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STUDY OF ADVANCED PROFESSIONAL EDUCATIONAL REQUIREMENTS
RELATIVE TO NUCLEAR FUEL CYCLE ENGINEERING
IN INDUSTRY AND GOVERNMENT

THIRD QUARTERLY REPORT

FOR THE PERIOD

April 1, 1978 - June 30, 1978

TIM A. JUR

AUGUST, 1978

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UNIVERSITY OF SOUTH CAROLINA
COLUMBIA, SOUTH CAROLINA 29208

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PREPARED FOR THE
U.S. DEPARTMENT OF ENERGY
FUEL CYCLE PROGRAM OFFICE
UNDER CONTRACT EY-76-S-09-0947
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ABSTRACT

The purpose of this project is to study the educational needs of engineers and scientists working in nuclear related industry in the southeastern United States. The results of the study are expected to form the basis for implementing a program to meet these educational needs. The project runs the duration of FY78, and this report covers the third quarter of operations, April through June, 1978. During the past quarter, that phase of the project concerning the needs analysis survey is now complete. A list of subject areas has been compiled based on the results of the survey. Work is now in process to develop a course description relative to each subject. These descriptions are to include level, depth, content, prerequisite information, makeup of the audience, learning resources, and suggested delivery format. Samples are given of course descriptions which have already been prepared.

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1. BRIEF SUMMARY OF THE PROJECT & ITS OBJECTIVES

The purpose of the project is to determine the educational needs of practicing engineers and scientists who work in nuclear fuel cycle related areas. The project is regional in nature and focuses on the relatively high concentration of nuclear industry in the southeastern United States. This industry includes power companies, commercial facilities involved in the production and processing of nuclear materials, production facilities under supervisions of the federal government, research laboratories and various state and federal regulatory agencies.

The educational needs addressed by the project are those at the post-baccalaureate level. The clientele is made up of practicing professionals who see a real need for further education in areas related to on-the-job performance. From the onset of the project, it was expected that education needs would be unique and would include many areas of technical know-how not typically covered in formal education in engineering and the sciences. The intention of this project, therefore, has been to find out what these subject areas are and to make this information available as a basis for the development of educational programs in step with the needs and professional development of the Southeast's nuclear industry.

The work of conducting the needs analysis has been undertaken by an interdisciplinary faculty team from the College of Engineering. The information gathering process is by way of a personalized survey of the engineers and scientists who the educational program would eventually serve. The survey seeks to define key subject areas and the content, level, depth, and breadth within subject areas. Background information

in terms of reference material and learning resources is also to be established. In addition, recognizing that the education of practicing professionals in technical areas is in itself unique, a part of the study is devoted to determining convenient and effective methods of delivery.

The project began October 1, 1977 and is to continue one year through FY78 and end on September 30, 1978. This report covers activities during the third quarter of operations from April 1, 1978 through June 30, 1978

2. REVIEW OF THE PROJECT PLAN

Reference here is made to the quarterly report relative to this contract dated May 10, 1978. In that report, four phases of the project were described in detail. These are revised and updated as follows:

Phase a

This first phase involved initial visits to upper management at locations throughout the Southeast where the survey was to be conducted. The purpose of these visits was to brief upper management regarding the project and to open the way for contact between persons working at these locations and members of the faculty team conducting the survey. This phase of the project is complete.

Phase b

The second phase of the project involved meeting with management and front-line engineers and scientists. These meetings were used to determine the nature of the education need, identify key subject areas, and obtain information regarding level, depth, and breadth of material

within individual subject areas. The meetings were also used to obtain input as regards methods of delivery and potential resources in educational materials and adjunct faculty. This phase of the project is complete.

Phase c

The third phase activity began with an in-house assessment of survey results and, in so doing, produce a list of subject areas upon which an education program would be based. This list of subjects is complete and is presented in the following section. The majority of third phase activity, however, has been covered with development of course descriptions within each subject area and an assessment of various possible methods of delivery. Both of these tasks have been ongoing during the third quarter and are to continue into the fourth quarter. The results are also discussed in the following section.

Phase d

The fourth phase is to involve preparation of the final report and is scheduled for the final one and one-half months of the project.

3. REVIEW OF THE MARKET PLACE

At the onset of the project, it was originally intended to visit and interview persons at all locations making up the nuclear industry throughout the Southeast. The plan was to make contact initially at locations geographically close to the University and subsequently visit more remote locations. In so doing, it was recognized that the faculty team would itself have to go through a learning process during the early stages of the project. For reasons of efficiency, therefore,

early visits were scheduled nearby.

As the series of initial interviews progressed, it became apparent that there existed considerable commonality of interests and needs from one location to the next. It was decided, therefore, to forego contact at all locations in favor of selectively interviewing at sites considered representative of the region's industry. Consistent with the original project plan, these locations were for the most part within a relatively short distance from the University. For example, as regards power companies serving the Southeast, the results of the survey are to be based on information obtained largely from Duke Power Company (a relatively large company with in-house architectural and engineering capability) and South Carolina Electric and Gas Company (a smaller company just in the process of bringing a nuclear power plant on line). Some contact has also been made with Carolina Power and Light Company and Southern Company Services. However, visits to more remote locations were not undertaken. The results of surveys at the locations mentioned indicated that little additional information would have been obtained through further interviews.

Figs. 1 and 2 describe the market place and provide a general picture of the extent of the survey. Fig. 1 is a list of the various locations which together make up the region's nuclear community. Fig. 2 is a list of places visited, both those at which extensive contact was made and those at which only limited contact was made. Also, contained in the Appendix is an updated list of visits made during the first, second, and third quarters of the contract period.

4. RESULTS - THIRD QUARTER

Efforts during the third quarter have been concerned with completing

the needs analysis survey (Phase b) and finalizing a list of subject areas and preparing course descriptions (Phase c).

The list of subject areas is given in Fig. 3 and is based on the results of engineers and scientists throughout the Southeast's nuclear industry. As such, the list represents their needs as they themselves have expressed them. It is a feature of the list that relatively few of the subjects are typical of what might ordinarily be found in a traditional undergraduate/graduate curriculum. As stated in the previous quarterly report, the majority of the professionals working in the region's nuclear industry have considerable experience. This does not mean, however, that there is little need for an educational program. Rather, the real need is for an educational effort which concentrates on specific areas of what we internally have come to refer to as peripheral study. These are subjects which augment day-to-day performance and which the individual identifies with his or her own professional growth on the job. Admittedly, the list in Fig. 3 contains many subjects which are common to the needs of professional practice in engineering and the sciences in general. However, as stated above, the list has been compiled directly from survey results. Taken as a whole, it is unique to the nuclear industry.

Also contained in Fig. 3 is information regarding the level of interest within each subject area. The locations identified in the vertical columns of the matrix are those which have made major contributions to the project's needs analysis survey.

Course descriptions for each of the subject areas in Fig. 3 are either complete or in process. Sample course descriptions are contained in the Appendix. A general format has been agreed upon internally. It

is intended that each course description convey the following information:

- (a) Statement of entry level knowledge
- (b) Course content
- (c) Expected makeup of the audience
- (d) Suggested learning materials
- (e) Possible methods of delivery
- (f) Duration

In addition, the course descriptions are intended to convey some statement of course philosophy as regards the makeup of the audience and the level, depth, and breadth of course material. It is most important that not only the list of subjects but also the content and delivery within each subject be consistent with the interest and needs of the market place.

Preparation of course descriptions have been based both on faculty expertise and research and on input from experts outside the University. Outside help has played an important role in this phase of the project. Many of the subjects listed in Fig. 3 are areas where faculty knowledge is limited. In addition, regardless of subject area, experts from the surrounding nuclear community have been sought out as being best able to insure consistency with the needs of potential participants.

5. REVIEW OF PROJECT SCHEDULE

Shown in Fig. 4 is a copy of the project timetable submitted with the previous quarterly report dated May, 1978. A revised timetable is shown in Fig. 5. The only changes in the timetable concern Items 6, 7, and 8. The timespans of each of these items has been adjusted to more correctly reflect actual events.

6. SUMMARY STATEMENT OF EXPENDITURES

A statement of original budget, expenditure for each of the first three quarters of operation, and balance in each account are shown in Fig. 6.

Commercial Facilities Involved in Producing and Processing Nuclear Materials

Westinghouse Fuel Fabrication Plant, Columbia, South Carolina
General Electric Fuel Fabrication Plant, Wilmington, North Carolina
Allied General Nuclear Services, Barnwell, South Carolina
Chem-Nuclear, Barnwell, South Carolina

Power Companies with Nuclear Capabilities

Duke Power Company, Charlotte, North Carolina
South Carolina Electric & Gas Co., Columbia, South Carolina
Carolina Power and Light, Raleigh, North Carolina
TVA, Knoxville, Tennessee
Southern Company Services, Birmingham, Alabama
Georgia Power Company, Atlanta, Georgia
Florida Light & Power
Alabama Power Company

Production Facilities Under Supervision of the Federal Government

Savannah River Plant, Aiken, South Carolina
Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee

Research Laboratories

Savannah River Laboratory, Aiken, South Carolina
Oak Ridge National Laboratory, Oak Ridge, Tennessee

Government Agencies

Savannah River Operations - DOE - Aiken, South Carolina
Nuclear Regulatory Regional Office, Atlanta, Georgia

Fig. 1. List of locations which make up the southeast's nuclear industry

Locations Visited as Basis for Survey Results

Westinghouse Fuel Fabrication Plant
Allied General Nuclear Services
Duke Power Company
South Carolina Electric and Gas Co.
Carolina Power and Light
Oak Ridge National Laboratory
Savannah River Laboratory
Savannah River Plant

Locations at Which Limited Contact was Made

Southern Company Services
Oak Ridge Gaseous Diffusion Plant
Savannah River Operations - DOE
Nuclear Regulatory Commission

Fig. 2. List of locations visited as part of the survey

	AGNS	WESTINGHOUSE	ORNL - NUCL. & ENGR. TECHNOLOGISTS	SRP	SRL		CPL	SCG	DUKE POWER
LICENSING OF NUCLEAR FACILITIES	S	M	S	S	S		H	H	H
QUALITY ASSURANCE	S	H	M	M	M	-	H	M	H
SAFEGUARDS	M	S	M	S	S		S	S	S
NUCLEAR FUEL CYCLE	S	M	M	M	S		M	M	M
SHIELDING	H	H	H	H	S		S	S	S
CRITICALITY	H	H	H	H	S		S	S	S
HEALTH PHYSICS	H	H	H	H	S	-	S	S	S
FUEL HANDLING & TRANSPORTATION	S	M	M	M	S		S	S	M
REMOTE HANDLING			M	M					
DISPOSAL OF NON-FUEL WASTES		S	M	S	S		M	S	M
DECOMMISSIONING			M	M	M		M	S	M
ENVIRONMENTAL ASPECTS OF THE FUEL CYCLE	M	M	S	S	S				
NUCLEAR POWER PLANT MAINTENANCE							M	H	M
REACTOR SAFETY									
+INTR. TO REACTOR SAFETY & DESIGN OF SAFETY SYS.	H	H	H	H	H		H	H	H
+NUCLEAR POWER REACTOR SAFETY		M	M	M	M		H	S	H
FIRE PROTECTION FOR NUCLEAR REACTORS		M	H	H	M		H	M	H
FUEL MANAGEMENT	S	S	M	S	S		M	S	M
POWER COMPANY ECONOMICS	S	S	S	S	S		M	M	M
NUCLEAR INSTRUMENTATION	M	M		H	H		H	M	H
ELECTRICAL ENGR. FOR NON-ELECTRICAL ENGRS.			H	H	M				
STRUCTURED PROGRAMMING	S	M		M	M		M	S	H
PRACTICAL STATISTICS	M	H	H				M	S	M
SYSTEM RELIABILITY	M		H						
FAULT TREE ANALYSIS	M		H						
RADIATION EFFECTS ON MATERIALS			H	H	H				M
BASIC CONCEPTS OF CORROSION	H	H	H	H				H	M
NON-DESTRUCTIVE TESTING				M			S	M	
WELDING METALLURGY		H	H	H					M
DESIGN OF WELDMENTS			H	H					M
DESIGN AGAINST MECHANICAL FAILURE									
* PROCEDURES - DESIGN AGAINST FATIGUE			H	H				H	H
* APPLICATIONS OF FRACTURE MECHANICS			H	H				H	H
* FAILURE ANALYSIS			H	H				H	H
* NUMERICAL STRESS ANALYSIS IN DESIGN			H	H					H
METALLURGY OF STAINLESS STEEL & NI-BASE ALLOYS		H	H	H				S	M
HYDRAULICS & FLUID MACHINERY	S	S	H	H	S		H	H	H
PRESSURE VESSEL & PIPING CODES			H	H				H	H
THEORY & DES. OF PRESSURE VESSELS & RELATED COMP.			H	M				S	H
MECHANICAL DESIGN OF PIPING SYSTEMS			H	M				S	H
PROJECT ENGINEERING	S	S	H	M	M		M	M	H
TECHNICAL MANAGEMENT	S	S	H	M	M		M	M	M
TECHNICAL COMMUNICATIONS	S	S	M	S	M		M	M	M
PROCESS DES. & ANALYSIS FOR NUCL. FUEL REPROCESSING	M	S	H	H	S			S	M
DESIGN AGAINST & IN THE EVENT OF ACCIDENTS	S	S	M	S	S				
UPDATE ON ENERGY PROGRAMS	H	H	H	H	H		M	M	M
INTERACTION OF ENGRS WITH THE POLITICAL SECTOR	H	H	H	H	H		H	H	H

Fig. 3 Subject areas identified during Phase I - level of interest at various locations identified as:

H - high

M - medium

S - specialized

Fig. 4. Project Timetable (April 1978 Update)

Fig. 5. Revised Timetable

	<u>Original</u>	<u>Incurred 1st Quarter</u>	<u>Incurred 2nd Quarter</u>	<u>Incurred 3rd Quarter</u>	<u>Balance</u>
A. Salaries and Wages					
1. Professional Staff	\$ 95,000	\$ 6,627	\$ 18,293	\$ 26,762	\$ 43,318
2. Secretary	2,000	-0-	-0-	-0-	2,000
3. Staff Budget	14,350	644	2,810	3,890	7,006
B. Other Direct Costs					
1. Travel	12,750	450	2,660	3,830	5,810
2. Seminar Program	1,800	-0-	-0-	247	1,553
3. Telephone	1,500	33	78	91	1,298
4. Supplies	1,500	-0-	30	593	877
C. Total Direct Costs	128,900	7,754	23,871	35,413	61,862
D. Indirect Costs	<u>50,440</u>	<u>3,446</u>	<u>9,513</u>	<u>13,915</u>	<u>23,566</u>
Total	\$179,340	\$ 11,200	\$ 33,384	\$ 49,328	\$ 85,428

Fig. 6. Summary Statement of Expenditures

APPENDIX I

SAFEGUARDS

Course Description: A review of the measures that may be employed to prevent theft and diversion of special nuclear materials and the sabotage of nuclear facilities.

Course Objectives: Familiarize those working in the nuclear industry with the safeguard problems, regulations, and licensing requirements.

Course Outline:

- I. Physical Security Measures at Fixed Sites
 - A. Physical Barriers and Alarm Systems
 - B. Access Control and Admittance Systems
 - C. Containment Mechanisms
 - D. Active Delaying Systems
 - E. Guard Forces
 - F. Communications
- II. Security for Special Strategic Nuclear Materials (SSNM) in Transit
 - A. Transport Vehicles
 - B. Special Material Containers
 - C. Escorts and Convoys
 - D. Shipment Planning and Control
 - E. Response to Attacks
- III. Material Control and Accounting
 - A. Management Control
 - B. Custodial Control
 - C. Inventory Control
 - D. Accounting Systems
 - E. Personnel Screening
 - F. Collocation
 - G. Modification of SSNM
 1. Spiking
 2. Blending
- IV. Current Requirements for Safeguarding SSNM
 - A. Physical Protection of Fuel Cycle Facilities
 - B. Physical Protection of SSNM in Transit

- C. Material Control and Accounting
- D. Implementation of Safeguards Requirements
 - 1. Licensing
 - 2. Inspection and Enforcement
 - 3. Experience in Safeguarding SSNM

Course Duration: Two Day Short Course

Estimated Demand: High

Prerequisites: An undergraduate degree

Learning Aides: Prepared notes

SUGGESTED REFERENCES

Safeguarding a Domestic Mixed Oxide Industry Against a Hypothetical Sub-national Threat, Office of Nuclear Materials Safety and Safeguards, U.S.N.R.C. Report No. NUREG-0414, May, 1978.

Methods for the Accountability of Plutonium Dioxide Powder, Regulatory Guide 5.40, U.S.A.E.C., December, 1974.

Management Review of Nuclear Material Control and Accounting Systems, Regulatory Guide 5.51, U.S.N.R.C., June, 1975.

Conduct of Nuclear Material Physical Inventories, Regulatory Guide 5.13, U.S.A.E.C., November, 1973.

Internal Transfers of Special Nuclear Materials, Regulatory Guide 5.49, U.S.N.R.C., March, 1975.

Shipping and Receiving Control of Special Nuclear Material, Regulatory Guide 5.57, U.D.N.R.C., June, 1976.

SHIELDING

Course Description: An overview of Shielding including Nuclear Decay, Radiation Attenuation, Dosimetry, Shielding Calculations and Types.

Course Objectives: The course is designed for the practicing engineer and to provide him with the capability of doing shield design.

Course Outline:

- A. Design Requirements and Philosophy
- B. Decay of Nuclides
- C. Kinds of Radiation and Energy Levels
- D. Penetration Depths and Range
- E. Attenuation of Gamma Rays by Distance and Material
 - 1. linear or mass attenuation coefficient
 - 2. energy absorption linear attenuation
- F. High Gamma Energies, Compton Scattering and Build-Up
- G. Geometry and Strength of Source
 - 1. sample calculations
- H. Physical Radiation Dose and Relative Biological Effectiveness
- I. Health Physics Terms
- J. Approximate Shielding Calculations
 - 1. point source
 - 2. distributed source
- K. Detailed Shielding Calculations
 - 1. Boltzmann Equation
 - 2. Monte Carlo method
 - 3. method of moments
 - 4. method of successive scattering
- L. Shield Types
 - 1. Homogeneous
 - 2. Laminated Shields
- M. Shield Quality
- N. Shield Heating
- O. Shield Contamination and Decontamination
- P. Other Considerations
 - 1. Bremsstrahlung Radiation
 - 2. Skyshine and Air shine
 - 3. Self-shielding or absorption
- Q. Uncertainties in Shielding Calculations

Course Duration: If survey only, the course could be delivered in three full days. For more intensive coverage, allow five days with some time between days for individual study.

Estimated Demand: High

Prerequisites: An undergraduate engineering degree

Learning Aides: Prepared course notes

SUGGESTED REFERENCES

Nomograms for the Calculation of Gamma Shielding, Balderston, J.L., Taylor, J.J., and Brucker, G.J., USAEC Report AECD-2934, Kellex Corp., Nov. 15, 1948.

Nuclear Radiation Physics, Lapp, R.E., and Andrews, H.L., Prentice-Hall, Inc., New York, 1949, p. 180.

Calculations of the Penetration of Gamma Rays, Goldstein, H., and Wilkins, J.E., USAEC Report NYO-3075 Nuclear Developments Associates, Inc., June 30, 1954.

Reactor Shielding Design Manual, Rockwell, T., McGraw-Hill Book Co., N.Y., 1956.

Radiation Shielding, Price, B.T., Horton, C.C., and Spinney, K.T., Pergamon Press, Inc., N.Y., 1957.

Procedures for Shielding Calculations, Dennis, R., Purohit, S.N., and Brownell, L.E., USAEC Report AECU-3510, Jan. 1957.

Gamma-Ray Attenuation Coefficients from 10 Kev to 100 Mev, White, G.R., Natl. Bur. Std. (U.S.), Circ. No. 583, April 1957.

Nuclear Engineering Handbook, ed. by Harold Etherington, McGraw-Hill Book Co., N.Y. 1958.

Stratified Slab Gamma-Ray Dose-Rate Buildup Factors for Lead and Water Shields. Bowman, L. A., and Trubey, D.K., USAEC report CF-S8-1-41, ORNL, January 1958.

Table of Isotopes, Strominger, D., Hollander, J.M., and Seaborg, G.T., Rev. Mod. Phys. 30, 585-904 (1958).

Fundamental Aspects of Reactor Shielding, Goldstein, H., Addison-Wesley Publishing Co., Reading, Mass., 1959.

Fission Product Radiation and Shielding Calculations, Van Tuyl, H.H., USAEC Report HW-69533, Hanford Atomic Products Operation, May 1961.

Approximate Shielding Calculations, Coppinger, E.A. USAEC Report HW-69789, Hanford Atomic Products Operation, May 1961.

Reactor Handbook, Vol. III, Part B, Shielding, Blizard, E.P., and Abbott, L.S., 2nd ed., Interscience Publishers, N.Y., 1962.

Dosimetry and Protection from Ionizing Radiation. Golubev, B.P. Translated from pp. 1-336 of Dozimetriy i Zashchita ot Ioniziruyushchikh Izlucheni, Gosudarstvennoe Energeticheskoe Izdatel'stvo, Moscow-Lenin-grad, 1963. 293p. (FTD-MT-64-291). CFSTI.

Beton V. Zashchite Yadernykh Ustanovok. (Concrete in Shielding of Nuclear Installations). Broder, D.L.; Zaitsev, L.N., Komochkov, M.M., Mal'kov, V.V., Sychev, B.S. Moscow, Atomizdat, 1966, 239p.

Zashchita Ot Ioniziruyushchikh Izlucheni; Spravochnik. (Protection Against Ionizing Radiation: A Manual). Kimel', Leonid Ruvimovich; Mashkovich, Vadim Pavlovich. Moscow, Atomizdat, 1966. 310p.

Voprosy Fiziki Zashchity Reaktorov. Sbornik Statei. Vypusk 2. (Problems in Physics of Reactor Shielding. Collection of Articles, Issue 2). Broder, D.L.; Veselkin, A.P.; Egorov, Yu. A.; Suvorov, A.P.; Tsypin, S.G. (eds.) Moscow, Atomizdat, 1966. 245p.

Physics of Reactor Shielding. Kazanskii, Yu. A., Kukhtevich, V.I., Matusevich, E.S., Sinitsyn, B.I., Tsypin, S.G. Translation of Fizicheskoy Issledovaniya Zashchity Reaktorov. Moscow, Atomidat, 1966. 359p. (TT-68-50324; IPST-Cat.-5138). Dep. CFSTI.

Course on Radiation Protection in Industry. Occupational Safety and Health Series No. 11. Geneva, International Labour Office, 1967. 266p. (NP-17447).

Zashchita Ot Gamma-Izlucheniya Produktov Delentya. (Handbook on Shielding Against Gamma Radiation of Fission Products). Gusev, N.G. Moscow, Atomizdat, 1968, 388p.

Engineering Compendium on Radiation Shielding, ed. by Jaeger, R.G., et al, Vol. 1, Springer-Verlag, New York, 1968.

Engineering Compendium on Radiation Shielding, ed. by Jaeger, R.G., Vol. III, Springer-Verlag Inc., New York, 1970.

Materialy I Konstruktsii Zashchit Yadernykh Ustanovok. (Materials and Construction of the Shielding of Nuclear Installations.) Komarovskii, A.N. (ed.). Collection of Moscow Engineering and Construction Institute, No.-77. Moscow, Izdatel'stvo Nauka (1971). 139p.

Weapons Radiation Shielding Handbook. Chapter 3. Methods for Calculating Neutron and Gamma-Ray Attenuation. Stevens, Paul N.; Trubey, David K. (Oak Ridge National Lab., Tenn.). March 1972. 179p. Dep. NTIS. Formerly DASA-1892-3.

Computerised Information File. Fraser, A.J. (Central Electricity Generating Board, Berkeley (England). Berkeley Nuclear Labs.). July 1972. 20p. Dept. NTIS (U.S. Sales Only).

Data Activity of the Radiation Shielding Information Center. Roussin, R.W., Trubey, D.K., Maskewitz, B.F. (Oak Ridge National Lab., TN).

European Shielding Information Service. Nicks, H., Ponti, C. (Commission of the European Communities, (Ispra, Italy). pp. 226-233 of Fourth International Conference on Reactor Shielding.

Proceedings of the Fourth International Conference on Reactor Shielding, Paris, France, October 9-13, 1972. Volume 1 to 5. (Organization for Economic Co-Operation and Development, 75-Paris (France), CEA, 75-Paris (France)). 1972.

Integral Experiments and Philosophy of Benchmark Calculations, Straker, E.A., Meeting on New Developments in Reactor Physics and Shielding Calculations; Klamesha Lake, N.Y. (Sept. 12, 1972).

Zashchita Ot Izlucheniia Yadernotekhnicheskikh Ustanovok, Tom II. (Radiation Shielding of Nuclear Installations. Volume II). Gusev, N.G., Kimel, L.P., Koval'ev, E.E., Mashkovich, V.P., Pologikh, B.G., Suvorov, A.P. Moscow, Atomizdat (1973). 344p.

Practical Radiation Protection Considerations. Howell, V.P. (Westinghouse Hanford Co., Richland, WA). pp. 1977-190 of Promethium Technology. Wheelwright, E.J., (Ed.). Hinsdale, IL, American Nuclear Society (1973).

Nuclear Design and Shielding. Tenth Quarterly Report, January-March 1974. (General Electric Co., Sunnyvale, Calif. (USA). Advanced Technology Dept.). April 1974. Contract AT(04-3)-893. 102p. AT.

Materials Information In The Radiation Shielding Information Center. Maskewitz, B.F., Trubey, D.K., Roussin, R.W. (Oak Ridge National Lab., Tenn. (USA)). April 1974. 10p. Dep. NTIS \$4.00.

Shielding Benchmark Problems. Simmons, G.L. (Ed.). (Oak Ridge National Lab., Tenn. (USA)). July 1974. Contract W-7405-eng-26. 71p. Dep. NTIS \$5.45.

Computer Codes and Data Available from the Radiation Shielding Information Center. Trubey, D.K., Maskewitz, B.F., Roussin, R.W., (Oak Ridge National Lab., Tenn. (USA)). (nd). 5p. Dep. NTIS \$4.00.

Development of Radiation Shielding Standards in the USA. Trubey, D.K. (Oak Ridge National Lab., Tenn. (USA)). (nd). 5p. Dep. NTIS \$4.00.

Unchanging Aspects of Radiation Exposure Limits. Meinhold, C.B. (Brookhaven National Lab., Upton, N.Y. (USA)). 1974. 17p. (CONF-740529-1; SM-184-19). Dep. NTIS \$4.00.

Application of Shielding Benchmark Experiments to the Testing of Nuclear Data, Computational Methods, and Procedures. LaBauve, R.J., Harris, D.R., Muir, D.W., Hemmig, P.B., (Los Alamos Scientific Lab., N. Mex. (USA); USAEC, Washington, D.C.). 1974. Contract W-7405-eng-36. 26p. (CONF-740440-1). Dep. NTIS \$4.50.

Radiation Shielding Information Center Data Activities. Roussin, R.W., Maskewitz, B.F., Trubey, D.K. (Oak Ridge National Lab., Tenn. (USA)). (nd.). 4p. Dept. NTIS \$4.00.

Brief Study of the Radiation Shielding Information Center. Summers, R.M. Union Carbide Corp., Oak Ridge, Tenn. (USA). Computer Sciences Div.). May 1975. Contract W-7405-eng-26, 69p. Dep. NTIS \$5.45.

Dosimetry for Human Exposures. Auxier, J.A., Haywood, F.F., Jones, T.D., Warner, G.G., Cheka, J.S., Kerr, G.D., Solomon, D.L., Yamad, H. Sep. 1975. In Health Physics Division annual progress report for period ending June 30, 1975. (Oak Ridge National Lab., Tenn. (USA)).

Development of Radiation Shielding Standards in the American Nuclear Society. Trubey, D.K. (Oak Ridge National Lab., TN). Trans. Am. Nucl. Soc., 22: 828-829 (November 1975).

Sensitivity Analysis in Shielding. An Overview. Gerstl, S.A.W. (Los Alamos Scientific Lab., NM). Trans. Am. Nucl. Soc., 22: 791-792 (Nov. 1975).

Available Computer Codes and Data for Radiation Transport Analysis. Trubey. D.K., Maskewitz, B.F., Roussin, R.W. (Oak Ridge National Lab., Tenn (USA)). 1975. 5p. Dep. NTIS \$4.00.

Engineering Compendium on Radiation Shielding. Volume II. Shielding Materials. Jaeger, R.G. (ed.). New York; Springer-Verlag New York Inc. (1975). 447p. \$137.60.

Survey of Shielding Sensitivity Analysis Development and Applications Program at ORNL. Oblow, E.M. (Oak Ridge National Lab., Tenn. (USA)). Jan. 1976. Contract W-7405-eng-26. 53p. (CONF-751063-2). AT.

QUALITY ASSURANCE FOR NUCLEAR FACILITIES

Level: Introductory
Length: Short course (5-10 hours)
Interest: High
Audience: All engineers working in nuclear related areas

The basic quality assurance requirements for nuclear power plants are specified in Appendix B, Code of Federal Regulations, Title 10, Part 50. In addition, the NRC has issued four separate documents which provide guidance on quality assurance requirements during the major phases of power plant development: (1) design and procurement stage, (2) construction stage, (3) preoperational and initial startup stage, and (4) operational stage. The course could be structured to emphasize the most appropriate area for the audience.

The 18 quality assurance areas specified by the Code of Federal Regulations are:

- I. Organization
- II. Quality Assurance Program
- III. Design Control
- IV. Procurement Document Control
- V. Instruction, Procedures and Drawings
- VI. Document Control
- VII. Control of Purchased Material, Equipment, and Services
- VIII. Indentification and Control of Materials, Parts, and Components
- IX. Control of Special Processes
- X. Inspection
- XI. Test Control
- XII. Control of Measuring and Test Equipment

- XIII. Handling, Storage, and Shipping
- XIV. Inspection, Test, and Operating Status
- XV. Non-conforming Materials, Parts, or Components
- XVI. Corrective Action
- XVII. Quality Assurance Records
- XVIII. Audits

This would be an area in which the NRC would be glad to cooperate and would probably be the best source of a lecturer for this course.

REFERENCES FOR QUALITY ASSURANCE

1. "Quality Assurance Criteria for Nuclear Power Plants," Code of Federal Regulations, Title 10, Part 50, Appendix B.
2. "Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants," ANSI N18.7 - 1972, Rev. 1 (Draft No. 5) (February 12, 1975).
3. "Quality Assurance Program Requirements," USAEC Regulatory Guide 1.33, (Safety Guide 33) (November 3, 1972).
4. "Administrative Controls for Nuclear Power Plants," ANSI N1817 - 1972, (December 20, 1972).
5. "Quality Assurance Program Requirements for Nuclear Power Plants," ANSI N45.2 - 1971, (October 20, 1971).
6. "Guidance on Quality Assurance Requirements During Design and Procurement Phase of Nuclear Power Plants - Revision 1," USAEC, WASH 1283, (May 24, 1974).
7. "Guidance on Quality Assurance Requirements During the Construction Phase of Nuclear Power Plants," USAEC, WASH 1309, (May 10, 1974).
8. "Guidance on Quality Assurance Requirements During the Operations Phase of Nuclear Power Plants," (USAEC Orange Book) (October 26, 1973).
9. "Preoperational and Initial Startup Test Programs for Water Cooled Reactors," USAEC Regulatory Guide 1.68, (November 1973).

FIRE PROTECTION FOR NUCLEAR REACTORS

1. Fundamentals of Combustion
 - A. Thermochemistry
 - B. Kinetics
 - C. Ignition
 - D. Flame propagation
 - E. Explosions and Detonations
2. Reactor Safety Considerations
 - A. Fire Control Problems Due to Radiation Effects
 - B. Accidents Involving Fissionable Materials
 - C. Fire in Control Systems
 - D. Electrical Circuits and Wiring
 - E. Incompatible Materials
3. Review of Fire Protection Regulations
 - A. NFPA Regulations
 - B. NRC Regulations
4. Design for Fire Protection
 - A. Location & Construction
 - B. Ventilation and Access
 - C. Electrical Equipment
 - D. Flammable Liquids and Gases
 - E. Extinguishing Systems
 - F. Fire Detection Systems
 - G. Alarm Systems
 - H. Analysis of Fire Potential
 - I. Special Problems
5. Fire Fighting Methodology
 - A. Plant Organization for Fire Protection
 - B. Self Inspection Program
 - C. Planning for Handling Emergencies
 - D. Interfacing Local and Plant Fire Departments
 - E. Security Aspects

Resources:

1. Recommended Fire Protection Practice for Nuclear Reactors
NFPA 802 - 1974
2. Fundamentals of Fire and Explosion, D. R. Stull,
AIChE Monograph Series, No. 10, Vol. 73 (1977)

APPENDIX II

Below is a list of visits thus far in the project.

1. Allied General Nuclear Services, Barnwell, South Carolina, on October 21, 1977. Huhns, M., Jur, T., Keating, D., and Stanford, T. To discuss program with representatives of plant management.
2. South Carolina Electric & Gas, Columbia, South Carolina, on October 26, 1977. Jur, T., Keating, D., and Orloff, D. To discuss program with upper management.
3. E. I. du Pont de Nemours & Company, Savannah River Laboratory on November 1, 1977. Jur, T., Keating, D., and Van Brunt, V. To review program plan with Mr. Paul Roggenkamp of the Advanced Operational Planning Division.
4. Duke Power Company, Charlotte, North Carolina, on Friday, November 4, 1977. Jur, T., Keating, D., Orloff, D., and Stanford, T. To discuss program with engineering management.
5. South Carolina Electric & Gas, Columbia, South Carolina, on November 8, 1977. Jur, T., Keating, D., and Orloff, D. To begin identifying areas of interaction with representatives of the engineering department.
6. DOE, Savannah River Operations Office, on November 15, 1977. Jur, T., Keating, D., Orloff, D., and Stephens, L. To discuss program with representatives of management.
7. E. I. du Pont de Nemours & Company, SRL and SRP on November 15, 1977. Jur, T., Keating, D., Orloff, D., and Stephens, L. To meet with representatives of the University Relations Office (SRL) and Personnel Office (SRP) and discuss the program.
8. Westinghouse Fuel Fabrication Plant, Columbia, South Carolina, on November 16, 1977. Jur, T. To discuss program with plant management.
9. South Carolina Electric & Gas, Columbia, South Carolina, on November , 1977. Stephens, L. To discuss licensing and regulation requirements.
10. E. I. du Pont de Nemours & Company, SRL and SRP on December 12, 1977. Jur, T., Keating, D., Orloff, D., and Stephens, L. To meet with representatives of the University Relations Office (SRL) and Personnel Office (SRP) to discuss mechanisms of contacting the professional staff at the Savannah River facilities.
11. Carolina Power & Light, Raleigh, North Carolina, on December 14, 1977. Jur, T., Keating, D., Orloff, D., and Rhodes, C. To discuss the program with upper management.

12. Westinghouse Fuel Fabrication Plant, Columbia, South Carolina, on December 15, 1977. Jur, T., Keating, D., Stephens, L., and Van Brunt, V. To further discuss the program and designated contact - the personnel manager.
13. Allied General Nuclear Services, Barnwell, South Carolina, on December 22, 1977. Stephens, L. To discuss licensing and regulation requirements.
14. Duke Power Company, Charlotte, North Carolina, on January 12, 1978. Jur, T., Huhns, M., Keating, D., Orloff, D., and Stephens, L. To meet with a large group of managers and engineers from design engineering and steam production.
15. Oak Ridge National Laboratory, Oak Ridge, Tennessee, on January 19, 1978. Jur, T., Keating, D., Stanford, T., and Van Brunt, V. To discuss program with representatives of lab management.
16. South Carolina Electric and Gas Company, Columbia, South Carolina, on January 26, 1978. Jur, T., Orloff, D., and Stephens, L. To meet with members of engineering staff to discuss educational needs and company organization.
17. Department of Energy, Savannah River Office, Aiken, South Carolina, on February 2, 1978. To discuss program with representatives of SRO management.
18. E. I. du Pont de Nemours & Company, SRL and SRP, on February 2, 1978. Huhns, M., Jur, T., Keating, D., Orloff, D., Stanford, T., Van Brunt, V. To meet with a large group of managers from SRL and SRP to discuss the program.
19. Duke Power Company, Charlotte, North Carolina, on February 9, 1978. Jur, T. To meet with engineering manager from the Mechanical Design Section of Design Engineering.
20. Duke Power Company, Charlotte, North Carolina, on February 9, 1978. Huhns, M., and Stephens, L. To meet with persons from Design Engineering (Electrical Division).
21. E. I. du Pont de Nemours & Company, SRL, on February 10, 1978. Orloff, D. To meet with representatives of Reactor Engineering and Environmental Effects to discuss educational needs and instructional expertise at SRL.
22. E. I. du Pont de Nemours & Company, SRP, on February 13, 1978. Keating, D. and Orloff, D. To identify educational needs and further contacts within SRP.
23. Westinghouse Fuel Fabrication Plant, Columbia, South Carolina, on February 15, 1978. Tatterson, G. and Van Brunt, V.

To discuss educational needs with representatives of Chemical Operations and Chemical Process Engineering.

24. Nuclear Regulatory Commission, Region II Office, Atlanta, Georgia, on February 16, 1978. Stephens, L. To discuss the project and to solicit NRC input in educational matters concerning regulatory activities.
25. Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, on February 16, 1978. Jur, T., Stanford, T. and Van Brunt, V. To introduce project to management.
26. South Carolina Electric and Gas Company, Columbia, South Carolina, on February 21. Stephens, L. To discuss in-core fuel management.
27. Duke Power Company, Charlotte, North Carolina, on February 22, 1978. Orloff, D. and Rhodes, C. To meet with persons from the Design Engineering (Fluid Systems and Environmental Sections) and Steam Production (Training Services).
28. Allied General Nuclear Services, Barnwell, South Carolina, on February 24, 1978. Stanford, T. and Tatterson, G. To discuss educational needs in the area of instrumentation and process control.
29. Southern Company Services, Birmingham, Alabama, on February 24, 1978. Jur, T. To discuss education needs in area of fuel procurement and management.
30. Duke Power Company, Charlotte, North Carolina, on March 4, 1978. Stephens, L. To meet with a member of the Design Engineering Division to discuss in-core fuel management.
31. Oak Ridge Associated Universities, Oak Ridge, Tennessee, on March 9, 1978. Keating, D. and Orloff, D. To explain the purpose and scope of project and to discuss areas of mutual interest and interaction.
32. Oak Ridge National Laboratory, Oak Ridge, Tennessee on March 9, 1978. Keating, D. and Orloff, D. To identify advanced professional needs within ORNL in mechanical engineering areas.
33. Georgia Tech Conference on Nuclear Power Safety March 14-16, 1978. Stephens, L.
34. Meeting - Back End of the LWR Fuel Cycle, Savannah Georgia, March 19-23. Orloff, D., Tatterson, G., Van Brunt, V.

35. E. I. du Pont de Nemours & Company, SRP on March 30, 1978. Jur, T. and Orloff, D. To meet with representatives of the Project Engineering Department to discuss education needs.
36. E. I. du Pont de Nemours & Company, SRL on March 30, 1978. Jur, T. and Orloff, D. To meet with representatives of Reaction Engineering to identify education needs and instructional expertise at SRL.
37. Carolina Power and Light, Raleigh, North Carolina on April 5, 1978. Keating, D., Orloff, D., and Rhodes, C. To discuss educational needs with representatives of engineering.
38. Oak Ridge National Laboratory, Oak Ridge, Tennessee, on April 11, 1978. Keating, D., Jur, T., Orloff, D., and Rhodes, C. To discuss project objectives with management of the Advanced Fuel Recycle Program.
39. Oak Ridge National Laboratory, Oak Ridge, Tennessee, on April 19, 1978. Stanford, T., Tatterson, G., and Van Brunt, V. To discuss educational needs with representatives of various chemical engineering departments.
40. Savannah River Plant, Aiken, South Carolina on April 27, 1978. Huhns, M. and Stephens, L. To discuss educational needs in the electrical engineering area.
41. Savannah River Laboratory, Aiken, South Carolina, on May 16, 1978. Stanford, T., Tatterson, G., and Van Brunt, V. To discuss educational needs in chemical engineering related areas.
42. Savannah River Plant, Aiken, South Carolina on May 16, 1978. Stanford, T., Tatterson, G., and Van Brunt, V. To discuss educational needs in chemical engineering related areas.
43. Electric Power Research Institute, Palo Alto, California on May 23, 1978. Keating, D. and Orloff, D. To discuss the program and its objective with representatives of management.
44. Savannah River Laboratory, Aiken, South Carolina on May 24, 1978. Huhns, M. and Stephens, L. To discuss educational needs in the electrical engineering area.
45. Savannah River Laboratory, Aiken, South Carolina on May 30, 1978. Tatterson, G. To discuss educational needs in chemical engineering related areas.
46. Oak Ridge National Laboratory, Oak Ridge, Tennessee on June 1, 1978. Jur, T., Orloff, D., and Rhodes C. To discuss educational needs with representatives of Engineering Technology Division.
47. Oak Ridge National Laboratories, Oak Ridge, Tennessee on June 1, 1978. Jur, T., Orloff, D., and Rhodes, C. To discuss in-house educational programs at ORNL with George Moore who heads that activity.

48. Oak Ridge National Laboratory, Oak Ridge, Tennessee on June 1, 1978. Jur, T., Orloff, D., and Rhodes, C. To discuss educational needs in Materials and Ceramics Division with J. Cunningham, Associate Director.
49. Savannah River Plant, Aiken, South Carolina on June 8, 1978. Hühns, M. and Stephens, L. To discuss educational needs in electrical engineering related areas.
50. Savannah River Laboratory, Aiken, South Carolina on June 14, 1978. Jur, T. To discuss content of courses in system reliability and fault tree analysis with E. Nomm.
51. Southern Company Services, Atlanta, Georgia on June 26, 1978. Jur, T. To discuss project objective and educational needs with representatives of the professional development department.
52. Oak Ridge National Laboratory, Oak Ridge, Tennessee on June 16, 1978. Jur, T. To discuss content of courses in pressure vessel and piping design with J. Corwin of the Engineering & Technology Division.