A curriculum model for Nevada Test Site Radiation Protection Technician training

Colleen F. Petullo

University of Nevada, Las Vegas

Follow this and additional works at: https://digitalscholarship.unlv.edu/rtds

Part of the Higher Education Commons

Repository Citation

https://digitalscholarship.unlv.edu/rtds/25

This Thesis is brought to you for free and open access by Digital Scholarship@UNLV. It has been accepted for inclusion in UNLV Retrospective Theses & Dissertations by an authorized administrator of Digital Scholarship@UNLV. For more information, please contact digitalscholarship@unlv.edu.
INFORMATION TO USERS

The most advanced technology has been used to photograph and reproduce this manuscript from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book. These are also available as one exposure on a standard 35mm slide or as a 17" x 23" black and white photographic print for an additional charge.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.
A curriculum model for Nevada Test Site Radiation Protection Technician training

Petullo, Colleen F., M.S.

University of Nevada, Las Vegas, 1989
THESIS APPROVAL

The thesis of Colleen F. Petullo for the degree of Master of Science in Adult/Technical Education is approved.

Chairperson, Dr. Thomas Kirkpatrick

Examin ing Committee Member, Dr. Clifford McClain

Examining Committee Member, Dr. Martha Young

Graduate Faculty Representative, Dr. Anthony Saville

Graduate Dean, Dr. Ronald Smith

University of Nevada
Las Vegas, Nevada
May, 1989

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
ABSTRACT

A research project was undertaken to develop a performance-based curriculum model for Nevada Test Site Radiation Protection Technicians. The study began with an overview of Radiation Protection Technician training curricula within the Department of Energy (DOE) Government Contractor system and the Training Accreditation Manuals used for program evaluation of DOE system training programs.

The research design included data from a two page questionnaire. Further data was provided from other Radiation Protection Technician training programs within the DOE system. The developed model utilized a five-phase/step approach to curriculum design encompassing (1) Needs Analysis, (2) Designing the Training Process, (3) Development of Curriculum and Support Materials, (4) Training Implementation, (5) Training Evaluation. The Needs Analysis determined the specific material to be covered in the training program.
Designing the Training Process involved choosing, from the core/generic job tasks identified in the Needs analysis, the specific knowledge and skills learning objectives for the program. Development of Curriculum and Support Materials involved choosing the method of instruction, identifying which tasks would be taught on-the-job and designing the qualification standard and lesson plans for the tasks. Implementing the training involved building a schedule of training that was workable within the constraints of normal Test Site operations. Evaluating the Training provided tools and suggested practices for the curriculum model to use.

Recommendations included the development of a documented and accountable on-the-job training program for newly hired Radiation Protection Technicians and develop a program for experienced Radiation Protection Technicians which helps them pass the National Registry examination.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>LIST OF TABLES</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF FIGURES</td>
<td>ix</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. THE PROBLEM</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>3</td>
</tr>
<tr>
<td>Assumptions of the Study</td>
<td>4</td>
</tr>
<tr>
<td>Limitations</td>
<td>10</td>
</tr>
<tr>
<td>Treatment of the Data and</td>
<td>11</td>
</tr>
<tr>
<td>Design of the Study</td>
<td></td>
</tr>
<tr>
<td>Definition of Radiation Protection</td>
<td>13</td>
</tr>
<tr>
<td>and Education Terms</td>
<td></td>
</tr>
<tr>
<td>Organization of the Study</td>
<td>13</td>
</tr>
<tr>
<td>2. REVIEW OF RELATED LITERATURE</td>
<td>15</td>
</tr>
<tr>
<td>Radiation Protection Training at</td>
<td>15</td>
</tr>
<tr>
<td>DOE Facilities</td>
<td></td>
</tr>
<tr>
<td>Background</td>
<td>15</td>
</tr>
<tr>
<td>DOE Contractor Radiation Protection</td>
<td>16</td>
</tr>
<tr>
<td>Technician Manpower Trends</td>
<td></td>
</tr>
<tr>
<td>DOE Contractor Radiation Protection</td>
<td>17</td>
</tr>
<tr>
<td>Technician Workforce Characteristics</td>
<td></td>
</tr>
<tr>
<td>General Job Description</td>
<td>17</td>
</tr>
<tr>
<td>Curriculum Development Theory</td>
<td>19</td>
</tr>
<tr>
<td>Chapter</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>Vocational Curriculum Development</td>
<td>22</td>
</tr>
<tr>
<td>Performance-Based Vocational Curriculum Development</td>
<td>24</td>
</tr>
<tr>
<td>Identifying Training Requirements</td>
<td>25</td>
</tr>
<tr>
<td>Method of Presentation</td>
<td>28</td>
</tr>
<tr>
<td>Chapter Summary</td>
<td>31</td>
</tr>
<tr>
<td>3. DESIGN OF THE STUDY</td>
<td>32</td>
</tr>
<tr>
<td>Research Design</td>
<td>32</td>
</tr>
<tr>
<td>Distribution</td>
<td>33</td>
</tr>
<tr>
<td>Instrument</td>
<td>33</td>
</tr>
<tr>
<td>Instrument Validity</td>
<td>34</td>
</tr>
<tr>
<td>Instrument Reliability</td>
<td>34</td>
</tr>
<tr>
<td>Treatment of the Data</td>
<td>35</td>
</tr>
<tr>
<td>Curriculum Models Surveyed</td>
<td>35</td>
</tr>
<tr>
<td>Chapter Summary</td>
<td>39</td>
</tr>
<tr>
<td>4. RADIATION PROTECTION TECHNICIAN CURRICULUM MODEL</td>
<td>40</td>
</tr>
<tr>
<td>Model Implementation</td>
<td>40</td>
</tr>
<tr>
<td>Phase 1 - Analyze Needs</td>
<td>40</td>
</tr>
<tr>
<td>Phase 2 - Design the Training Process</td>
<td>46</td>
</tr>
<tr>
<td>Phase 3 - Develop Curriculum and Support Materials</td>
<td>46</td>
</tr>
<tr>
<td>Phase 4 - Implement the Training</td>
<td>50</td>
</tr>
<tr>
<td>Phase 5 - Evaluate the Training</td>
<td>51</td>
</tr>
<tr>
<td>Chapter Summary</td>
<td>52</td>
</tr>
</tbody>
</table>
5. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS. 53
   Summary of the Findings .............................. 53
   Conclusions ......................................... 54
   Recommendations for Radiation Protection
   Technician Training Curricula ....................... 55
   Recommendations for Future Study ................. 57

SELECTED BIBLIOGRAPHY ................................. 58

APPENDICES ...............................................
   A. NEVADA TEST SITE RADIATION PROTECTION
      TECHNICIAN TECHNICIAN QUESTIONNAIRE ... 61
   B. REYNOLDS ELECTRICAL & ENGINEERING CO.,
      INC., RADIATION PROTECTION TECHNICIAN
      JOB DESCRIPTION ................................. 64
   C. RADIATION PROTECTION & EDUCATION
      TERMS AND DEFINITIONS .......................... 65
   D. QUESTIONNAIRE COVER LETTER .................... 72
## TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Major Data Source Categories</td>
<td>11</td>
</tr>
<tr>
<td>2. Standard Verbs for the Identification of Human Capability</td>
<td>30</td>
</tr>
<tr>
<td>3. Results of the Questionnaire Survey</td>
<td>43</td>
</tr>
</tbody>
</table>
### FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Field Operations Section Organizational Chart</td>
<td>5</td>
</tr>
<tr>
<td>2. Defense Waste Management Department Organizational Chart</td>
<td>6</td>
</tr>
<tr>
<td>3. Laboratory Operations Section Organizational Chart</td>
<td>7</td>
</tr>
<tr>
<td>4. Environmental Training Organizational Chart</td>
<td>8</td>
</tr>
<tr>
<td>5. A Model for Curriculum Design (Taba)</td>
<td>37</td>
</tr>
<tr>
<td>6. The Goldstein Model of an Instructional System</td>
<td>38</td>
</tr>
</tbody>
</table>
CHAPTER 1

THE PROBLEM

Introduction

The purpose of this study was to determine the contents and common subject areas associated with the Reynolds Electrical & Engineering Company, Incorporated (REECo) Radiation Protection Technician (Radiation Monitor) job at the Nevada Test Site (NTS). Once the common subject areas were found, an appropriate training curriculum was developed so that Radiation Protection Technicians (RPTs), in future training programs, could be trained in these common areas.

The philosophy of radiation exposure "as low as practicable" (ALAP) had its origins in the post-Manhattan Project era. Before World War II, radiation protection was based on the Tolerance Dose concept. This radiation protection standard was based on the belief of the "threshold theory" (meaning there existed a minimum dose to cause deleterious effects). Observations of
occupationally exposed persons to exposures within this limit had revealed no deleterious effects of any kind attributable to radiation.

With the flurry of new data and information regarding radiation and radiation exposures from the Manhattan Project, it was believed that the period of observation of these occupationally exposed workers may not have been long enough to be sure that exposure at this rate could be safely continued through life.

The first meeting of the National Committee on Radiation Protection (NCRP) was held in December 1946. Committee No. 1, dealing with radiation from external sources was regarded as the prime committee for developing the basic protection philosophy for the whole NCRP. The new concept of "permissible dose standard" emerged. This standard was based on the probability that any practical limit of radiation exposure may involve some risk of possible harm. The goal of the setting of the "permissible dose" was to create a limit where the risk was so small that it would be readily acceptable to the normal individual; that is, a risk essentially the same as in ordinary present occupations not involving exposure to radiation.

It was emphasized at this time, that with adherence to the principles of radiation protection, radiation exposure could be minimized. Thus the philosophy of
maintaining doses to the lowest practical level, or as low as practicable (ALAP) had emerged. ALAP was based on the most conservative view that any exposure has a risk of a deleterious effect (linear dose-response relationship). The philosophy was to emphasize sound radiation protection plans and programs that would actively minimize radiation exposure; therefore, minimizing the risk of deleterious effect.

The philosophy ALARA found its origins in ICRP Report No. 9, and ALARA was later clarified by ICRP Report No. 22 ("readily" was later changed to "reasonably"). The philosophy of ALARA exists today in Title 10 of the Code of Federal Regulations Part 20.1(c) and in DOE Order 5480.11.

With the birth of ALAP/ALARA came the birth of a new vocation/occupation, that of the Radiation Protection Technician to ensure adherence of this philosophy and the regulations which carry the weight of the law.

Statement of the Problem

There has been a problem with past Reynolds Electrical & Engineering Company, Inc. (REECo) Radiation Protection Technician (RPT) training programs at the Nevada Test Site (NTS) not meeting the needs of most of
the students. The reason training has not met the needs is because these RPTs, once hired and trained, are assigned to one of several work locations around the NTS. Typical work locations are the Decontamination Facility, drilling rigs, experimental tunnels, laboratory support services and/or environmental monitoring support. (Reference Figures 1 through 4 showing the REECo organization and personnel charts.) These facilities all require that the RPTs have some common fundamental knowledge of radioactivity and radiation protection procedures. Specifically, this study attempted to determine the following:

1. What the core curriculum for the Radiation Protection Technician training program should be.

2. What portions of the curriculum should be On-the-Job training.

3. What evaluation methods should be included in the curriculum model.

Assumptions of the Study

In this study several assumptions were made:

1. It was assumed that the foundation of a Radiation Protection Technician (RPT) training curriculum should contain basic technical and/or vocational components such as knowledge of nuclear physics theory, radioactive decay, radiation detection instrumentation...
**Figure 1. Field Operations Section Organizational Chart.**

<table>
<thead>
<tr>
<th>Field Operations Section (A3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Radiological Field Operations Section Chief (5)</td>
</tr>
<tr>
<td>1. Senior Health Physicist (5)</td>
</tr>
<tr>
<td>1. Health Physicist II (5)</td>
</tr>
<tr>
<td>1. Environmental Analyst (5)</td>
</tr>
<tr>
<td>1. Secretary II (1)</td>
</tr>
<tr>
<td>1. Senior Clerk (1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field Support Services Branch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Radiological Field Operations Branch Chief</td>
</tr>
<tr>
<td>1. Radiological Instrumentation Supervision (5)</td>
</tr>
<tr>
<td>2. Director (1)</td>
</tr>
<tr>
<td>12. Instrumentation Technician (1)</td>
</tr>
<tr>
<td>1. Laboratory Technician (1)</td>
</tr>
<tr>
<td>1. Senior Clerk (1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>User Support Services Branch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Radiological Field Operations Branch Chief (5)</td>
</tr>
<tr>
<td>5. Radiological Field Operations Supervision</td>
</tr>
<tr>
<td>5. Radiological Field Operations (5)</td>
</tr>
<tr>
<td>33. Director (1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sewing Services Branch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Radiological Field Operations Branch Chief</td>
</tr>
<tr>
<td>4. Radiological Field Support Supervision (5)</td>
</tr>
<tr>
<td>22. Director (1)</td>
</tr>
<tr>
<td>1. Chief Clerk (1)</td>
</tr>
<tr>
<td>2. Senior Clerk (1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field Operations Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
</tr>
</tbody>
</table>
Figure 2. Defense Waste Management Department Organizational Chart.
Figure 3. Laboratory Operations Section Organizational Chart.
ENVIRONMENTAL TRAINING

Figure 1. Environmental Training Section Organizational Chart.
(operation and theory), fundamental practices in radiation protection (such as using time, distance and shielding countermeasures to reduce radiation exposure) and the federal regulations/DOE Orders followed by all NTS employees.

2. It was assumed in this study that the personnel employed in radiation protection at the NTS were qualified to report, with a reasonable degree of accuracy, the basic educational and/or training needs of NTS RPTs.

3. It was assumed for this study that individual respondents would judge the importance of the various questionnaire items based on their own frame of reference and career experience.

4. It was assumed for this study that the respondents realized the necessity of both "formal education" and "work experience" for the training requirements of an entry level RPT.

5. It was assumed that opinions expressed by those respondents used in this study would have reasonable long-term applicability and validity for NTS RPTs of the future.

6. Usually a Job Analysis questionnaire contains questions on the "Difficulty, Importance and Frequency" of task performance. It was assumed for this study that all tasks performed by the RPTs are important and are of
sufficient difficulty to warrant training. The average frequency the tasks were performed was what was determined to facilitate the development of the generic curriculum model.

Limitations

The limitations of this particular study were as follows:

1. The study was developmental; therefore, input from job incumbents followed no previously established patterns and represented unscientific, divergent views.

2. Job content research was based primarily on data gathered from job incumbents, with other Radiation Protection Technicians in the Department of Energy (DOE) system and Nuclear Power industry serving as secondary data sources.

3. Distribution of the questionnaire was conducted by "in-house" mailings to all job incumbents with a cover sheet signed by the Health Physics Department Manager (See Appendix D). Distribution like this carries inherent limitations therein.
## Treatment of the Data and Design of the Study

Data for analysis was gathered from three major sources and categorized as shown in Table 1.

<table>
<thead>
<tr>
<th>Radiation Protection Personnel</th>
<th>Education</th>
<th>Publications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervisors</td>
<td>Administrators</td>
<td>EDUCATION</td>
</tr>
<tr>
<td>Incumbents</td>
<td>Instructional Staff</td>
<td>Books</td>
</tr>
<tr>
<td>Regulators</td>
<td>Students</td>
<td>Journals</td>
</tr>
<tr>
<td>Training Programs</td>
<td>Vocational/Trade Schools</td>
<td>Dissertations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Magazines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INDUSTRY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Books</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Magazines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trade Journals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Training Manuals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GENERAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Govt. Documents</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Opinions varied among managers and training staff concerning the contents of the NTS Radiation Protection Technician training curriculum. The curriculum in use prior to the completion of this study was constructed primarily by Training Advisory Committee (managers and trainers) member decisions with no RPT input. As the research and analysis continued, the curriculum's composition was determined more and more from incumbent and first-line supervision input.

Several models in the field of curriculum design were examined before the final selection was made:

1. Tyler's Model, because of its use of multiple information sources, as a basis for deciding objectives (15, 1949, p.5).

2. Taba's Model, due to its wide scope and general application (13, 1962, p.438).

3. Goldstein's Model, due to its emphasis on planning and evaluation, and the ability to provide ongoing program revision (6, 1974, p.18).

The model that was finally chosen for this study was from The Guide to Good Practices in Radiation Protection Training (20, 1988, p.3-17). This model was chosen because the curriculum development method outlined gave the best assurances that a competent, entry level employee would result at the end of the training program.
Definition of Radiation Protection and Education Terms

A selected glossary of Radiation Protection and Education terms is included in Appendix C.

Organization of the Study

The study was divided into five chapters:

Chapter 1 reveals the problem, which included a short history of the weapons testing program and the As Low As Reasonably Achievable (ALARA) philosophy. The chapter clarifies that the purpose of the study was to develop a generic curriculum model for NTS Radiation Protection Technician training. Also included, were definitions of radiation protection and education terms used in the study.

Chapter 2 is a selective review of related literature, which included studies of existing curriculum models in Radiation Protection Technician training and vocational/technical curriculum development models were also reviewed. Special attention was given to the roles of advisory committees, instructional staff, students and industry in curriculum development. Additionally, the
cognitive domain in Bloom's Taxonomy of Educational Objectives was reviewed, keeping in mind its relation to Radiation Protection Technician training.

Chapter 3 reflects the design of the study, demonstrated instrumentation, distribution procedures, treatment of the data, and a survey of curriculum models used in the study.

Chapter 4 is the NTS Radiation Protection Technician curriculum model, which contained schematic and narrative versions of the final model.

Chapter 5 is the summary, conclusions, and recommendations, which contained a summary and conclusive analysis of the study and made final recommendations to the Company and recommendations for future studies.
Chapter 2

REVIEW OF RELATED LITERATURE

Radiation Protection Technician

Training at DOE Facilities

The review of related literature was selective and computed by researching existing Radiation Protection Technician (RPT) training curriculums within the DOE contractor system using a performance-based approach to training. The Training Accreditation Program Manuals which described the objectives and criteria against which DOE nuclear facility training is evaluated for accreditation were also reviewed. Other publications dealing with curriculum development for adult training programs were also reviewed.

Background

In recent years increased attention has been given to all aspects of the operation of Department of Energy
(DOE) nuclear facilities. Contributing to this is the finding that the severity of the accident at the Three Mile Island nuclear power plant in Pennsylvania in 1979 had, in large part, been attributed to personnel training deficiencies. Initially the impact of the Three Mile Island accident and the lessons learned were directed only to DOE reactor facilities. This resulted in numerous initiatives by the DOE to upgrade the safety of operations and to improve the training of personnel responsible for operating these facilities.

Many of the DOE facility training programs have been in place for years and while their development was not structured using the performance-based training approach, over time, these programs have evolved to include many performance-based training characteristics. For other programs, efforts have occurred to enhance the programs by using performance-based training approaches. It is the wish of the DOE that these programs not be discarded, but rather that performance-based training methods be used to validate the content and methods of conducting these programs and to revise them where required.

DOE Contractor Radiation Protection Technician Manpower Trends

"Growth in radiation protection manpower has not occurred evenly throughout the DOE contractor system, but has been concentrated in those facilities whose functions
are primarily waste processing and management, fuel reprocessing, and weapons fabrication and testing. Seventy-two percent of the FY-1983 Radiation Protection Technicians were employed in weapons fabrication and testing, the fuel cycle, reactors and waste processing and management" (20, 1984, p. 10).

DOE Contractor RPT Workforce Characteristics

In general, the facilities that provided formal in-house training, as a condition of employment, for their RPTs did not require any formal education beyond high school. This observation held true for the REECo RPTs as well (see Appendix C).

The applicants, more often than not, were required to pass an exam which tests for specific, entry level, math and science knowledge necessary for successful completion of the training program.

The facilities with lower entry-level requirements tended to provide more hours of formal classroom training and have designed their programs so that all classroom training was completed before new employees were assigned to work locations for the on-the-job portion of their training program.

General Job Description

Radiological Protection Technicians at the Nevada Test Site perform fundamental assignments relating to the protection of NTS workers from unwarranted radiation exposure, aid in the evaluation or radiation hazards, and
help in the development/implementation of methods and procedures necessary to ensure radiological safety within their area of control.

These individuals:

1. Assist in the control of entry and exit requirements at radiation exclusion areas;

2. Issue protective clothing and equipment to personnel and instruct workers in its proper use;

3. Perform simple radioactive waste management duties including receipt and disposal of radioactive waste and associated minor recordkeeping;

4. Perform decontamination of equipment, operate mobile decontamination equipment, washing machines, extractors and dryers used in the decontamination of protective clothing and equipment;

5. Perform radiation surveys and collect samples;

6. Perform physical checks and maintain records on the location and operating condition of equipment used by the Health Physics Department;

7. Assist in the selection and collection of environmental samples for evaluation;

8. Assist in the handling and use of radiation sources;

9. Perform radiation surveys on equipment and material prior to its disposal (11, 1988, p. 1).
Curriculum Development Theory

Although little material was available that used Radiation Protection as the subject, the literature showed that curriculum design was not simply a function of subject matter area. A model gives order to the process. Hilda Taba states that:

Generally speaking, a conceptual system for curriculum or theory of curriculum is a way of organizing thinking about all matters that are important to curriculum development: what the curriculum consists of, what its important elements are, how these are chosen and organized, what the sources of curriculum decisions are, and how the information and criteria from these sources are translated into curriculum decisions (12, 1962, p. 420).

Ms. Taba believed that the curriculum should be designed by the teachers (Subject Matter Experts) rather than handed down by higher authority. She advocated an inductive approach to curriculum development, starting with specifics and building up to a general design as opposed to the more traditional deductive approach of starting with the general design and working down to the specifics (21, 1982, p. 161).
The following five-step sequence of steps is what Taba proposed for accomplishing curriculum change:

1. Production by teachers of pilot teaching-learning units representative of the grade level or subject area. Taba saw this step as linking theory with practice.

2. Testing experimental units. The units must be tested to establish their validity and teachability and to set their upper and lower limits of required abilities.

3. Revising and consolidating. The units are modified to conform to variations in students needs and abilities, available resources and different styles of teaching so that the curriculum may suit all types of classrooms. Taba would charge training supervisors with the task of "stating the principles and theoretical considerations on which the structure of the units and the selection of content and learning activities are based and suggesting the limits within which modifications in the classroom can take place."

Taba recommended that such "considerations and suggestions might be assembled in a handbook explaining the use of the units." (This is done at the NTS by the use of Training Plan Manuals.)
4. Developing a framework. After a number of units have been constructed, the curriculum planners must examine them as to adequacy of scope and appropriateness of sequence. The curriculum specialist would assume the responsibility of drafting a rationale for the curriculum which has been developed through this process.

5. Installing and disseminating new units. In order for teachers to effectively put the teaching-learning units into operation in their classrooms, Taba stated administrators should arrange appropriate training (21, 1982, pp. 161-164).

Ralph Tyler's model is perhaps one of the best known models for curriculum development because of the special attention given to the planning phases. Tyler recommended that curriculum planners identify general objectives by gathering data from three sources: the learners, contemporary life outside the school and the subject matter.

The learners: Educational objectives should be obtained by gathering and analyzing data relevant to student needs and interests. The total range of needs, (i.e., educational, social, occupational, physical, psychological, and recreational) is studied. Tyler recommended observations by teachers, interviews with students, interviews with parents (in this case supervisors), questionnaires and tests as techniques for collecting data about students (13, 1949, p. 12).
Contemporary Life: Tyler suggested that curriculum planners develop a classification scheme that divides life into various aspects such as health, family, recreation, vocation, religion, consumption, and civic roles (13, 1949, p.19).

The Subject Matter: The general objectives come from the subject matter experts. These objectives or goals may be pertinent to specific disciplines or may cut across disciplines.

He then said that the general objectives should be "filtered" through two screens: the educational and social philosophy of the school (Company) and the psychology of learning. The general objectives that pass through the two "screens" then become specific instructional objectives (21, 1982, p. 156).

Vocational Curriculum Development

While the systematic development of instruction is a specific procedure that can be described in detail, the procedure is not specific to subject matter or vocations. It seems that regardless of the subject matter, the procedure for development is basically the same.

Mager and Beach describe three phases of course development: the preparation phase, the development phase and the improvement phase. Each phase includes several steps:

1. Preparation Phase: Designed to insure that all the information and practice necessary to perform the job are included in the course. This phase leads to the systematic derivation of course objectives, and begin with the job itself rather than with content.

   a. Job Description: Describe, in general terms, what someone does when performing the job.
b. Task Analysis: Describe job performance in finer detail, listing each of the tasks which the job is composed and describing the steps in each of these tasks.

c. Target Population: The student population is described, as it exists, rather than as you would like it to be.

d. Course Prerequisites: These are prepared primarily on the basis of the student description, and are adjusted on the basis of the course objectives.

e. Course Objectives: Derived from the task analysis information and may be adjusted on the basis of course prerequisites and such administrative constraints as available time and facilities.

f. Criterion Examination: (Similar to final inspection) is developed strictly from the course objectives, and the prerequisites test (entering skill test) is developed strictly from the course prerequisites (9, 1967, p. 3).

2. Development Phase: Begins by outlining instructional units in terms of job tasks so that at the end of each unit the student will be able to do something that he/she couldn't do before, thus helping to insure continued motivation of the student. Preliminary sequencing of the units is then carried out according to guides intended to maximize student skill and course efficiency. Content is identified, instructional procedures or materials relevant to each lesson are listed, and an appropriate selection is made. Final sequencing is established, lesson plans are completed and the course is ready for tryout (9, 1967, p. 5).

3. Improvement Phase: Involves checking to see how well the instruction meets the objectives, and checking to see how the objectives continue to meet the job. Indicated modifications are then made, and another tryout is conducted (9, 1967, p. 6).
Performance-Based Vocational Curriculum Development

Performance-based training has proven to be a highly effective means of ensuring that technical support personnel like Radiation Protection Technicians are trained to conduct their assignments safely and efficiently. "The commercial nuclear power industry, as well as others in private industry, initiated a performance-based training development process which has had significant positive impact on personnel training" (21, 1988, p. I.2).

Following along with performance-based training development and evaluation practices, the NTS Basic Radiation Protection Technician training program comprised a mixture of both classroom and on-the-job training. The process by which the curriculum was developed, however, did not. The Company plans to adopt the performance-based training development process by the end of Fiscal Year 1989. It should be noted that the Nevada Test Site Radiation Protection Technician training program does not fall under the DOE order for accreditation. REECo plans to adhere to DOE facility
training accreditation requirements so that if/when NTS RPT training accreditation comes to pass, an "accreditable" training program will already be in place.

Identifying Training Requirements

The primary methods used for identifying training requirements include: Needs Analysis; Job Analysis; and Task Analysis. These analyses provide assurance that training is the appropriate solution to performance problems, and will identify requirements that serve as the basis for the design and development of performance-based training programs.

Job and task analyses are two distinct phases of the analytical procedure used to find out exactly:

- What people do in their jobs;
- What conditions they work under;
- What are the knowledge, skills and abilities (KSAs) they must possess to perform their jobs adequately;
- What are the standards for adequate performance; and
- What are the consequences of improper job performance (20, 1988, p. 6)?

The knowledge and skills required to perform the job are identified by structured interviews of highly experienced job incumbents, often called the subject-matter expert (SME). These interviews are planned, specific-subject dialogues and are conducted and controlled by the interviewer. The interviewer needs to
be familiar with both the subject area and the individuals being interviewed. Facility procedures should also be analyzed, either instead of or in conjunction with job incumbent interviews to obtain the required information.

It should be noted that there are several variations to this approach that provide essentially the same results. Sometime the SME is the person performing the analysis (This was the case for this study.). In this case, interviews are unnecessary. The members of the training staff are often the subject-matter experts, and they perform the analysis through group discussion. This particular approach is called a "Table Top Analysis" (20, 1988, p. 7).

A job analysis simply identifies and ranks all the tasks associated with a job. A task analysis identifies the elements, and the knowledge and skills for each element, that are necessary to perform each of the many tasks which make up an individual job (20, 1983, p. 6).

In developing a competency/performance-based training program, how the tasks are stated is almost as important as the selection of the tasks themselves. Blank gives a guide to writing task statements by saying that it should meet the following criteria:
A job task:

1. Is a valuable accomplishment for which an employer or consumer is willing to pay.
2. Is a complete unit of work performed on the job; when completed, the worker feels that something has been accomplished.
3. Has definite beginning and ending points.
4. May be broken down into several procedural steps, from start to finish.
5. May be typical assignment given to a worker on the job.
6. Results in a finished product or service or change in the work environment.
7. Has meaning for the trainee to want to learn; results in some meaningful accomplishment.
8. Makes sense for the student to learn as a separate instructional unit.
10. Is short and precise.
11. Can usually be learned in about 6 to 30 hours (1, 1982, p. 78).

Mager and Beach have identified five types of performance with which we can associate expected learner performance. These are:

1. Discrimination - (Knowing when to do it, Knowing when it is done)
2. Problem Solving - (How to decide what to do)
3. Recall - (Knowing what to do, Knowing why to do it)
4. Manipulation - (How to do it)
5. Speech - (How to say it) (9, 1967, pp. 44-51).
Method of Presentation

Many different methods of presentation are available to choose from to use in the process of changing behavior. There is no one method which will serve best under all circumstances. Each method has its advantages, limitations, and special applications. It becomes a problem of selecting the instructional method which best helps the learner reach the instructional objective.

The retention of learned material is influenced by the nature of the material, the use to which it is put, and the way in which it is learned (16, 1971, p. 11).

The key to instructional method selection, then, is the learning objective itself. What is it you want the learner to be able to do after his/her encounter with the learning situation? What kind of performance will be expected of the learner? Only after you have answered these questions are you in a position to pick an appropriate instructional method.

Concerning the instructional method, Trice stated:

Formal training (lecture) is most effective as a means of presenting generic radiation protection concepts and of introducing trainees to methods and procedures of comprehensive radiation safety programs. Because such
theoretical concepts are applicable across the broad range of radiation protection situations encountered by trainees, the structured uniformity imposed by formal classroom training is appropriate to the materials to be presented, and formal testing is an appropriate technique for determining whether or not trainees have sufficiently mastered the training material (14, 1984, p. 41).

Material that is meaningful to the learner is retained longer than that which is not. Thus understanding the material, seeing its relationship to previous learning or the individual's goals and objectives, and his/her awareness of the practical utility of the material to be learned will increase retention (16, 1971, p. 11).

One of the main benefits to be derived from task analysis research is the derivation of behavioral learning objectives.

According to Gagne and Briggs: The behavioral objectives should contain a description of the desired terminal behavior, including specification of the necessary evidence to ensure completion. This includes stating the conditions of performance and the acceptable level of performance. For example, from memory the Radiation Protection Technician will state the emergency call-out personnel list. With the development of these objectives completed, the second step is to classify the objectives into categories of learned capabilities. These learned capabilities are:

a) Intellectual Skill
b) Cognitive Strategy
c) Information
d) Attitude
e) Motor Skill

The classification of the knowledge categories into the learning capabilities is accomplished by relying on the verbs contained in the task statements. Table 2 gives examples of standard verbs used in the identification of
human capabilities. After the appropriate human capability has been identified, the best presentation method can be selected.

Table 2. STANDARD VERBS FOR THE IDENTIFICATION OF HUMAN CAPABILITY

<table>
<thead>
<tr>
<th>Human Capability</th>
<th>Sample Standard Capability Verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intellectual Skill</td>
<td>Discriminates</td>
</tr>
<tr>
<td></td>
<td>Identifies</td>
</tr>
<tr>
<td></td>
<td>Classifies</td>
</tr>
<tr>
<td></td>
<td>Demonstrates</td>
</tr>
<tr>
<td></td>
<td>Generates</td>
</tr>
<tr>
<td>Cognitive Strategy</td>
<td>Originates</td>
</tr>
<tr>
<td>Information</td>
<td>States</td>
</tr>
<tr>
<td>Attitude</td>
<td>Chooses</td>
</tr>
<tr>
<td>Motor Skill</td>
<td>Executes</td>
</tr>
</tbody>
</table>
Chapter Summary

This chapter concentrated on research on existing Radiation Protection Technician curriculums within the DOE system.

Also examined were various curricular models and principles. Included were acknowledged components used in curriculum development and evaluation such as management, instructional staff, advisory committees and students.
Chapter 3

DESIGN OF THE STUDY

This study was conducted by using various resources, including questionnaires and formal research. The research provided the theoretical and practical foundation on which other elements of the study could be based. The research instrument was created by developing a shortened version of the questionnaire used in the national, job content study of nuclear power plant Health Physics Technicians, done by the Institute of Nuclear Power Operations (INPO), existing NTS Radiation Protection Technician training curriculums, other DOE contractor RPT curriculums and the REECo job description for a Radiation Monitor I (entry level, see Appendix B) as a base.

Research Design

Groups surveyed for this study included:

1. Job incumbents at the NTS.
2. Supervisors of RPTs at the NTS.
3. Managers of the work groups/agencies where the RPTs are assigned.
Distribution

The questionnaire (see Appendix A) was administered to a 55 person universe which included job incumbents, supervisors and managers. The population universe that was chosen was the NTS employees because the NTS is the only facility in the United States where nuclear weapons testing is performed. The NTS employees were the only population that could provide the information needed for this study. Distribution of the questionnaire was accomplished primarily through the intra-company mail system using the Health Physics Department employee listing as the mailing list source.

Instrument

One instrument was used to gather the data. The questionnaire, shown in Appendix A, focused on the frequency with which common job tasks were performed and also had a remarks section. The questionnaire had 19 items and used a six-response, numbered scale for the frequency of performance of the task(s). Number 0 on the
scale was "Never", meaning "Not part of the job"; number 1, "Rarely", meaning "Must be able to perform the task but the task was actually only performed once a year or less often"; number 2, "Seldom", meaning "Performed about 3 or 4 times/year"; number 3, "Occasionally", meaning "Performed about once a month"; number 4, "Often", meaning "Performed about once a week"; and number 5, "Very Often", meaning "Performed daily". The 20th item was the remarks section for the respondent to indicate any special task knowledge (i.e., not listed in questions 1 through 19) they used in the performance of their job.

Instrument Validity

The instrument was developed by using a shortened version of a questionnaire created by the Institute for Nuclear Power Operations (INPO) for a national, job content study of Health Physics Technicians in nuclear power plants, existing Radiation Protection Technician training curriculums which were developed jointly by training personnel and RPT supervisory personnel, and NTS Health Physics personnel.

Instrument Reliability

The instrument was submitted to a panel of intra-Company experts and they agreed the questions were relevant to the job tasks performed by the NTS RPTs.
Treatment of the Data

The questionnaire results were counted manually using a Radio Shack EC-4008 scientific calculator for computations. The data was summed up to determine what the majority of respondents answered with respect to a questionnaire item. Depending on which side of the majority a questionnaire item fell, the decision to train or not train for that skill/ability was determined. The results are shown in Appendix A. Tables and figures indicating any response comparisons and patterns are displayed and analyzed in Chapter 4.

Curriculum Models Surveyed

Curriculum models reported in the literature appeared both in narrative form and schematic configuration. Models used in the study were limited to those with some degree of relevance to Radiation Protection Technician training.

Taba, cited in Chapter 2, developed a basic model for curriculum design. Her model, shown in Figure 5, had certain components useful in specialized programs like Radiation Protection such as;
Goldstein's model was a systems approach schematic emphasizing specific instructional objectives, controlled learning experiences to achieve the objectives, criteria for performance, and evaluation.

This model, shown in Figure 6, involved three phases: assessment, training and development, and evaluation. The most important aspect of the model was that it represented the total system, incorporating the important instructional processes that should be part of a well conceived educational and/or training program (6, 1974, p. 18).

The model had several advantages when applied to health physics industry related programs. First it provided a frame of reference for planning and evaluation. It emphasized that evaluation was an important part of the total system and not an activity undertaken only when something was wrong. Second, use of the model gave impetus to the establishment of training objectives and the development of evaluation procedures. It directed attention to the agreement that should exist between industry goals and overall educational objectives and added the necessary emphasis to evaluation planning.
Objectives to be Achieved

Determined by Analysis of:
1. Culture and its needs
2. The learner and learning processes, and principles
3. Areas of human knowledge and their unique functions
4. Democratic ideals

Classified by:
1. Types of behavior
2. Content areas
3. Areas of needs

Levels of:
1. Over-all aims of education
2. School-wide objectives
3. Specific instructional objectives

Selecting Curriculum Experiences

Determined by what is known about:
- Nature of Knowledge Development
- Learning
- Learner

Dimensions of:
- Content
- Learning experiences

Affected by:
- Resources of the school
- Role of other educational agencies

Possible Centers for Organizing Curriculum

Determined by requirement of:
- Continuity of learning
- Integration of learning

Centers of organization:
- Subjects
- Broad fields
- Areas of living
- Needs, experiences
- Activities of children
- Focusing ideas
- Etc.

Affected by and affecting:
- The school organization
- Methods of using staff
- Methods of accounting for learning

The Scheme of Scope and Sequence

Determined by:
- Requirements of scope of learning
- Requirements of continuity of learning

Dimensions of:
- Scope and sequence of content
- Scope and sequence of mental operations

Affected by:
- Centers of organizing curriculum

Figure 5: A Model for Curriculum Design (Taba)
Figure 6: The Goldstein Model of an Instructional System
This model also represented a closed-loop system that used feedback to modify the program continually which is necessary in a dynamic industry training program. Programs were always viewed as unfinished products; they could be continually modified as a result of feedback information indicating whether the program objectives were being met.

Chapter Summary

This chapter identified the research approach, reviewed the elements and instrumentation of the research design, and surveyed various curriculum models. The curriculum models surveyed provided several components which were used in selecting the final Radiation Protection Technician Training Curriculum Model including:

1. The Taba Model contained methods for selecting curricular experiences and organizing curriculum.

2. The Goldstein Model emphasized the need for correlating Company (industry) goals with educational goals.

These components were all found in The Guide to Good Practice in Radiation Protection Training Document (20, 1988, pp. 3-17) which became the practical and/or operational base for the final Radiation Protection Technician Training Curriculum Model.
Chapter 4

RADIATION PROTECTION TECHNICIAN CURRICULUM MODEL

The program model described in the Guide to Good Practice in Radiation Protection Training Manual (20, 1988, p. 3-17) utilized a 5 step/phase outline to Performance-Based Training Program Development. When employed for the NTS Radiation Protection Technician (RPT) training program development, this approach required that the Training Staff gather developmental input from the Field Operations Section of the Health Physics Department.

Model Implementation

The objective of a training program is to ensure the safe and efficient operation of the facility. To accomplish this, the following was done:

Phase 1 - Analyze Needs

Some of the circumstances which indicate a Needs Analysis should be completed include: 40
1. Changes in organizational goals, objectives, and future plans;
2. Development and implementation of a performance-based training program;
3. Major changes in the scope of jobs and/or tasks;
4. Shortages of qualified personnel or other changes in the composition of the work force;
5. Changes in regulatory requirements;
6. Facility modifications (existing and planned) and technological changes;
7. Job performance deficiencies;
8. Training not being conducted on tasks that impact safety and reliability; and
9. Training not being conducted on tasks which are difficult to learn on the job.

The distributed questionnaire had clearly defined objectives which ensured that the amount and kind of data that was gathered was sufficient to make a well-informed and effective decision about staff development. The following describes the job analysis performed for this study:

Of the 55 questionnaires distributed, 43 were returned but one was unusable. Therefore, 42 questionnaires were used to compile the data.
If a majority of the respondents answered in the ranges from 0 to 2, then the material would not be included in the generic curriculum. The rationale for this decision was that if a majority of the respondents, at the most, only seldomly required the knowledge/skill, it would more appropriately be included in the Qualification Standard (Qualification Check-Off list) of a work location where the knowledge/skill was frequently required.

If a majority of the respondents answered in the ranges from 3 to 5, then the material would be included in the developed generic curriculum. This indicated that a majority of the respondents required this knowledge/skill, therefore, it should be included in the generic curriculum.

The items that would not be included in the "generic" training curriculum would still be trainable items. The training of these items, however, would only occur when the Radiation Protection Technician was finally assigned to his/her work location. These items would be included in the Qualification Standard for the specific work location (i.e., tunnels, decontamination facility, low level radioactive waste management).
<table>
<thead>
<tr>
<th>Question</th>
<th>% Ans. 0-2</th>
<th>% Ans. 3-5</th>
<th>Curriculum Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Do you supervise the operation of or operate a Counter/Scaler or any other type of sample counting equipment?</td>
<td>7%</td>
<td>93%</td>
<td>Train</td>
</tr>
<tr>
<td>2. Do you supervise, handle, leak test, monitor, transfer, inventory, or dispose of radioactive sources in your job?</td>
<td>41%</td>
<td>59%</td>
<td>Train</td>
</tr>
<tr>
<td>3. Do you supervise, monitor, perform, or record effluent release information?</td>
<td>64%</td>
<td>36%</td>
<td>No Train</td>
</tr>
<tr>
<td>4. Do you supervise the operation of or operate neutron REM Counters (PNR-4), Alpha survey meters, Ion Chambers, G-M detectors, Tritium detectors or Teletectors?</td>
<td>14%</td>
<td>86%</td>
<td>Train</td>
</tr>
<tr>
<td>5. Do you supervise the performance of or perform decontamination of materials, equipment, personnel or clothing?</td>
<td>12%</td>
<td>88%</td>
<td>Train</td>
</tr>
<tr>
<td>6. Do you supervise the performance of or perform radiation contamination surveys of materials, equipment, personnel or clothing?</td>
<td>6%</td>
<td>94%</td>
<td>Train</td>
</tr>
</tbody>
</table>
7. Do you supervise, read, zero, issue and/or record the issue of pocket dosimeters or extremity dosimetry (such as ring badges)? 11% 89% Train

8. Do you supervise or perform the collection of urine, nasal or throat smear samples? 29% 71% Train

9. Do you supervise the performance of or perform pre and/or post event, area monitoring? 36% 64% Train

10. Do you select or supervise the selection of appropriate respiratory protection equipment based on air sample or other results? 57% 44% No train

11. Do you supervise, obtain, count, document or review the results of a smear survey for loose contamination? 9% 91% Train

12. Do you supervise, perform or interpret the results of an Industrial Hygiene survey (air quality or temperature) to determine the habitability of an area? 59% 41% No Train

13. Do you supervise, setup, or maintain the operation of a contamination control point area? 33% 67% Train

14. Do you supervise or perform the entry into a radiation area where dosimetry equipment and protective clothing are worn? 16% 84% Train
15. Do you supervise the installation of or evaluate the effectiveness of temporary shielding?  

78%  22%  No Train

16. Do you supervise, survey, select appropriate containers for or package (including labelling and placarding) dry radioactive waste material for shipment?  

62%  38%  No Train

17. Do you supervise or perform the routine maintenance or any equipment? (such as change filters, cleaning solutions or adding oil)  

60%  40%  No Train

18. Do you supervise, obtain or package for laboratory analysis any environmental samples? (such as water, air or soil samples)  

17%  83%  Train

19. In your job, do you refer to the DOT regulations, DOE Orders, Radiological Health Handbook Health Physics Textbooks, or Chart of the Nuclides?  

22%  78%  Train
Phase 2 - Design the Training Process

Tasks that were identified for training from the questionnaire results were used to prepare the generic knowledge and skills and instructional objectives that the RPTs must know before going on to the On-the-Job portion of their training. The best teaching approach for the chosen objectives was selected at this time.

Phase 3 - Develop Curriculum and Support Materials

The curriculum developed from the data results provided for a broad based learning approach. The Phase 1 portion of the program (the generic portion) is taught all in the classroom with only work simulation exercises used.

The following material/subject matter was included in Phase 1 portion of the training program:

1. Course Orientation
2. Nevada Test Site Orientation
3. Safety Orientation and First Aid
4. Science and Math review (Note: All the students have taken an entry skills pretest prior to being hired, therefore, they are all supposed to have the same baseline math knowledge with which to build the specific math skills needed as a RPT.)
5. Basic Concepts of Nuclear Physics
6. Basic Concepts of Radioactivity
7. Nuclear Reactions
8. Biological Effects of Ionizing Radiation
9. Radiation/Radiation Protection Quantities & Units
10. Exposure Guides (Operational and Emergency)
11. Fundamentals of Radiation principles/practices
12. Sources of Radiation (Natural & Artificial)
13. Portable Instruments (Theory of Operation and Operating characteristics)
14. Personnel surveying techniques
15. Personnel Dosimetry (permanent and immediate readout types)
16. Suiting up and removal procedures for Anti-Contamination clothing
17. Contamination Control Line Procedures (Work Simulation Exercise)
18. Surface contamination and removal procedures (Work Simulation Exercise)
19. Performing a swipe survey and counting the swipes (Work Simulation Exercise)
20. Onsite and Offsite Release limits for material that was contaminated with radioactive material
21. Underground safety requirements
22. Industrial Hygiene as it relates, generically, to all the RPTs
23. Start-up and operation of scaler (Work Simulation Exercise)

24. Determining Scaler Efficiency, Scaler Correction Factor and Chi Square Statistics for Scaler use (Work Simulation Exercise)

The following material/subject matter was included in the Phase 2 portion (On-The-Job) of the training program:

1. Use of a Scaler (Startup and Operation)
2. Determining Scaler efficiency and correction factor
3. Chi Square Statistics for scaler use
4. Personnel Survey Techniques
5. Personnel Decontamination Techniques
6. Equipment swipe survey Techniques
7. Selection of proper Radiation Survey Instrument for the given situation
8. Obtaining and Interpreting a Grab Air Sample using a "Hurricane" High Volume Air Sampler (As part of a qualification standard for a specific work location)
9. Operation of the MSA Explosimeter that is designed to measure the percent of the lower explosive mixture of hydrogen in air. (As part of a qualification standard for a specific work location)
10. Operation of the Draeger Multi-gas Detector which has a manual air pump with bellows and an opening in the inlet side of the pump for insertion of the particular chemical indicator tube used to detect a particular gas. (As part of a qualification standard for a specific work location)
11. Operation of the "GPK" combustible gas and oxygen indicating instrument (As part of a qualification standard for a specific work location)

12. "Core" Sample recovery procedure for either Los Alamos National Laboratory or Lawrence Livermore National Laboratory support (As appropriate, as part of a qualification standard for a specific work location)

13. "Core" Sample Shipment Procedures for either Los Alamos National Laboratory or Lawrence Livermore National Laboratory support (As appropriate, as part of a qualification standard for a specific work location)

14. Lawrence Livermore National Laboratory Ventline Calculations (As appropriate, as part of a qualification standard for a specific work location)

15. Use of Two Way Radio (i.e., radio etiquette and 10 code meanings)

16. How to write a "Radiological Occurrence Report"

17. Field checking respirator fit

18. Decontamination Facility Water Systems Operation (As part of a qualification standard for a specific work location)

19. Decontamination Facility "Dip Tanks" Operation (As part of a qualification standard for a specific work location)

20. Decontamination Facility "Dyna-Drill" Flush system operation (As part of a qualification standard for a specific work location)

21. Decontamination Facility Heated Turbulator Operation used in decontaminating small drill tools (As part of a qualification standard for a specific work location)

22. Decontamination Facility Safety (As part of a qualification standard for a specific work location)
23. Receiving Procedure for Contaminated Equipment at the Decontamination Facility (As part of a qualification standard for a specific work location)

24. Decontamination Facility Decontamination Procedure (As part of a qualification standard for a specific work location)

25. Decontamination Facility Fork Lift Operation (As part of a qualification standard for a specific work location)

26. Decontamination Laundry Washing Machine and Dryer Operation (As part of a qualification standard for a specific work location)

27. Decontamination Laundry Radiation Survey Machine Operation (As part of a qualification standard for a specific work location)

**Phase 4 - Implement the Training**

The training schedule is published once the instructional staff is notified that a new class will be starting.

In the strictest sense, a performance-based training program has no starting or ending dates, that is, it is at the pace of the student. This can be done in proprietary schools that cater to the student, however, in an industrial setting this is not practical. The instructional staff is required to teach many different types of courses, each requiring a "Phase 1" theory portion which makes use of the few classrooms available. In addition, the on-the-job portion of the training is carried out by first-line field supervisors who do not
have the time to train excessively or repeatedly. Therefore, the newly hired RPTs are required to complete the objectives of the program in the allotted time so the Field Operations Section can place them in their specific work locations.

While in the specific work locations the newly hired RPT is given a qualification standard which must be completed in a reasonable period of time (i.e., before their probationary period ends).

**Phase 5 - Evaluate the Training**

In order to establish and maintain an effective training program, a periodic evaluation of the program is necessary.

In the evaluation process the following should be monitored:

1. Training delivery (instructional skills, technical skills and subject matter knowledge and delivery techniques).

2. Feedback from trainees (Formal survey questionnaire, trainees performance during training, and examination results)

3. Trainee's entry level skills upon completion of the training program.

4. Changes in procedures, equipment, regulations and/or standards should be monitored and evaluated for their applicability to the development of modification of training programs.

5. Contracted training programs should undergo the same evaluation procedure as inhouse training programs to ensure they are meeting job performance requirements.
6. Training programs evaluations should include the determination that training records are being kept in accordance with DOE and REECo requirements.

Chapter Summary

This chapter showed the results of the data to be the following: Of the 55 questionnaires distributed, 42 were filled out properly and returned for a total response of 76%. Of the 19 questionnaire questions, 6 questions resulted in a "No Train" decision. These 6 subject areas will be excluded in the Phase 1 portion (generic/classroom) of the developed curriculum model but included in the appropriate work location Qualification Standard. A model curriculum of a generic NTS Radiation Protection Technician training program was developed using The Guide to Good Practice in Radiation Protection Training manual's step-by-step approach.
Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The conclusions and recommendations presented in Chapter 5 were recognized to be subject to continual adaptation, change and evolution. It was impossible to predict what forms the REECo Radiation Protection Technician job would take in the future. Federal regulations, public attitudes, DOE orders and any changes in the weapons testing program would all impact the Radiation Protection Technician job and hence the curriculum.

Summary of the Findings

Research of the literature provided the following summary information:

1. Radiation Protection Technician Training is a relatively new field in post-secondary education.
2. Post-secondary education in Radiation Protection Technology is mainly performed by the employers of RPTs.
3. Much of the Radiation Protection Technician job functions do not require excessive physical strength. That is, RPTs are not required to lift more than 40 pounds, routinely, without assistance.

4. Radiation Protection Technician training followed other allied fields in its vocational/technical emphasis.

5. Much of the Radiation Protection Technician job functions do require considerable mental ability in order to understand conditions and assimilate information prior to making routine and emergency condition decisions.

Conclusions

Conclusions concerning the Radiation Protection Technician Curriculum resulted from: a review of the literature, the outcomes from the data, and an analysis of the final Radiation Protection Technician Training Curriculum Model.

The following conclusions were made:

1. The REECo RPT training curriculum should and does have a strong vocational/technical foundation.

2. Knowledge of the fundamentals of radiation and radiation protection was a basic requirement for the RPT curriculum with REECo operating procedures being very important during the operational (On-the-Job) phase of training.
3. Knowledge of tunnel industrial hygiene and tunnel safety are requirements prior to any permanent tunnel job assignment.

4. Managerial tools such as supervision of workers in a radiation area, administration of Company procedures, policies, regulations, DOE orders and public relations as it relates to weapons testing are additional requirements of the job.

5. A majority of the curriculum must be actual work experience and/or work simulation. This will provide the student the opportunity to perform the procedures and practices of radiation protection under supervision prior to any job assignment alone.

Recommendations for Radiation Protection Technician Training Curricula

Radiation Protection Technician training should continue to be separated into several types of programs including:

1. Basic Radiation Protection Technician Training
   Phase 1 - Generic/Classroom Portion

2. Basic Radiation Protection Technician Training
   Phase 2 - On-The-Job Training Portion
3. Basic Radiation Protection Technician Training
   Phase 3 - Entry Level Operational
   Procedures/Skills Portion (Qualification
   Standard Sign-Off portion)
4. Recertification - every 2 years
5. Miscellaneous certificates awarded for seminars,
   job conferences, limited training as new job
   functions appear, supervisory training etc.

The recommendations relevant to REECO, as based upon
the model developed in Chapter 4, were as follows:
   1. Base the curriculum on vocational/technical
      skills relevant to the NTS RPT position.
   2. Institute a documented, performance based,
      On-the-Job portion of the Radiation Protection Technician
      training program. (This is being done concurrently with
      the writing of the results of this study.
   3. Institute an "accountable" (i.e., with either
      theory and/or performance examinations) continuing
      education training program for the experienced RPTs.
   4. Institute a formalized National Registry of
      Radiation Protection Technician exam preparation library
      for Technicians aspiring to study for National Registry
      certification.
Recommendations for Further Study

The following are recommendations for further study and development:

1. Qualification Standards could be developed for each work location the RPTs may be assigned to upon completion of the Phase I and Phase II portions of the training program outlined in this study. At this work location they would be trained by local supervisors in the required knowledge, skills and abilities necessary to perform the tasks specific to the work location. The RPT would be given a "Qualification Card" with these tasks listed. When the RPT performed the task according to some predetermined acceptance criteria the supervisor would sign the Qualification Card thereby certifying the RPT as able to perform the task satisfactorily. The "satisfactory performance" criteria would be outlined in the Qualification Standards Manual developed from this study.

2. An evaluation instrument needs to be developed to facilitate the evaluation of all of the training program components.
SELECTED BIBLIOGRAPHY


16. Verner, C. and Davison C. (1971). Psychological Factors in Adult Learning and Instruction. Tallahassee: Florida State University, Research Information Processing Center, Department of Adult Education.
18. DOE Order 5480.11, Radiation Protection for Occupational Workers, 12/21/88.


## APPENDIX A

1. Do you supervise the operation of or operate a Counter/Scaler or any other type of sample counting equipment?  
   - Never: 0%  
   - Occasionally: 17%  
   - Often: 20%  
   - Very Often: 33%  
   - Very Often: 55%

2. Do you supervise, handle, leak test, monitor, transfer, inventory, or dispose of radioactive sources in your job?  
   - Never: 0.7%  
   - Occasionally: 17%  
   - Often: 17%  
   - Very Often: 32%  
   - Very Often: 14%

3. Do you supervise, monitor, perform, or record effluent release information?  
   - Never: 0.1%  
   - Occasionally: 33%  
   - Often: 21%  
   - Very Often: 24%  
   - Very Often: 10%

4. Do you supervise the operation of or operate neutron REM Counters (PNR-4), Alpha surveymeters, Ion Chambers, Geiger-Mueller detectors, Tritium detectors or teletectors?  
   - Never: 0.2%  
   - Occasionally: 5%  
   - Often: 27%  
   - Very Often: 32%  
   - Very Often: 17%

5. Do you supervise the performance of or perform decontamination of materials, equipment, personnel, or clothing?  
   - Never: 0.2%  
   - Occasionally: 5%  
   - Often: 25%  
   - Very Often: 22%  
   - Very Often: 20%

6. Do you supervise the performance of or perform radiation contamination surveys of materials, equipment, personnel or clothing?  
   - Never: 0.2%  
   - Occasionally: 12%  
   - Often: 22%  
   - Very Often: 30%  
   - Very Often: 15%

7. Do you supervise, read, zero, issue and/or record the issue of pocket dosimeters or extremity dosimetry (such as ring badges)?  
   - Never: 0.2%  
   - Occasionally: 12%  
   - Often: 27%  
   - Very Often: 44%  
   - Very Often: 15%

8. Do you supervise or perform the collection of urine, nasal, or throat smear samples?  
   - Never: 0.5%  
   - Occasionally: 17%  
   - Often: 38%  
   - Very Often: 17%

9. Do you supervise the performance of or perform pre and/or post event, area radiation surveys?  
   - Never: 0.1%  
   - Occasionally: 10%  
   - Often: 14%  
   - Very Often: 29%  
   - Very Often: 24%

10. Do you select or supervise the selection of appropriate respiratory protection equipment based on air sample or other results?  
    - Never: 0.1%  
    - Occasionally: 22%  
    - Often: 20%  
    - Very Often: 34%  
    - Very Often: 4%

11. Do you supervise, obtain, count, document or review the results of a smear survey for loose contamination?  
    - Never: 0.7%  
    - Occasionally: 12%  
    - Often: 2%  
    - Very Often: 32%  
    - Very Often: 4%

12. Do you supervise, perform or interpret the results of an Industrial Hygiene Survey (air quality or temperature) to determine the habitability of an area?  
    - Never: 0.2%  
    - Occasionally: 19%  
    - Often: 24%  
    - Very Often: 41%  
    - Very Often: 5%

13. Do you supervise, setup, or maintain the operation of a control point area?  
    - Never: 0.1%  
    - Occasionally: 17%  
    - Often: 31%  
    - Very Often: 42%  
    - Very Often: 2%

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
14. Do you supervise or perform the entry into a radiation area where dosimetry equipment and protective clothing (Anti-Cs) are worn?

15. Do you supervise the installation of or evaluate the effectiveness of temporary shielding?

16. Do you supervise, survey, select appropriate containers for or package (including labeling and placarding) dry radioactive waste material for shipment?

17. Do you supervise or perform the routine maintenance of any equipment? (such as change filters, cleaning solutions, or adding oil)

18. Do you supervise, obtain or package for laboratory analysis any environmental samples (such as water, air, or soil samples)?

19. In your job, do you refer to the DOT regulations, DOE Orders, Radiological Health Handbook, Health Physics Textbooks, or Chart of the Nuclides?

20. Please indicate any special knowledge, not covered in any of the above questions, that you feel you need to perform your job?
DIRECTIONS

Indicate how often you perform the questioned function. When estimating the frequency of performance, think back over your activities and indicate how often you personally have performed the questioned task(s) by circling the appropriate frequency code from the scale below:

- Never = 0 = Not part of the job
- Rarely = 1 = Must be able to perform but actually performed once a year or less often
- Seldom = 2 = About 3 or 4 times/year
- Occasionally = 3 = About once a month
- Often = 4 = About once a week
- Very Often = 5 = Daily
Position Title: Monitor I

Job Code: 011547

Date Prepared: July 29, 1985

Summary Statement: The incumbent performs fundamental assignments relating to the protection of NTS workers from unwarranted radiation exposure, aides in the evaluation of radiation hazards, and helps in the development/implementation of methods and procedures necessary to ensure radiological safety within area of control.

Dimensions: The incumbent has remote impact on the department's operating budget, reports to the Radiological Field Operations Supervisor or higher level supervision, and receives guidance from lead persons or higher level monitors.

Nature and Scope: Under close supervision, the incumbent performs fundamental assignments including the following: assists in the control of entry and exit requirements at radiation exclusion areas; issues protective clothing and equipment to personnel and instructs in its proper use; performs basic radioactive material control duties including maintenance of records; performs simple radioactive waste management duties including receipt and disposal of radioactive waste and associated minor recordkeeping; performs radiation surveys and collects samples as required; decontaminates equipment, operates mobile decontamination equipment, washing machines, extractors, and dryers used in the decontamination of protective clothing and equipment; performs physical checks and maintains records on the location and operating condition of equipment used by the Environmental Sciences Department (ESD), assists in the selection and collection of environmental samples for radiological evaluation, assists in the handling and use of radiation sources, performs radiation surveys on equipment and material prior to its disposal; and performs other duties as required to fulfill the obligations of the ESD.

Principal Contacts: Daily contacts with craft personnel and user representatives are normally maintained.

Working Conditions: The incumbent works in field and shop areas throughout the NTS including tunnels and drill rigs under the direction of lead persons, higher level monitors, and supervisors.

Desirable Training and Work Experience:

High School Diploma.

Other Special Qualifications: None.
## APPENDIX C

### DEFINITION OF RADIATION PROTECTION AND EDUCATION TERMS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>absorbed dose</td>
<td>When IONIZING RADIATION passes through MATTER, some of its energy is imparted to the matter. The amount absorbed per unit mass of irradiated material is called the absorbed dose, and is measured in REMs and RADs.</td>
</tr>
<tr>
<td>air sampling</td>
<td>The collection and analysis of samples of air to measure its radioactivity or to detect the presence of radioactive substances.</td>
</tr>
<tr>
<td>decontamination</td>
<td>The removal of radioactive contaminants from surfaces or equipment, as by cleaning and washing with chemicals.</td>
</tr>
<tr>
<td>detector</td>
<td>Material or a device that is sensitive to radiation and can produce a response signal suitable for measurement or analysis. A radiation detection.</td>
</tr>
<tr>
<td>dose equivalent (REM)</td>
<td>A term used to express the amount of effective radiation when modifying factors have been considered. The product of absorbed dose multiplied by a quality factor multiplied by a distribution factor. It is expressed numerically in REMs.</td>
</tr>
<tr>
<td>dose rate</td>
<td>The radiation dose delivered per unit time and measured, for instance, in REMs per hour.</td>
</tr>
<tr>
<td>dosimeter</td>
<td>A device that measures radiation dose, such as a film badge or ionization chamber.</td>
</tr>
</tbody>
</table>
Geiger-Muller Counter
A radiation detection and measuring instrument. It consists of a gas-filled (Geiger-Muller) tube containing electrodes, between which there is an electrical voltage but no current flowing. When ionizing radiation passes through the tube, a short, intense pulse of current passes from the negative electrode to the positive electrode and is measured or counted. The number of pulses per second measures the intensity of radiation. It is also often known as Geiger counter; it was named for Hans Geiger and W. Muller who invented it in the 1920s.

Health Physics
The science concerned with recognition, evaluation, and control of health hazards from ionizing radiations.

Job Analysis
A method used to obtain a complete list of the duties and tasks of a specific job. Job analysis is the first step in obtaining the data required for task analysis.

Learning Objective
A well defined, concise statement describing a specific behavior. Learning objectives usually contain the following: 1) Action, 2) Condition, and 3) Standard.

Maximum Permissible Concentration (MPC)
The amount of radioactive material in air, water, or food which might be expected to result in the maximum permissible dose to persons consuming them at a standard rate of intake. An obsolescent term.

micro
A prefix that divides a basic unit by one million.

milli
A prefix that divides a basic unit by one thousand.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needs Analysis</td>
<td>A procedure used to identify and document the training needs of a facility.</td>
</tr>
<tr>
<td>neutron</td>
<td>(Symbol n) An uncharged elementary particle with a mass slightly greater than that of the proton, and found in the nucleus of every atom heavier than hydrogen. A free neutron is unstable and decays with a half-life of about 13 minutes into an electron, proton, and neutrino. Neutrons sustain the fission chain reaction in a nuclear reactor.</td>
</tr>
<tr>
<td>On-the-Job Training</td>
<td>Training sessions composed of knowledge items, performance items, and observation items done at the job site.</td>
</tr>
<tr>
<td>Performance-Based Training</td>
<td>A formal, systematic approach to the development of training programs. This approach is based on the actual tasks being performed to ensure that all of the skills and knowledge required to perform a particular job are identified and presented in the most effective manner.</td>
</tr>
<tr>
<td>pico</td>
<td>A prefix that divides a basic unit by one trillion. Same as micromicro.</td>
</tr>
<tr>
<td>pig</td>
<td>Heavily shielded container (usually lead) used to ship or store radioactive materials.</td>
</tr>
<tr>
<td>protection</td>
<td>Provisions to reduce exposure of persons to radiation. For example, protective barriers to reduce external radiation or measures to prevent inhalation of radioactive materials.</td>
</tr>
<tr>
<td>protective clothing</td>
<td>Special clothing worn by a radiation worker to prevent contamination of his body or his personal clothing.</td>
</tr>
<tr>
<td>protective survey</td>
<td>An evaluation of the radiation hazards incidental to the production, use, or existence of radioactive materials or other sources of radiation under a specific set of conditions.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Qualification Standard</td>
<td>A documented record of the knowledge and skill objectives required for qualification.</td>
</tr>
<tr>
<td>RAD</td>
<td>(Acronym for Radiation Absorbed Dose.) The basic unit of absorbed dose of ionizing radiation. A dose of one RAD means the absorption of 100 ergs of radiation energy per gram of absorbing material.</td>
</tr>
<tr>
<td>radiation</td>
<td>The emission and propagation of energy through matter or space by means of electromagnetic disturbances which display both wave-like and particle-like behavior; in this context the &quot;particles&quot; are known as photons. Also, the energy so propagated. The term has been extended to include streams of fast-moving particles (alpha and beta particles, free neutrons, cosmic radiation, etc.). Nuclear radiation is that emitted from atomic nuclei in various nuclear reactions, including alpha, beta and gamma radiation and neutrons.</td>
</tr>
<tr>
<td>radiation area</td>
<td>Any accessible area in which the level of radiation is such that a major portion of an individual's body could receive in any one hour a dose in excess of 5 milliREM, or in any 5 consecutive days a dose in excess of 150 milliREM.</td>
</tr>
<tr>
<td>radiation detection instruments</td>
<td>Devices that detect and record the characteristics of ionizing radiation.</td>
</tr>
<tr>
<td>radiation dosimetry</td>
<td>The measurement of the amount of radiation delivered to specific place or the amount of radiation that was absorbed there.</td>
</tr>
<tr>
<td>radiation monitoring</td>
<td>Continuous or periodic determination of the amount of radiation present in a given area.</td>
</tr>
<tr>
<td><strong>radiation protection guides</strong></td>
<td>Legislation and regulations to protect the public and laboratory or industrial workers against radiation. Also measures to reduce exposure to radiation.</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>radiation source</strong></td>
<td>Usually a man-made, sealed source of radioactivity used in teletherapy, radiography, as a power source for batteries, or in various types of industrial gauges. Machines such as accelerators, and radioisotopic generators and natural radionuclides may also be considered as sources.</td>
</tr>
<tr>
<td><strong>radiation standards</strong></td>
<td>Exposure standards, permissible concentrations, rules for safe handling, regulations for transportation, regulations for industrial control of radiation, and control of radiation exposure by legislative means.</td>
</tr>
<tr>
<td><strong>radioactive contamination</strong></td>
<td>Deposition of radioactive material in any place where it may harm persons, spoil experiments, or make products or equipment unsuitable or unsafe for some specific use. The presence of unwanted radioactive matter. Also radioactive material found on the walls of vessels in used-fuel processing plants, or radioactive material that has leaked into a reactor coolant. Often referred to only as contamination.</td>
</tr>
<tr>
<td><strong>radioactivity</strong></td>
<td>The spontaneous decay or disintegration of an unstable atomic nucleus, usually accompanied by the emission of ionizing radiation.</td>
</tr>
<tr>
<td><strong>radioisotope</strong></td>
<td>A radioactive isotope. An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. More than 1300 natural and artificial radioisotopes have been identified.</td>
</tr>
</tbody>
</table>
roentgen (Abbreviation r) A unit of exposure to ionizing radiation. It is the amount of gamma or X-rays required to produce ions carrying 1 electrostatic unit of electrical charge (either positive or negative) in 1 cubic centimeter of dry air under standard conditions. Named after Wilhelm Roentgen, German scientist who discovered X-rays in 1895.

scintillation counter An instrument that detects and measures ionizing radiation by counting the light flashes (scintillations) caused by radiation impinging on certain materials.

shield A mass of absorbing material placed around a reactor or radioactive source to reduce the radiation to a level that is safe for human beings.

surface contamination The deposition and attachment of radioactive materials to a surface.

waste, radioactive Equipment and materials (from nuclear operations) which are radioactive and for which there is no further use. Wastes are generally classified as high level (having radioactivity concentrations of hundreds to thousands of Curies per gallon or cubic foot), low level (in the range of 1 microCurie per gallon or cubic foot), or intermediate (between these extremes).

whole body counter A device used to identify and measure the radiation in the body (body burden) of human beings and animals; it uses heavy shielding to keep out background radiation and ultrasensitive scintillation detectors and electronic equipment.
X-ray

A penetrating form of electromagnetic radiation emitted either when the inner orbital electrons of an excited atom return to their normal state (these are characteristic X-rays), or when a metal target is bombarded with high speed electrons (these are Bremsstrahlung). X-rays are always nonnuclear in origin.
To: Distribution
From: B. P. Smith
Date: June 7, 1988
Subject: RADIATION MONITOR JOB QUESTIONNAIRE

Attached is a questionnaire that needs to be completed by Radiation Monitors and the Supervisors. This questionnaire is part of a research project designed to upgrade and improve the Basic Radiation Monitor Training (BRMT) program and the Continuing Education Workshops.

It should only take 15 or 20 minutes to complete both sections of the questionnaire (Biographical and Job Information). Return the completed questionnaire to M/S 631 by June 30, 1988.

If you have any questions on any portion of the questionnaire, call Colleen Petullo or Dennis Vetter at 5-5820.

Enclosure
As stated

Distribution
See Page 2

cc w/o encl.:

Central Files
M. W. Chilton
E. W. Kendall
C. F. Petullo
J. W. Shugart
R. J. Straight
L. S. Sygitowicz