the

TABLE III

RESPONSES TO "GENERAL EDUCATIONAL REQUIREMENTS (ENTRY-LEVEL) - DEGREE TYPES"

Degree Type	most desirable x=4	desirable x=3	useful x=2	unsatis-factory x=1	$\bar{x}$
Health Physics (Radiation Sciences)	100%	--	--	--	4.00
Nuclear Engineering	--	55%	36%	9%	2.45
Physics	--	27%	73%	--	2.27
Other engineering or engineering technology	--	--	100%	--	2.00
Biology	--	--	73%	27%	1.73

TABLE IV

RESPONSES TO "GENERAL EDUCATIONAL REQUIREMENTS (ENTRY-LEVEL) - DEGREE LEVEL"

Degree Level	essential x=4	important x=3	useful x=2	unim-portant x=1	$\bar{x}$
Bachelors Degree	82%	18%	--	--	3.82
Masters Degree	--	91%	9%	--	2.91
Doctoral Degree	--	--	55%	45%	1.55

integral ratings scale for each item allows further refinement of ranking within the major categories.

Entry Level Technical Areas of Study

The second objective of this study was to determine which specific technical areas of study should be required for an entry level power reactor health physicist. This area was defined as educational study at the professional level. Once again, the frame of reference was established at an entry level professional first entering the job market in 1983.

The data in Table V indicate the responses to the degree of importance of 21 technical areas of study. According to the established criteria for majority opinion, the areas of study were rated as follows:

1. Essential:
    a. Radiation Detection and Measurement
    b. Health Physics
    c. Radiation Dosimetry
    d. Atomic/Nuclear Physics
    e. ALARA
    f. Radiation Shielding
    g. Technical Writing/Communications
2. Essential - Important:
    a. Radiation Biology
    b. Waste Disposal
3. Important:
    a. Regulations
    b. Chemistry/Radiological Chemistry

TABLE V

RESPONSES TO "SPECIFIC TECHNICAL AREAS OF STUDY (ENTRY LEVEL)"

Area of Study	essential x=4	important x=3	useful x=2	unimportant x=1	$\overline{x}$
Radiation Detection and Measurement	100%	--	--	--	4.00
Health Physics	100%	--	--	--	4.00
Radiation Dosimetry	91%	9%	--	--	3.91
Atomic/Nuclear Physics	64%	36%	--	--	3.64
ALARA	64%	36%	--	--	3.64
Radiation Shielding	55%	36%	9%	--	3.46
Radiological Emergencies	45%	55%	--	--	3.46
Tech. Writing/Comm.	55%	36%	9%	--	3.46
Waste Disposal	45%	45%	9%	--	3.36
Radiation Biology	45%	45%	9%	--	3.36
Regulations	36%	64%	--	--	3.36
Envir. Health Physics	36%	55%	9%	--	3.27
Chemistry/Rad. Chemistry	18%	64%	18%	--	3.00
Statistics	27%	36%	36%	--	2.91
Systems Engineering	18%	45%	27%	9%	2.73
Nuclear Reactor Engrg.	--	64%	36%	--	2.64
Computer Science/Tech.	18%	18%	64%	--	2.55
Meteorology	9%	27%	64%	--	2.46
Supervision	9%	18%	73%	--	2.36
Risk Analysis	--	27%	64%	9%	2.18
Epidemiology	--	--	64%	36%	1.64

c. Nuclear Reactor Engineering

d. Radiological Emergencies

e. Environmental Health Physics

4. <u>Useful</u>:

a. Supervision

b. Computer Science/Technology

c. Meteorology

d. Risk Analysis

e. Epidemiology

5. <u>Indeterminant</u>:

a. Statistics

b. Systems Engineering

Entry Level Orientation and Training

The third objective of this study was to make a determination of the type and amount of plant-specific orientation and training that the entry level power reactor health physicist should receive within the first few months of employment at a plant site. The data shown in Table VI 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, the orientation/ training topics were rated as follows:

1. <u>Essential</u>:

a. Plant Systems Training

b. Plant Layout

c. Radiological Controls

d. Health Physics Procedures

TABLE VI

RESPONSES TO "PLANT-SPECIFIC ORIENTATION AND TRAINING (ENTRY LEVEL)"

Orientation/ Training Topic	essential x=4	important x=3	useful x=2	unim- portant x=1	$\overline{x}$
Plant Systems Training	100%	--	--	--	4.00
Plant Layout	100%	--	--	--	4.00
Radiological Controls	82%	18%	--	--	3.82
HP Procedures	73%	27%	--	--	3.73
Emer. Prep. Training	73%	27%	--	--	3.73
Admin. Controls & Proc.	64%	27%	9%	--	3.55
ALARA Implementation	45%	45%	9%	--	3.36
Nuclear Power Plant Technology	36%	64%	--	--	3.36
Surveys & Protection	45%	45%	9%	--	3.36
In. Assignment Rotation	45%	55%	9%	--	3.27
Personnel Safety	45%	36%	18%	--	3.27
Rad/Chem Operations	36%	55%	9%	--	3.27
Regulation/Site Experience	27%	55%	18%	--	3.09
Process/Effluent Data Acquisition & Analysis	18%	73%	9%	--	3.09
Radioactive Waste Practices	18%	82%	--	9%	3.00
General Employee Training	45%	9%	27%	18%	2.82
RAM Packaging & Trans- portation	9%	73%	9%	--	2.82
Public Relations	9%	18%	64%	9%	2.27
R O Equivalent Training	--	27%	64%	9%	2.18
Reactor Physics	--	18%	55%	27%	1.91

e. Emergency Preparedness Training

f. Administrative Controls and Procedures

2. Essential - Important:

a. Surveys and Protection

b. ALARA Implementation

c. Personnel Safety

3. Important:

a. Radioactive Waste Practices

b. Process/Effluent Data Acquisition and Analysis

c. Radioactive Material Packaging and Transportation

d. Nuclear Power Plant Technology

e. Initial Assignment Rotation

f. Radiological Chemistry Operations

g. Regulation/Site Experience

4. Useful:

a. Public Relations

b. Reactor Operator Equivalent Training

c. Reactor Physics

5. Indeterminant:

a. General Employee Training

Radiation Protection Manager Education/Training

A fourth objective of this study was to determine the additional areas of study (education and training) that should be required of a power reactor health physicist filling the position of Radiation Protection Manager (RPM), the senior health physics position at a plant site. This applied to both technical and non-technical education and training topics over and above those considered necessary for the entry level professional. Table VII shows data indicating the responses to the degree of importance of 10 technical and non-technical education and training topics relevant to the RPM position. According to the established criteria for majority opinion, the topics were rated as follows:

1. Essential:
    a. Management/Supervisory Training
    b. Time Management
    c. Periodic Technical Refresher Training
2. Essential - Important:
    a. Radiological Engineering
3. Important:
    a. Administrative Functions
4. Useful:
    a. Senior Reactor Operator Training
5. Indeterminant:
    a. Public Relations
    b. Labor Relations
    c. Public Speaking

Radiation Protection Manager Experience

The fifth objective of this study was to determine the level of experience that should be required of a power reactor health physicist filling the position of RPM. Table VIII data indicates the responses to the two categories of character of experience examined. The responses to "total radiation protection experience" indicated an average of 7.46 years of experience in this category, but the results were indeterminant in accordance with the established majority opinion criteria. "Power reactor radiation protection experience" did meet the majority opinion criteria, and the results indicated that five years of this type of experience was considered necessary.

TABLE VII

RESPONSES TO "RADIATION PROTECTION MANAGER EDUCATION/TRAINING"

Education/ Training Topic	essential x=4	important x=3	useful x=2	unimportant x=1	$\overline{x}$
Management/Supervisory Training	82%	18%	--	--	3.82
Time Management	64%	36%	--	--	3.64
Periodic Technical Refresher Training	55%	45%	--	--	3.55
Public Relations	45%	27%	27%	--	3.18
Administrative Functions	27%	64%	9%	--	3.18
Radiological Engineering	36%	45%	18%	--	3.18
Team Building	27%	55%	18%	--	3.09
Labor Relations	45%	18%	36%	--	3.09
Public Speaking	27%	36%	36%	--	2.91
SRO Training	--	36%	64%	--	2.36

TABLE VIII

RESPONSES TO "RADIATION PROTECTION MANAGER EXPERIENCE"

Character of Experience	Years				
	x=5	x=7	x=10		$\bar{x}$
Total Radiation Protection Experience	45%	9%	45%		7.46
	x=2	x=3	x=4	x=5	$\bar{x}$
Power Reactor Radiation Protection Experience	18%	18%	9%	55%	4.00

Licensing/Certification

The final objective of this study was to determine whether some form of licensing or certification should be required or encouraged for power reactor health physicists. The position of RPM specifically, and other senior health physics positions in general, were addressed. Table IX data show responses to five statements concerning licensing or formal certification of power reactor health physicists. The results that met the criteria for majority opinion indicated that the respondents generally agreed that formal certification should be encouraged for the position of RPM and for other senior health physics positions. Respondents disagreed that the NRC should <u>require</u> some type of license or formal certification for senior health physics positions other than that of RPM. There was a tendency to agree that the NRC should <u>require</u> some type of license or formal certification for the position of RPM, but the results were indeterminant in accordance with the majority opinion criteria. Likewise, there was a tendency to disagree that licensing and/or formal certification was unnecessary for professional health physics positions at commercial power reactors, but the results were indeterminant.

TABLE IX

RESPONSES TO "LICENSING/CERTIFICATION"

Statement	Strongly Agree x=4	Agree x=3	Disagree x=2	Strongly Disagree x=1	$\bar{x}$
Formal certification should be encouraged for the position of RPM.	27%	55%	18%	--	3.09
Formal certification should be encouraged for other senior health physics positions.	18%	73%	9%	--	3.09
The NRC should require some type of license or formal certification for the position of RPM.	45%	18%	27%	9%	3.00
The NRC should require some type of license or formal certification for other senior health physics positions.	9%	9%	73%	9%	2.18
Licensing and/or formal certification is unnecessary for professional health physics positions at commercial power reactors.	9%	18%	45%	27%	2.09

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The objectives of this study were to establish detailed qualification criteria for the generic positions of entry level power reactor health physicist and Radiation Protection Manager, and to examine the question of licensing or certifying individuals in certain plant health physics positions. A series of questionnaires using the Delphi Technique were sent to practicing power reactor health physicists to gather data and opinions on the subject. According to an operationally defined criteria, a majority opinion was attained on 86.4% of 66 specific qualification elements involved in the study. This chapter summarizes the study and presents the conclusions reached. Recommendations for practice and further study are also addressed.

Summary

The specific problem with which this study dealt was the lack of detailed qualification criteria for the power reactor health physicist. The purpose of this study was to establish detailed qualification criteria on a generic basis for the position of power reactor health physicist.

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. This methodology, known as the Delphi Technique, was employed to achieve or at least approximate a consensus opinion on specific qualification criteria. Several general areas were identified as being most relevant to establishing qualification criteria for professional health physics positions at commercial power reactors. These included general education requirements and specific technical areas of study for entry level professionals, as well as plant-specific orientation and training for such individuals. The education, training, and experience required for the position of Radiation Protection Manager (RPM), the senior health physics position at a nuclear plant site, was identified as well, and the question of licensing or formal certification of power reactor health physicists completed the areas of study.

The first of the three questionnaires was mailed to 27 individuals in the power reactor health physics profession, and successive questionnaires were mailed only to respondents of the preceding questionnaire. The overall response rate, that is, the numbers of individuals who completed all three questionnaires (11) as compared to the total number of individuals who were sent the first questionnaire was 40.7%. When participants were given the opportunity to modify their opinions on the third questionnaire, responses were changed an average of 9.1% of the time. It was interesting to note that 100% of changes made 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 57 out of 66 specific items, a rate of 86.4%.

The findings of this study rated each qualification element examined under the several categories of Entry Level Educational Requirements, Entry Level Technical Areas of Study, Entry Level Orientation and Training, Radiation Protection Manager Education/Training, Radiation Protection Manager Experience, and Licensing/Certification. For an entry level professional, it was found that a degree in Health Physics was considered most desirable, followed by degrees in Nuclear Engineering, degrees in other engineering disciplines or engineering technologies, and degrees in Physics or Biology, in decending order of desirability. A Bachelor's degree was considered to be essential and Master's and Doctoral degrees were rated as important. Technical areas of study for entry level professionals rated 21 specific elements in the following order:

1. Essential:
   a. Radiation Detection and Measurement
   b. Health Physics
   c. Radiation Dosimetry
   d. Atomic/Nuclear Physics
   e. ALARA
   f. Radiation Shielding
   g. Technical Writing/Communications
2. Essential - Important:
   a. Radiation Biology
   b. Waste Disposal
3. Important:
   a. Regulations
   b. Chemistry/Radiological Chemistry

c. Nuclear Reactor Engineering

d. Radiological Emergencies

e. Environmental Health Physics

4. <u>Useful</u>:

a. Supervision

b. Computer Science/Technology

c. Meteorology

d. Risk Analysis

e. Epidemiology

5. <u>Indeterminant</u>:

a. Statistics

b. Systems Engineering

A set of 20 orientation/training topics considered for the entry level professional during the first few months of employment at a plant were rated as follows:

1. <u>Essential</u>:

a. Plant Systems Training

b. Plant Layout

c. Radiological Controls

d. Health Physics Procedures

e. Emergency Preparedness Training

f. Administrative Controls and Procedures

2. <u>Essential - Important</u>:

a. Surveys and Protection

b. ALARA Implementation

c. Personnel Safety

3. Important:

    a. Radioactive Waste Practices

    b. Process/Effluent Data Acquisition and Analysis

    c. Radioactive Material Packaging and Transportation

    d. Nuclear Power Plant Technology

    e. Initial Assignment Rotation

    f. Radiological Chemistry Operations

    g. Regulation/Site Experience

4. Useful:

    a. Public Relations

    b. Reactor Operator Equivalent Training

    c. Reactor Physics

5. Indeterminant:

    a. General Employee Training

Ten technical and non-technical education and training topics relevent to the position of Radiation Protection Manager (RPM) yielded the following ratings:

1. Essential:

    a. Management/Supervisory Training

    b. Time Management

    c. Periodic Technical Refresher Training

2. Essential - Important:

    a. Radiological Engineering

3. Important:

    a. Administrative Functions

4. Useful:

    a. Senior Reactor Operator Training

5. <u>Indeterminant</u>:

   a. Public Relations

   b. Labor Relations

   c. Public Speaking

An examination of the desired level experience for the position of RPM indicated that five years of radiation protection experience at a power reactor was considered necessary to fill this position. Finally, in the category of licensing and certification, respondents generally agreed that formal certification should be encouraged for the position of RPM and for other senior health physics positions. However, respondents disagreed that the NRC should require licensing or formal certification for senior health physics positions other than that of RPM.

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 both entry level power reactor health physicists and for individuals filling the position of RPM.

2. The question of licensing or formal certification of power reactor health physicists was the area involving the greatest differences of opinion, indicating that some controversy remained unresolved among the participants.

3. The generic qualification criteria set forth in Appendix D and Appendix F were developed from the findings as a basis for detailed qualification criteria for entry level power reactor health physicists and for the position of RPM.

4. The Delphi Technique appeared to be a sound methodology for studying qualification criteria for professional-technical positions such as that of power reactor health physicist.

Recommendations

It is recommended that the generic qualification criteria set forth in Appendix D and Appendix F be utilized as resource information for individuals charged with developing qualification criteria for power reactor health physicists. Such generic qualification criteria provide a basis for development of detailed criteria meeting the specific needs of individual organizations employing power reactor health physicists. Furthermore, individuals responsible for establishing training and orientation programs for entry level power reactor health physicists should consider the training and orientation topics set forth in Appendix E for potential inclusion in their programs.

Academic institutions supplying graduates for the power reactor health physics profession should consider the areas of study listed in the curriculum section of Appendix D 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.

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APPENDIXES

APPENDIX A

DELPHI QUESTIONNAIRE I

QUALIFICATION CRITERIA FOR THE POWER REACTOR HEALTH PHYSICIST

Introduction

This is the first in a series of three (possibly four) questionnaires submitted to you as part of a Delphi study of qualification criteria for power reactor health physicists. 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 professional level power reactor health physicists. Please do not consider technician or foreman level personnel when answering this or succeeding questionnaires. Qualification criteria are considered for both entry level professionals (new graduates) and for individuals holding the Radiation Protection Manager (RPM) position at a reactor site. This study considers only positions at a commercial nuclear power plant; however, study participants represent all major aspects of the commercial nuclear industry involved in plant radiation protection programs, including consultants, regulatory personnel, and utility site and corporate health physicists.

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 health physics: ____________________

6. Number of years experience in reactor health physics: ____________

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 REQUIREMENTS (ENTRY LEVEL)

Please enter general educational requirements which you deem necessary or highly desirable for a professional power reactor health physicist first entering the job market in 1983. Include both degree level(s) (B.S./M.S./Ph.D) and degree type(s) (Engineering/Health Physics/Math/etc.).

Degree level(s): ____

____

Degree type(s): ____

____

DELPHI QUESTIONNAIRE I

II. SPECIFIC TECHNICAL AREAS OF STUDY (ENTRY LEVEL)

Some potential technical areas of study are listed below. These areas should be considered as educational study at the professional level. 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) for a professional power reactor health physicist first entering the job market in 1983.

Atomic/Nuclear Physics

Radiation Detection and Measurement

Health Physics

Radiation Biology

Radiation Shielding

Environmental Health Physics

Radiation Dosimetry

Waste Disposal

Nuclear Reactor Engineering

____

____

____

DELPHI QUESTIONNAIRE I

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

A few potential 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 a professional power reactor health physicist during the first few months of his or her assignment to a plant health physics staff.

Nuclear Power Plant Technology

Plant Systems Training

*On-The-Job Training

____

____

____

____

*Please cite specific areas for OJT.

DELPHI QUESTIONNAIRE I

IV. RADIATION PROTECTION MANAGER (RPM) EDUCATION/TRAINING AND EXPERIENCE

Please enter specific education/training and experience criteria which you deem to be either essential, important, or useful (do not rate importance at this time) for an individual filling the RPM position at a nuclear plant. It is not necessary to duplicate education/training items already entered in preceding questions. Both technical and non-technical topics should be addressed.

EDUCATION/TRAINING:

Management/Supervisory Training

____

____

EXPERIENCE:

Total radiation protection experience: ________ years.

Power reactor radiation protection experience: ______ years.

Comments: ____

____

DELPHI QUESTIONNAIRE I

V. LICENSING/CERTIFICATION

Should some form of licensing or certification be considered for the position of RPM and/or other senior health physics positions at nuclear power plant? ______________________
(yes/no)

If yes, what form should it take? Please address the generic position (RPM or other) involved, and the type of licensing/ certification (NRC/ABHP/other) which should be considered.

APPENDIX B

DELPHI QUESTIONNAIRE II

QUALIFICATION CRITERIA FOR THE
POWER REACTOR HEALTH PHYSICIST

Dear Study Participant:

Response to the first questionnaire was very good. All questionnaires received to date have yielded thoughtful and comprehensive information. Your replies to the first questionnaire have been factored into this questionnaire.

Several good comments and suggestions were received with respect to the first questionnaire. Where feasible, these have been incorporated into the study. One consistent comment was to expand the scope of the study to include mid-level (between entry-level and RPM) power reactor health physicists. This is a valid comment and, in fact, was considered when initially scoping the study. At that time it was felt that the addition of the mid-level position, which is much more difficult to define than entry-level or RPM, would greatly increase the complexity of the study and negatively impact the schedule. This would be an excellent topic for a subsequent study.

Instructions

Please provide the information requested on 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 21, 1983. Your prompt response would be greatly appreciated.

Thank you,

Lee R. Lacey

DELPHI QUESTIONNAIRE II

Respondent's Name: ________________________________ Date: ________

I. GENERAL EDUCATIONAL REQUIREMENTS (ENTRY-LEVEL)

This part of the questionnaire addresses the general educational requirements of a professional power reactor health physicist first entering the job market in 1983. Please rate the desirability of the various degree types and levels as indicated below:

---

1. Please rate the desirability of the below listed degree types 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
Health Physics (Radiation Sciences)	4	3	2	1
Physics	4	3	2	1
Biology	4	3	2	1
Other engineering or engineering technology	4	3	2	1

DELPHI QUESTIONNAIRE II

II. GENERAL EDUCATIONAL REQUIREMENTS (Continued)

2. Assuming that the degree types involved are satisfactory, please rate the importance of the following degree levels by circling the appropriate number to the right of the degree level listed:

	essential	important	useful	unim-portant
Bachelors Degree	4	3	2	1
Masters Degree	4	3	2	1
Doctoral Degree	4	3	2	1

DELPHI QUESTIONNAIRE II

III. SPECIFIC TECHNICAL AREAS OF STUDY (ENTRY-LEVEL)

This part of the questionnaire addresses specific technical areas of study for a professional power reactor health physicist first entering the job market in 1983. These areas should be considered as educational study at the professional level. Please rate the importance of these areas as indicated below:

---

1. Please rate the importance of the below listed technical areas of study by circling the appropriate number to the right of the area of study listed:

	essential	important	useful	unimportant
Atomic/Nuclear Physics	4	3	2	1
Radiation Detection and Measurement	4	3	2	1
Health Physics	4	3	2	1
Radiation Biology	4	3	2	1
Radiation Shielding	4	3	2	1
Environmental Health Physics	4	3	2	1
Radiation Dosimetry	4	3	2	1
Waste Disposal	4	3	2	1
Nuclear Reactor Engrg.	4	3	2	1

DELPHI QUESTIONNAIRE II

II. SPECIFIC TECHNICAL AREAS OF STUDY (Continued)

Computer Science/Tech.	4	3	2	1
Chemistry/Rad. Chemistry	4	3	2	1
Meteorology	4	3	2	1
Statistics	4	3	2	1
Systems Engineering	4	3	2	1
Risk Analysis	4	3	2	1
Epidemiology	4	3	2	1
Radiological Emergencies	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

DELPHI QUESTIONNAIRE II

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

This part of the questionnaire addresses plant-specific orientation and training for a professional power reactor health physicist during the first few months of his or her assignment to a plant health physics staff. Please rate the importance of these orientation and training topics as listed below:

---

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

	essential	important	useful	unimportant
Nuclear Power Plant Technology	4	3	2	1
Plant Systems Training	4	3	2	1
Emergency Preparedness Training	4	3	2	1
Initial Assignment Rotation (all HP specialties)	4	3	2	1
ALARA Implementation	4	3	2	1
Process/Effluent Data Acquisition & Analysis	4	3	2	1
General Employee Training	4	3	2	1
Plant Layout	4	3	2	1

DELPHI QUESTIONNAIRE II

III. PLANT-SPECIFIC ORIENTATION AND TRAINING (Continued)

Rad/Chem Operations	4	3	2	1
HP Procedures	4	3	2	1
Regulation/Site Experience	4	3	2	1
RAM Packaging & Transportation	4	3	2	1
Admin. Controls & Procedures	4	3	2	1
Radiological Controls	4	3	2	1
Radioactive Waste Practices	4	3	2	1
R O Equivalent Training	4	3	2	1
Public Relations	4	3	2	1
Reactor Physics	4	3	2	1
Surveys & Protection	4	3	2	1
Personnel Safety	4	3	2	1

DELPHI QUESTIONNAIRE II

IV. RADIATION PROTECTION MANAGER (RPM) EDUCATION/TRAINING AND EXPERIENCE

This part of the questionnaire addresses specific education/training and experience criteria relevant to the RPM position at a commercial nuclear power plant. This educational training is in addition to entry-level college education and initial plant orientation and training.

1. Please rate the importance of the below listed educational training topics (technical & non-technical) relevant to the individual filling the RPM position at a nuclear plant:

	essential	important	useful	unimportant
Management/Supervisory Training	4	3	2	1
Public Relations	4	3	2	1
Public Speaking	4	3	2	1
Time Management	4	3	2	1
Periodic Technical Refresher Training	4	3	2	1
Team Building	4	3	2	1
SRO Training	4	3	2	1
Labor Relations	4	3	2	1
Administrative Functions	4	3	2	1
Radiological Engineering	4	3	2	1

DELPHI QUESTIONNAIRE II

IV. RADIATION PROTECTION MANAGER (RPM) EDUCATION/TRAINING AND EXPERIENCE (Continued)

2. Please circle the number representing the minimum years of experience that should be required (in each category listed below) for the position of RPM.

Total radiation protection experience (in years):

2 3 4 5 6 7 8 10

Power reactor radiation protection experience (in years):

2 3 4 5

DELPHI QUESTIONNAIRE II

V. LICENSING/CERTIFICATION

This part of the questionnaire addresses licensing or certification for the position of RPM and/or other senior health physics positions at a commercial nuclear power plant.

---

1. Please respond to the following statement by circling the appropriate number to the right of each statement:

	strongly agree	agree	disagree	strongly disagree
The NRC should require some type of license or formal certification for the position of RPM.	4	3	2	1
The NRC should require some type of license or formal certification for other senior health physics positions.	4	3	2	1
Formal certification should be encouraged for the position of RPM.	4	3	2	1
Formal certification should be encouraged for other senior health physics positions.	4	3	2	1

V. LICENSING/CERTIFICATION (Continued)

Licensing and/or formal certification is unnecessary for professional health physics positions at commercial power reactors.	4	3	2	1

APPENDIX C

DELPHI QUESTIONNAIRE III

QUALIFICATION CRITERIA FOR THE
POWER REACTOR HEALTH PHYSICIST

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 as to 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 collegues.

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 March 11, 1983. Responses received after March 18, 1983 cannot be considered.

Thank you,

Lee R. Lacey

DELPHI QUESTIONNAIRE III

Respondent's Name: ______________________________ Date: ________

I. GENERAL EDUCATIONAL REQUIREMENTS (ENTRY-LEVEL)

This part of the questionnaire addresses the general educational requirements of a professional power reactor health physicist first entering the job market in 1983. Please rate the desirability of the various degree types and levels 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):

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

	most desirable	desirable	useful	unsatis-factory
Nuclear Engineering	4 7%	3 53%	2 33%	1 7%
Health Physics (Radiation Sciences)	4 100%	3 0%	2 0%	1 0%
Physics	4 0%	3 33%	2 60%	1 7%
Biology	4 0%	3 0%	2 67%	1 33%
Other engineering or engineering technology	4 0%	3 7%	2 87%	1 7%

DELPHI QUESTIONNAIRE III

II. GENERAL EDUCATIONAL REQUIREMENTS (Continued)

2. Assuming that the degree types involved are satisfactory, please rate the importance of the following degree levels by circling the appropriate number to the right of the degree level listed:

	essential	important	useful	unim-portant
Bachelors Degree	4 87%	3 7%	2 7%	1 0%
Masters Degree	4 0%	3 93%	2 7%	1 0%
Doctoral Degree	4 0%	3 13%	2 40%	1 47%

DELPHI QUESTIONNAIRE III

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

This part of the questionnaire addresses specific technical areas of study for a professional power reactor health physicist first entering the job market in 1983. These areas should be considered as educational study at the professional level. 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):

---

1. Please rate the importance of the below listed technical areas of study by circling the appropriate number to the right of the area of study listed:

	essential	important	useful	unim- portant
Atomic/Nuclear Physics	4 53%	3 33%	2 13%	1 0%
Radiation Detection and Measurement	4 100%	3 0%	2 0%	1 0%
Health Physics	4 93%	3 7%	2 0%	1 0%
Radiation Biology	4 47%	3 47%	2 7%	1 0%
Radiation Shielding	4 60%	3 20%	2 20%	1 0%

DELPHI QUESTIONNAIRE III

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

Environmental Health Physics	4 40%	3 40%	2 20%	1 0%
Radiation Dosimetry	4 80%	3 20%	2 0%	1 0%
Waste Disposal	4 40%	3 53%	2 7%	1 0%
Nuclear Reactor Engrg.	4 13%	3 47%	2 40%	1 0%
Computer Science/Tech.	4 33%	3 20%	2 47%	1 0%
Chemistry/Rad. Chemistry	4 27%	3 53%	2 20%	1 0%
Meteorology	4 13%	3 33%	2 53%	1 0%
Statistics	4 27%	3 40%	2 33%	1 0%
Systems Engineering	4 13%	3 40%	2 40%	1 7%
Risk Analysis	4 7%	3 33%	2 47%	1 13%
Epidemiology	4 7%	3 7%	2 53%	1 33%
Radiological Emergencies	4 40%	3 60%	2 0%	1 0%
ALARA	4 60%	3 40%	2 0%	1 0%
Technical Writing/ Communications	4 47%	3 47%	2 7%	1 0%
Supervision	4 20%	3 20%	2 60%	1 0%
Regulations	4 40%	3 47%	2 13%	1 0%

DELPHI QUESTIONNAIRE III

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

This part of the questionnaire addresses plant-specific orientation and training for a professional power reactor health physicist during the first few months of his or her assignment to a plant health physics staff. Please rate the importance of these 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 below listed plant-specific orientation and training topics by circling the appropriate number to the right of each topic:

	essential	important	useful	unim-portant
Nuclear Power Plant Technology	4 40%	3 53%	2 7%	1 0%
Plant Systems Training	4 87%	3 13%	2 0%	1 0%
Emergency Preparedness Training	4 67%	3 33%	2 0%	1 0%
Initial Assignment Rotation (all HP specialties)	4 40%	3 47%	2 13%	1 0%

DELPHI QUESTIONNAIRE III

	4	3	2	1
ALARA Implementation	33%	53%	13%	0%
Process/Effluent Data Acquisition & Analysis	27%	47%	27%	0%
General Employee Training	40%	20%	20%	20%
Plant Layout	93%	7%	0%	0%
Rad/Chem Operations	47%	40%	13%	0%
HP Procedures	73%	20%	7%	0%
Regulation/Site Experience	20%	47%	33%	0%
RAM Packaging & Transportation	13%	60%	20%	7%
Admin. Controls & Procedures	60%	37%	13%	0%
Radiological Controls	60%	40%	0%	0%
Radioactive Waste Practices	20%	67%	7%	7%
R O Equivalent Training	7%	20%	67%	7%
Public Relations	13%	27%	47%	13%
Reactor Physics	7%	20%	53%	20%
Surveys & Protection	47%	33%	20%	0%
Personnel Safety	53%	27%	20%	0%

DELPHI QUESTIONNAIRE III

IV. RADIATION PROTECTION MANAGER (RPM) EDUCATION/TRAINING AND EXPERIENCE

This part of the questionnaire addresses specific education/ training and experience criteria relevant to the RPM position at a commercial nuclear power plant. This educational training is in addition to entry-level college education and initial plant orientation and training (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 below listed educational training topics (technical & non-technical) relevant to the individual filling the RPM position at a nuclear plant:

	essential	important	useful	unimportant
Management/Supervisory Training	4 73%	3 20%	2 7%	1 0%
Public Relations	4 33%	3 33%	2 33%	1 0%
Public Speaking	4 20%	3 40%	2 40%	1 0%
Time Management	4 60%	3 33%	2 7%	1 0%

DELPHI QUESTIONNAIRE III

IV. RADIATION PROTECTION MANAGER (RPM) EDUCATION/TRAINING AND EXPERIENCE (Continued)

Periodic Technical Refresher Training	4 47%	3 47%	2 7%	1 0%
Team Building	4 33%	3 47%	2 20%	1 0%
SRO Training	4 0%	3 27%	2 73%	1 0%
Labor Relations	4 53%	3 20%	2 27%	1 0%
Administrative Functions	4 33%	3 53%	2 13%	1 0%
Radiological Engineering	4 33%	3 47%	2 20%	1 0%

2. Please circle the number representing the minimum years of experience that should be required (in each category listed below) for the position of RPM.

Total radiation protection experience (in years):

5	7	10
47%	20%	33%

Power reactor radiation protection experience (in years):

2	3	4	5
13%	20%	13%	53%

DELPHI QUESTIONNAIRE III

V. LICENSING/CERTIFICATION

This part of the questionnaire addresses licensing or certification for the position of RPM and/or other senior health physics positions at a commercial nuclear power plant (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 respond to the following statement by circling the appropriate number to the right of each statement:

	strongly agree	agree	disagree	strongly disagree
The NRC should require some type of license or formal certification for the position of RPM.	4 40%	3 13%	2 33%	1 13%
The NRC should require some type of license or formal certification for other senior health physics positions.	4 13%	3 13%	2 53%	1 20%
Formal certification should be encouraged for the position of RPM.	4 27%	3 47%	2 20%	1 7%
Formal certification should be encouraged for other senior health physics positions.	4 20%	3 67%	2 7%	1 7%

DELPHI QUESTIONNAIRE III

V. LICENSING/CERTIFICATION (Continued)

Licensing and/or formal certification is unnecessary for professional health physics positions at commercial power reactors.	4 7%	3 33%	2 27%	1 33%

APPENDIX D

GENERIC QUALIFICATION CRITERIA FOR THE ENTRY LEVEL POWER REACTOR HEALTH PHYSICIST

The following criteria should be followed in placing entry level professional personnel in power reactor health physics positions on the radiation protection staff of a nuclear power plant:

1. Degree Criteria

   1.1 Candidates shall have a Bachelor's Degree or equivalent experience. Individuals holding Master's Degrees should receive extra consideration.

   1.2 Degrees in Health Physics or Radiation Sciences are preferred. Degrees in Nuclear Engineering are acceptable. Degrees in other engineering or engineering technologies, Physics or Biology should be closely examined as to curriculum and required remedial training and education.

2. Curriculum Guidelines

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

1. Radiation Detection and Measurement
2. Health Physics
3. Radiation Dosimetry

4. Atomic/Nuclear Physics
5. Radiation Shielding
6. Technical Writing/Communications
7. Radiation Biology
8. Radioactive Waste
9. Chemistry/Radiological Chemistry
10. Nuclear Reactor Engineering
11. Radiological Emergencies
12. Environmental Health Physics

APPENDIX E

PLANT-SPECIFIC ORIENTATION AND TRAINING FOR THE ENTRY LEVEL POWER REACTOR HEALTH PHYSICIST

During the first few months of his or her initial assignment on the radiation protection staff of a nuclear power plant, the entry level power reactor health physicist should receive plant-specific orientation and training commensurate with the skill and knowledge factors required. The following orientation/training topics should be considered for this period. They are listed generally in order of importance, most important first:

1. Plant Systems Training
2. Plant Layout
3. Radiological Controls
4. Health Physics Procedures
5. Emergency Preparedness Training
6. Administrative Controls and Procedures
7. Surveys and Protection
8. ALARA Implementation
9. Personnel Safety
10. Radioactive Waste Practices
11. Process/Effluent Data Acquisition and Analysis
12. Radioactive Material Packaging and Transportation
13. Nuclear Power Plant Technology

14. Initial Assignment Rotation (Through all Health Physics Sections)
15. Radiological Chemistry Operations
16. Regulation/Site Regulatory History and Experience

APPENDIX F

GENERIC QUALIFICATION CRITERIA FOR THE RADIATION PROTECTION MANAGER

The following criteria should be considered in placing an individual in the position of Radiation Protection Manager (RPM):

1. Basic Technical Educational Criteria

   The basic technical educational criteria for a candidate for RPM should be consistent with that required for an entry level power reactor health physicist.

2. Advanced Education/Training Criteria

   Candidates for the position of RPM should have completed additional study in the following technical and non-technical areas of study. They are presented in order of importance, most important first:

   A. Management/Supervisory Training

   B. Periodic Technical Refresher Training

   C. Radiological Engineering

   D. Administrative Functions

3. Experience Criteria

   Candidates for the position of RPM should have a minimum of five years of power reactor health physics experience. Candidates with additional radiation protection experience outside the power reactor health physics area should receive extra consideration.

2

VITA

Lee Roy Lacey

Candidate for the Degree of

Master of Science

Thesis: QUALIFICATION CRITERIA FOR THE POWER REACTOR HEALTH PHYSICIST: A DELPHI APPROACH

Major Field: Occupational and Adult Education

Biographical:

Personal Data: Born in Seminole, Oklahoma, December 31, 1944, the son of Mr. and Mrs. L. R. Lacey. Married Carolyn S. Lacey March 25, 1967. Laurel L. Lacey, a daughter, was born April 17, 1969.

Education: Graduated from Summerville High School, Summerville, South Carolina, in May 1963; received Associate of Science degree from Bee County College in 1972; received Bachelor of Science in Engineering Technology degree from Oklahoma State University in 1977; completed the requirements for the Master of Science degree at Oklahoma State University in May, 1983.

Professional Experience: Nuclear Submarine Reactor Operator and Electronics Technician, U.S. Navy, 1966-1967; Staff Health Physicist, Duke Power Company, 1977-80; Reactor Health Physics Inspector, U.S. Nuclear Regulatory Commission, 1980; Manager, Radiological Training and Services, Quadrex Corporation, 1980-1983. American Board of Health Physics Certification, Part I, 1979; Certified Hazard Control Manager, 1981; member of the Atomic Industrial Forum Subcommittee on Radiation Protection; member of the Health Physics Society, American Nuclear Society, and American Society for Training and Development.