UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of LONG ISLAND LIGHTING COMPANY (Shoreham Nuclear Power Station, Unit 1)	Docket No. 50-322-OL-3 (Emergency Planning)

TESTIMONY OF FRED C. FINLAYSON,
GREGORY C. MINOR AND EDWARD P. RADFORD
ON BEHALF OF SUFFOLK COUNTY
REGARDING CONTENTION 61

Q. Please state your names and positions.

A. My name is Fred C. Finlayson. I am a Principal Associate of F.C. Finlayson & Associates, 12844 East Cuesta St., Cerritos, Claifornia. A copy of my professional qualifications is attached to this testimony as Attachment 1.

A. My name is Gregory C. Minor. I am a founder and vice-president of MHB Technical Associates, 1723 Hamilton Avenue, San Jose, California. A copy of my professional qualifications is attached to this testimony as Attachment 2.

A. My name is Dr. Edward P. Radford, and I am Professor of Epidemiology at University of Pittsburgh. I received my

M.D. degree from the Harvard Medical School in 1946. My specialty is the subject of the health effects of ionizing radiation, which I have taught at the Harvard University School of Public Health, the University of Cincinnati School of Medicine, Johns Hopkins University School of Hygiene and Public Health, and the University of Pittsburgh. I am presently on leave of absence from Pittsburgh in order to conduct research in Japan on new data that have been compiled ragarding the health effects of the atomic explosions in Japan in 1945. My professional qualifications and background are set forth in my curriculum vita which is Attachment 3 to this testimony.

Q. What is the purpose of this testimony?

A. (Finlayson, Minor, Radford) The purpose of this testimony is to address portions of Emergency Planning Contention 61.

Q. Many subparts of Contention 61 refer to "shielding factors." What is a shielding factor?

A. (Finlayson, Minor) A shielding factor is the ratio of the dose a person would receive while in a shelter, compared to the dose he would receive if shelter were not taken. For example, a shielding factor of 0.2 means that a person in a

shelter would receive 20% of the dose he would have received if he had not taken shelter; a shelter with a shielding factor of 0.2 results in an 80 percent dose reduction. In Table 3.6.5 of the LILCO Plan, LILCO identifies shielding factors from a cloud dose for various structures in the EPZ as follows:

Structure	Shielding Factor
Wood frame without basement	0.9
Wood frame with basement	0.6
Masonry house without basement	0.6
Masonry house with basement	0.4
Large office or industrial building	0.2
Vehicles	1.0

Q. Subpart G of Contention 61 states:

> G. Many other homes in the EPZ, even if they provide more shielding than a wood house, will only reduce doses about 50 percent. In a severe accident, a 50-percent dose reduction will still result in health-threatening doses.

What kind of homes in the EPZ will reduce doses by about 50 percent?

A. (Finlayson, Minor) A shielding factor of approximately 0.5 -- that is, a 50 percent dose reduction -- approximates the average shielding available from houses that are constructed of masonry with and without basements.

Q. In a severe accident at the Shoreham plant, assuming a 50 percent dose reduction is achieved by sheltering, will health-threatening doses result to people within the EPZ?

A. (Finlayson, Minor) Yes. Assuming a 50 percent dose reduction, 8 percent of severe accidents at Shoreham involving a release of radioactive material will result in a person within ten miles of the plant receiving a dose exceeding 30 rems. See Table 1 which is Attachment 4 hereto. Five percent of those accidents will result in a person within two miles of the plant receiving a dose exceeding 100 rems; one percent of those accidents will result in a person within five miles of the plant receiving a dose exceeding 100 rems.

A. (Radford) A 30 rem dose is considered the threshold of early injuries. People who receive 30 rem doses will probably not experience any acute effects (i.e., deaths or injuries occurring within 60 days after exposure), but their lifetime chances of developing cancer will increase by about 21 percent over the normal rate. Doses above 30 rem are more likely to cause early acute effects and result in even greater increases in the chances of developing cancer.

Q. Subpart H of Contention 61 states:

H. According to LILCO, the average shielding factor available in the EPZ is 0.7, which means that, on the average, those who follow a sheltering recommendation will nonetheless receive 70 percent of the dose they would receive from the plume if they were outside the shelter.

Where does LILCO identify 0.7 as the average shielding factor available in the EPZ?

A. (Finlayson, Minor) LILCO states in OPIP 3.6.1 (page 36)[1/] that the average shielding factor in the EPZ is 0.7. This means that on the average, a person taking shelter in the EPZ would experience a 30 percent reduction in the dose he or she would receive if he or she did not shelter.

Q. Subpart I of Contention 61 states:

I. The cloud doses resulting from a release of radioactive fission products from the Shoreham plant could be so substantial that even taking into account the 30 percent average dose reduction provided by shelter in the EPZ, persons who follow a sheltering recommendation could still receive doses that would cause adverse health effects.

In a severe accident at Shoreham, assuming a 30 percent dose

1/ In Revisions 0, 1 and 2 of OPIP 3.6.1, Attachment 7 states that "[t]he average shielding factor from surveys taken in the EPZ was found to be 0.7." This attachment was eliminated in Revision 3, but the 0.7 average shielding factor is still identified for use in performing the calculations described in OPIP 3.6.1.

reduction is achieved by sheltering, will persons in the EPZ who follow a sheltering recommendation receive doses that could cause adverse health effects?

A. (Finlayson, Minor) Yes. In a severe accident at Shoreham involving the release of radioactive material, and assuming LILCO's average cloud shielding factor of 0.7 and a 0.2 ground dose shielding factor, 12 percent of those accidents will result in persons within the 10 mile EPZ receiving a dose exceeding 30 rems. (See Table 1) Nine percent of those accidents will result in persons within two miles of the plant receiving a 100 rem dose. One percent of those accidents will result in persons within nine miles of the plant receiving a dose exceeding 100 rems. For those people in the EPZ who take shelter in wood frame houses without basements, only a 10 percent cloud dose reduction will be available. In a severe accident at Shoreham involving a release of radioactive material, and assuming a 60 percent reduction in ground dose, 15 percent of those accidents will result in a dose of 30 rems to persons in wood houses without basements located within ten miles of the plant. Five percent will result in a 100 rem dose to persons in such houses located within two miles of the plant; one percent will result in a 100 rem dose to persons in wood houses without basements located within ten miles of the plant.

Q. In light of the average shielding factor in the EPZ identified by LILCO, do you agree with the portion of Contention 61 which alleges that assuming people were willing and able to follow a sheltering recommendation, there is no assurance that taking such action would provide the dose savings necessary to prevent persons from receiving health-threatening radiation doses?

A. (Finlayson, Minor, Radford). Yes. Sheltering, if implemented, does provide for a reduction in dose compared to the situation without sheltering and shielding factors are used to express this reduction. Sheltering can, in many circumstances, reduce doses to the point where they are not immediately life-threatening. However, assuming the average shielding factor identified by LILCO in the Shoreham EPZ, in the event of a severe accident there is no assurance that the dose savings from sheltering would be significant enough to reduce doses to levels below those which are threatening to health.

(Finlayson, Minor) For example, in the area within two miles of the plant, the type of sheltering has little effect on the chances of receiving a health-threatening dose of 30 rems. Even at a distance of ten miles from the plant, the chances of

receiving a dose exceeding 30 rems, assuming sheltering is implemented, range from eight to fifteen percent; with LILCO's average shielding factor sheltering results in a twelve percent chance of such a dose. In addition, there is a five to twenty percent chance of people within two miles of the plant receiving a 100 rem dose, depending on what type of shelter is available, assuming a sheltering recommendation is followed.

Q. Subpart B of Contention 61 states:

> Persons who are traveling in their cars or other vehicles at the time of a sheltering recommendation may not be able to reach shelter fast enough to obtain any protection from a release of radioactive fission products. Vehicles offer essentially no protection from radioactive doses.

If persons are in vehicles at the time of a sheltering recommendation, and are unable to reach shelter before passage of the radioactive plume, what protection from radioactive doses will they receive?

A. (Finlayson, Minor) In Table 3.6.5 of the Plan, LILCO identifies vehicles as having a shielding factor of 1.0, which is the same as providing no effective cloud shielding. Thus, assuming a severe accident at Shoreham involving a release of radiation, people who are in cars or other vehicles within ten

miles of the plant for about two hours would have a 15 to 35 percent chance of receiving a dose in excess of 30 rems.

Q. Does that conclude your testimony?

A. (Finlayson, Minor, Radford) Yes.

ATTACHMENT 1

FRED C. FINLAYSON
PRINCIPAL ASSOCIATE
F. C. FINLAYSON & ASSOCIATES
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REACTOR SAFETY ASSESSMENT
NUCLEAR POWER PLANT
PROBABILISTIC RISK
ASSESSMENT
REACTOR ACCIDENT CONSEQUENCE
ASSESSMENT
ENERGY SYSTEMS DESIGN AND
ANALYSIS

BACKGROUND SUMMARY

Dr. Finlayson has extensive experience in the field of assessment of the safety, reliability and risks of nuclear power reactors. He has recently conducted an evaluation of potential risks and consequences of severe reactor accidents in the Shoreham Nuclear Power Plant. He supported an evaluation of the impact and application of BWR suppression pool scrubbing capabilities on emergency planning as part of an evaluation of a probabilistic risk assessment of General Electric's BWR-6, standardized nuclear power plant design. He also provided technical direction of the probabilistic risk analyses conducted for the State of California's evaluation of Emergency Planning Zone requirements. He was the principal investigator and program manager of the NRC's first investigation of the adequacy of human engineering in nuclear power plant control rooms under severe accident conditions. He is currently conducting an investigation for the NRC of the feasibility of instituting a voluntary non-punitive reporting system for human errors in nuclear power plants. Dr. Finlayson was also the manager of The Aerospace Corporation program that provided systems integration and technical direction of the California Energy Commission's study of underground nuclear power plant designs, costs, and their relative effectiveness in reducing the consequences of extremely severe accidents.

Dr. Finlayson has been a consultant to the NRC, U.S. General Accounting Office, and other federal and state governmental agencies on nuclear safety related issues such as site-specific risk analyses, human engineering, large-scale reactor test program design and effectiveness, sabotage, waste transport hazards, and a wide variety of other related topics. He is currently a member of the American Physical Society's Review Committee for evaluation of the status and adequacy of source terms for product releases from severe nuclear power plant accidents. He served on several review committees for the "PRA Procedures Guide" (NUREG/CR-2300) for probabilistic risk assessments for nuclear power plants. He was a member of the NRC's 1980/1981 LOFT Special Review Group and was consultant to the NRC's Rogovin Special Inquiry Group in their investigation of human engineering factors associated with the Three Mile Island incident. He has performed several assessments of the design and effectiveness of ECCS for LWRs, including the analysis which he prepared as a member of the American Physical Society's Review Committee (1975) on Light Water Reactor Safety.

EDUCATION

BS Mechanical Engineering, Brigham Young University, 1958
PhD Mechanical Engineering, Northwestern University, 1964

EXPERIENCE

The Aerospace Corporation, Los Angeles, CA (1972-Present). Dr. Finlayson is currently Manager, Nuclear Systems and Safety, Energy and Resources Division. In this capacity, he is responsible for programs dealing with nuclear power plant safety, reliability and risk assessment. He directed the systems engineering and technical management efforts for the recent California study of statewide nuclear power plant risks and associated emergency planning zone requirements; and directed a similar program for a major study of underground nuclear power plant siting. He was also the program manager for an assessment of the impact of plutonium fuel cycle safeguards, and an evaluation of nuclear control room human engineering. He has also managed and performed systems analyses of industrial process heat applications of geothermal power as well as conceptual design and evaluation studies of hybrid solar/geothermal power systems. Studies of local and national energy consumption patterns and the effectiveness of selected conservation measures have also been performed under his direction.

Physics International Company, San Leandro, CA (1968-1972). Dr. Finlayson directed and conducted research in strategic and tactical weapon systems survivability/vulnerability, numerical analyses of the propagation of strong shocks in geologic media and structural materials, and structure-medium interactions.

The Aerospace Corporation, Los Angeles, CA (1964-1968). Dr. Finlayson conducted investigations of ground based system survivability to all relevant effects of nuclear weapons.

The General American Transportation Corporation, Chicago, IL (1960-1964). Dr. Finlayson conducted research on the interactions of strong shocks in air and earth materials with above-ground and buried structures.

PROFESSIONAL ACTIVITIES

Dr. Finlayson is a registered Professional Nuclear Engineer in the State of California. He is a member of the American Nuclear Society and the Institute of Electrical and Electronics Engineers (Reliability Society).

PUBLICATIONS

"Closures for Hardened Protective Hangers", AFSWC-TDR-62-77, MRD Division of General American Transport Corporation, Niles, Illinois, August 1962.

"Air Blast Load Reduction on Above Ground Structures", Proceedings of the 32nd Symposium on Shock, Vibration, and Associated Environments, Part II, Bulletin No. 32, Office of the Director of Defense Research and Engineering, November 1963.

"Design Procedures for Shock Isolation Systems of Underground Protective Structures, Volume II, Structure Interior Motions Due to Directly Transmitted Ground Shock", AFWL RTD-TRD-63-3096, Vol. II, General American Transportation Corporation, Niles, Illinois, December 1965. (Coauthor).

"Wave Interaction of a Viscoelastic Medium with an Elastic Cylindrical Shell", Journal of the Acoustical Society of America, Vol. 40, No. 6, pp. 1496-1500, December 1966. (Coauthor).

"System Vulnerabilities to Craters and Ejecta", (U) Proceedings of the Symposium on Nuclear Craters and Ejecta, Vol. I, SAMSO-TR-68-107, November 1967 (S-RD).

Proceedings of the Symposium on Nuclear Craters and Ejecta, (U) Vol. I and II, SAMSO-TR-68-107, November 1967 (S-RD). (Coeditor).

"A Theoretical and Experimental Study of Detonations in Connection with Decoupling," DASA 2505, Physics International Company, San Leandro, California, November 1969. (Coauthor).

"Deep Based Sanguine System Survivability" (U) PIFR-327, Physics International Company, San Leandro, California, August 1971 (S-RD). (Coauthor).

"Estimated SPRINT II Ground Motions" PITR 350-4, Physic International Company, San Leandro, California, March 1972 (S-3). (Coauthor).

"Relative Effectiveness of Energy Conservation Measures Taken in the Pacific Northwest," Aerospace Report No. ATR-74(8166)-1, January 1974.

"Emergency Core Cooling Systems for Light Water Reactors," EQL Report No. 9, California Institute of Technology, Environmental Quality Laboratory, May 1975.

Report to the American Physical Society by the Study Group on Light-Water Reactor Safety, Reviews of Modern Physics, Volume 47, Supplement No. 1, Summer 1975. (Coauthor).

"Integrated Solar/Geothermal Power Systems Conceptual Design and Analysis", ATR-75(7512)-1, July 1975. (Coauthor).

"Nuclear Reactor Safety: A View from the Outside", Bulletin of the Atomic Scientists, September 1975 pp. 20-25.

"Review of the NRC/ERDA Loss-of-Fluid Test Facility", 19 November 1975, pp. 67-108 of Enclosure A to This Country's Most Expensive Light Water Reactor Safety Facility, GAO document RED-76-68 A, May 26, 1976.

"Effectiveness of Safeguards Program for the LWR Plutonium Recycling Industry", ATR-76(6879)-1, April 1976. (Coauthor).

"Poor Management of a Nuclear Light Water Reactor Safety Project," GAO document EMD-76-4, 25 August 1976. (Coauthor). Documentation of review of ERDA/NRC Plenum Fill Experiment Program.

"Transportation Risks for New and Spent Fuels and Radioactive Wastes with Respect to Road Accident Hazards and Purposeful Diversion", Direct Testimony, SDG&E Sundesert NOI Hearings, 30 November 1976.

"Technical Brief - Issues of Record Related to Plans for Protection Against Sabotage and Diversion of Nuclear Materials for the Sundesert Nuclear Power Plant", SDG&E Sundesert NOI Proceedings, 29 December 1976.

"Technical Brief - Issues of Record Related to Transportation Risks for New and Spent Reactor Fuels and Radioactive Waste", SDG&E Sundesert NOI Proceedings, 30 December 1976.

"Control Room Human Engineering Influences on Operator Performance", Proceedings of Topical Meeting on Thermal Reactor Safety. CONF-770708, Sun Valley, Idaho, 31 July - 4 August 1977.

"Systems Management Support for ERCDC Study of Undergrounding and Berm Containment: Interim Report, Preliminary Program Assessment and Follow-on Program Development", ATR-77(7652-01)-1, August 1977. (Coauthor).

Review and Critique of Draft "Report to the U.S. Congress on NRC's Plans for Research Directed Toward the Improvement of Light-Water Nuclear Power Plant Safety", Letter report, 22 February 1978.

"Evaluation of the Feasibility, Economic Impact, and Effectiveness of Underground Nuclear Power Plants - Final Technical Report", ATR-78 (7652-14)-1, May 1978. (Coauthor).

"Underground Siting of Nuclear Power Reactors - An Analysis of the California Energy Commission Study", Transactions of the American Nuclear Society, Vol. 32, 1979 Annual Meeting, Atlanta, GA., June 3-7, 1979, pp. 553, 554. (Coauthor).

"Human Engineering Influences on the Performance of Nuclear Power Plant Operators", Testimony for the record of the May 22-24 1979 Hearings on Nuclear Power Plant Safety Systems, Committee on Science and Technology, U.S. House of Representatives. U.S. Government Printing Office, 1979, pp. 255-270.

"Residential Photovoltaic Systems - A Review and Comparative Evaluation of Four Independent Studies of Potential Concepts", ATR-80(7823)-1, December 1979 (also published as SAND 80-7010, Sandia National Laboratories, October 1980).

"Review of Rogovin Special Investigative Group Staff Report on Human Factors Evaluation Related to the Three Mile Island Accident", Letter Report, 30 November 1979.

"Industrial Process Heat Applications of Solar and Geothermal Energy and Human Engineering Influences on the Performance of Nuclear Power Plants", ATR-79(9538)-1, September 1979.

"Emergency Planning Zones for Serious Nuclear Power Plant Accidents", State of California - Office of Emergency Services, November 1980. (Coauthor).

"The Technical Basis for Emergency Planning Zones for Serious Accidents at Nuclear Power Plants in California", ATR-81(7870)-1, November 1980.

"Report of the LOFT Special Review Group", U.S. Nuclear Regulatory Commission, NUREG-0758, February 1981. (Coauthor).

"The Feasibility and Effectiveness of Underground Nuclear Power Plants - a Review of the California Energy Commission's Study", pp. 19-33, Proceedings of the Symposium on Underground Siting of Nuclear Power Plants, Hanover, West Germany (16-20 March 1981), E Schweizerbart'sche Verlagsbuchhandlung (Nagele u Obermiller) Stuttgart, 1982.

"Development of Emergency Planning Zones for Nuclear Accidents in California", American Nuclear Society Transactions, 1981 Annual Meeting, Miami, Florida, June 7-11, 1982, TANSAO 38 1-776 (1981), June 1981, pp. 124-126.

"Basis for Selection of Emergency Planning Zones from the Shoreham Nuclear Power Plant, Suffolk County, New York," F.C. Finlayson & Associates, October, 1982 (Coauthor with Edward P. Radford, M.D.)

"Impact and Application of Suppression Pool Scrubbing Capability to Emergency Planning," Future Resources Associates, Inc., December, 1982. (Coauthor with Robert J. Budnitz)

"Nuclear Power Safety Reporting System, Vol. I: Feasibility Analysis," U.S. Nuclear Regulatory Commission, NUREG/CR-3119 (Vol. I), February, 1983. (Coauthor with J.R. Ims)

"Nuclear Power Safety Reporting System, Vol. II: Concept Description," U.S. Nuclear Regulatory Commission, NUREG/CR-3119 (Vol. II), April, 1983

"Nuclear Power Safety Reporting System - Feasibility Analysis and Concept Description," Transactions of the 11th Water Reactor Safety Research Information Meeting, NUREG/CP-0047, October 1983. (Coauthor with J.R. Ims and T.A. Hussman)

ATTACHMENT 2

PROFESSIONAL QUALIFICATIONS OF GREGORY C. MINOR

GREGORY C. MINOR
MHB Technical Associates
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EXPERIENCE:

1976 to PRESENT

Vice-President - MHB Technical Associates, San Jose, California

Engineering and energy consultant to state, federal, and private organizations and individuals. Major activities include studies of safety and risk involved in energy generation, providing technical consulting to legislative, regulatory, public and private groups and expert witness in behalf of state organizations and citizens' groups. Was co-editor of a critique of the Reactor Safety Study (WASH-1400) for the Union of Concerned Scientists and co-author of a risk analysis of Swedish reactors for the Swedish Energy Commission. Served on the Peer Review Group of the NRC/TMI Special Inquiry Group (Rogovin Committee). Actively involved in the Nuclear Power Plant Standards Committee work for the Instrument Society of America (ISA).

1972-1976

Manager, Advanced Control and Instrumentation Engineering, General Electric Company, Nuclear Energy Division, San Jose, California

Managed a design and development group of thirty-four engineers and support personnel designing systems for use in the measurement, control and operation of nuclear reactors. Involved coordination with other reactor design organizations, the Nuclear Regulatory Commission, and customers, both overseas and domestic. Responsibilities included coordinating and managing and design and development of control systems, safety systems, and new control concepts for use on the next generation of reactors. The position included responsibility for standards applicable to control and instrumentation, as well as the design of short-term solutions to field problems. The disciplines involved included electrical and mechanical engineering, seismic design and process computer control/programming, and equipment qualification.

1970 - 1972

Manager, Reactor Control Systems Design, General Electric Company, Nuclear Energy Division, San Jose, California

Managed a group of seven engineers and two support personnel in the design and preparation of the detailed system drawings and control documents relating to safety and emergency systems for nuclear reactors. Responsibility required coordination with other design organizations and interaction with the customer's engineering personnel, as well as regulatory personnel.

1963 - 1970

Design Engineer, General Electric Company, Nuclear Energy Division, San Jose, California

Responsible for the design of specific control and instrumentation systems for nuclear reactors. Lead design responsibility for various subsystems of instrumentation used to measure neutron flux in the reactor during startup and intermediate power operation. Performed lead system design function in the design of a major system for measuring the power generated in nuclear reactors. Other responsibilities included on-site checkout and testing of a complete reactor control system at an experimental reactor in the Southwest. Received patent for Nuclear Power Monitoring System.

1960 - 1963

Advanced Engineering Program, General Electric Company, Assignments in Washington, California, and Arizona

Rotating assignments in a variety of disciplines:

- Engineer, reactor maintenance and instrument design, KE and D reactors, Hanford, Washington, circuit design and equipment maintenance coordination.
- Design engineer, Microwave Department, Palo Alto, California. Worked on design of cavity couplers for Microwave Traveling Wave Tubes (TWT).
- Design engineer, Computer Department, Phoenix, Arizona. Design of core driving circuitry.
- Design engineer, Atomic Power Equipment Department, San Jose, California. Circuit design and analysis.
- Design engineer, Space Systems Department, Santa Barbara, California. Prepared control portion of satellite proposal.

- Technical Staff - Technical Military Planning operation. (TEMPO), Santa Barbara, California. Prepare analyses of missile exchanges.

During this period, completed three-year General Electric program of extensive education in advanced engineering principles of higher mathematics, probability and analysis. Also completed courses in Kepner-Tregoe, Effective Presentation, Management Training Program, and various technical seminars.

EDUCATION

University of California at Berkeley, BSEE, 1960.

Advanced Course in Engineering - three-year curriculum, General Electric Company, 1963.

Stanford University, MSEE, 1966.

HONORS AND ASSOCIATIONS

- Tau Beta Pi Engineering Honorary Society
- Co-holder of U.S. Patent No. 3,565-760, "Nuclear Reactor Power Monitoring System," February, 1971.
- Member: American Association for Advance of Science.
- Member: Nuclear Power Plant Standards Committee, Instrument Society of America.

PERSONAL DATA

Born: June 7, 1937
Married, three children
Residence: San Jose, California

PUBLICATIONS AND TESTIMONY

1. G. C. Minor, S. E. Moore, "Control Rod Signal Multiplexing," IEEE Transactions on Nuclear Science, Vol. NS-19, February, 1972.
2. G C. Minor, W. G. Milam, "An Integrated Control Room System for a Nuclear Power Plant," NEDO-10658, presented at International Nuclear Industries Fair and Technical Meetings, October, 1972, Basle, Switzerland.

3. The above article was also published in the German Technical Magazine, NT, March, 1973.

4. Testimony of G. C. Minor, D. G. Bridenbaugh, and R. B. Hubbard before the Joint Committee on Atomic Energy, Hearing held February 18, 1976, and published by the Union of Concerned Scientists, Cambridge, Massachusetts.

5. Testimony of G. C. Minor, D. G. Bridenbaugh, and R. B. Hubbard before the California State Assembly Committee on Resources, Land Use, and Energy, March 8, 1976.

6. Testimony of G. C. Minor and R. B. Hubbard before the California State Senate Committee on Public Utilities, Transit, and Energy, March 23, 1976.

7. Testimony of G. C. Minor regarding the Grafenrheinfeld Nuclear Plant, March 16-17, 1977, Wurzburg, Germany.

8. Testimony of G. C. Minor before the Cluff Lake Board of Inquiry, Regina, Saskatchewan, Canada, Department 21, 1977.

9. The Risks of Nuclear Power Reactors: A Review of the NRC Reactor Safety Study WASH-1400 (NUREG-75/0140), H. Kendall, et al, edited by G. C. Minor and R. B. Hubbard for the Union of Concerned Scientists, August, 1977.

10. Swedish Reactor Safety Study: Barseback Risk Assessment, MHB Technical Associates, January, 1978. (Published by Swedish Department of Industry as Document SdI 1978:1)

11. Testimony by G. C. Minor before the Wisconsin Public Service Commission, February 13, 1978, Loss of Coolant Accidents: Their Probability and Consequence.

12. Testimony by G. C. Minor before the California Legislature Assembly Committee on Resources, Land Use, and Energy, AB 3108, April 26, 1978, Sacramento, California.

13. Presentation by G. C. Minor before the Federal Ministry for Research and Technology (BMFT), Meeting on Reactor Safety Research, Man/Machine Interface in Nuclear Reactors, August 21, and September 1, 1978, Bonn, Germany.

14. Testimony of G. C. Minor, D. G. Bridenbaugh, and R. B. Hubbard, before the Atomic Safety and Licensing Board, September 25, 1978, in the matter of Black Fox Nuclear Power Station Construction Permit Hearings, Tulsa, Oklahoma.

15. Testimony of G. C. Minor, ASLB Hearings Related to TMI-2 Accident, Rancho Seco Power Plant, on behalf of Friends of the Earth, September 13, 1979.

16. Testimony of G. C. Minor before the Michigan State Legislature, Special Joint Committee on Nuclear Energy, Implications of Three Mile Island Accident for Nuclear Power Plants in Michigan, October 15, 1979.

17. A Critical View of Reactor Safety, by G. C. Minor, paper presented to the American Association for the Advancement of Science, Symposium on Nuclear Reactor Safety, January 7, 1980, San Francisco, California.

18. The Effects of Aging on Safety of Nuclear Power Plants., paper presented at Forum on Swedish Nuclear Referendum, Stockholm, Sweden, March 1, 1980.

19. Minnesota Nuclear Plants Gaseous Emissions Study, MHB Technical Associates, September, 1980, prepared for the Minnesota Pollution Control Agency, Roseville, MN.

20. Testimony of G. C. Minor and D. G. Bridenbaugh before the New York State Public Service Commission, Shoreham Nuclear Plant Construction Schedule, in the matter of Long Island Lighting Company Temporary Rate Case, September 22, 1980.

21. Testimony of G. C. Minor and D. G. Bridenbaugh before the New Jersey Board of Public Utilities, Oyster Creek 1980 Refueling Outage Investigation, in the matter of Jeresey Central Power and Light Rate Case, February 19, 1981.

22. Systems Interaction and Single Failure Criterion, MHB Technical Associates, January, 1981, prepared for and available from the Swedish Nuclear Power Inspectorate, Stockholm, Sweden.

23. Systems Interaction and Single Failure Criterion: Phase II Report, MHB Technical Associates, February 1982, prepared for and available from the Swedish Nuclear Power Inspectorate, Stockholm, Sweden.

24. Testimony of G. C. Minor and D. G. Bridenbaugh on PORV's and Pressurizer Heaters. Diablo Canyon Operating License hearing before ASLB, January 11, 1982.

25. Testimony of G. C. Minor and R. B. Hubbard on Emergency Response Planning. Diablo Canyon Operating License hearing before ASLB, January 10, 1982.

26. Testimony of G. C. Minor, R. B. Hubbard, M. W. Goldsmith, S. J. Harwood on behalf of Suffolk County, before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station, Unit 1, regarding Contention 7B, Safety Classification and Systems Interaction, April 13, 1982.

27. Testimony of G. C. Minor and D. G. Bridenbaugh on behalf of Suffolk County, before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting company, Shoreham Nuclear Power Station, Unit 1, regarding Suffolk County Contention 11, Passive Mechanical Valve Failure, April 13, 1982.

28. Testimony of G. C. Minor and R. B. Hubbard on behalf of Suffolk County, before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station, Unit 1, regarding Suffolk County Contention 27 and SOC Contention 3, Post-Accident Monitoring, May 25, 1982.

29. Testimony of G. C. Minor and D. G. Bridenbaugh on behalf of Suffolk County, before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station, Unit 1, regarding Suffolk County Contention 22, SRV Test Program, May 25, 1982.

30. Testimony of G. C. Minor and D. G. Bridenbaugh on behalf of Suffolk County, before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station, Unit 1, regarding Suffolk County Contention 28(a)(vi) and SOC Contention 7A(6), Reduction of SRV Challenges, June 14, 1982.

31. Testimony of G. C. Minor on behalf of Suffolk County, before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station Unit 1, regarding Environmental Qualification, January 18, 1983.

32. Testimony of G. C. Minor and D. G. Bridenbaugh before the Pennsylvania Public Utility Commission, on behalf of the Office of Consumer Advocate, Regarding the Cost of Constructing the Susquehanna Steam Electric Station, Unit I, Re: Pennsylvania Power and Light, March 18, 1983.

33. Supplemental testimony of G. C. Minor, R. B. Hubbard, and M. W. Goldsmith on behalf of Suffolk County, before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station, Unit 1, regarding Suffolk County Contention 7B, Safety Classification and Systems Interaction, March 23, 1983.

34. Testimony before the District Court Judge in the case of Sierra Club et al. vs. DOE regarding the Clean-up of Uranium Mill Tailings. June 20, 1983.

35. Systems Interaction and Single Failure Criterion: Phase 3 Report, MHB Technical Associates, June, 1983, prepared for and available from the Swedish Nuclear Power Inspectorate, Stockholm, Sweden.

36. Systematic Evaluation Program: Status Report and Initial Evaluation, MHB Technical Associates, June, 1983, prepared for and available from the Swedish Nuclear Power Inspectorate, Stockholm, Sweden.

ATTACHMENT 3

CURRICULUM VITAE

Name: Edward Parish Radford, M.D.
Social Security No.: 022-16-4231
Birthdate: February 21, 1922
Telephone (Office): (412) 624-3009
Birthplace: Springfield, Massachusetts
Citizenship: U.S.A.
Business Address:
Department of Epidemiology
Graduate School of Public Health
University of Pittsburgh
Pittsburgh, PA 15261

EDUCATION AND TRAINING

Undergraduate

Massachusetts Institute of Technology,	1940-43	Biology

Graduate

Harvard Medical School	1943-46	Medicine M.D. 1946

APPOINTMENTS AND POSITIONS

Academic

1949-50	Teaching Fellow, Department of Physiology, Harvard Medical School
1950-52	Instructor, Department of Physiology, Harvard Medical School
1952-55	Associate, Department of Physiology, Harvard School of Public Health
1959-65	Associate Professor Physiology, Harvard School of Public Health
1965-68	Professor and Director, Department of Environmental Health Director of Kettering Laboratory: Professor of Physiology, College of Medicine, University of Cincinnati
1968-77	Professor of Environmental Medicine, School of Hygiene and Public Health, Johns Hopkins University
1975-76	Visiting Professor, Department of Regius Professor of Medicine, University of Oxford, Oxford, England
1977-	Professor of Environmental Epidemiology, Graduate School of Public Health, University of Pittsburgh, Pittsburgh, PA
1979-	Director, Center for Environmental Epidemiology, Graduate School of Public Health, University of Pittsburgh, Pittsburgh, PA

Non-Academic Positions

1947-49	Active Duty, U.S. Air Force Chief of Medical Service, Maxwell Air Force Base, Montgomery, Alabama Radiological Health Officer, Atomic Bomb Tests, Eniwetak Atoll 1948
1955-59	Physiologist, Haskell Laboratory for Toxicology and Industrial Medicine, E.I. duPont deNemours and Company, Newark, Delaware

MEMBERSHIPS IN PROFESSIONAL AND SCIENTIFIC SOCIETIES

American Physiological Society
Radiation Research Society
American Public Health Association
Society for Environmental and Occupational Health
Society for Epidemiologic Research

SERVICE ON COMMITTEES OR OTHER PROFESSIONAL ACTIVITIES

Member: Physiology Training Committee, National Institute of General Medical Sciences, 1967-70
Member: National Academy of Sciences Advisory Committee on the Biological Effects of Ionizing Radiation, 1970-72
Member: Health Research Facilities Scientific Review Committee, National Institutes of Health, 1970-73
Chairman: Power Plants and Human Health and Welfare Studies Group Department of Natural Resources, State of Maryland, 1972-73
Member: The Governor's Advisory Council on Nuclear Reactors, State of Pennsylvania, 1973-74
Consultant in Occupational Health, State of Maryland, Division of Labor and Industries, 1973-75
Medical Consultant to Council on Environmental Quality, Washington, DC, 1975
Chairman: National Academy of Sciences Advisory Committee on the Biological Effects of Ionizing Radiation; Chairman; Subcommittee on Somatic Effects, 1977-80
Member: United States Environmental Protection Agency Administrator's Toxic Substances Advisory Committee, 1977-80
Member: American Public Health Association Technical Panel on Environmental Hazards, 1977-
Medical Consultant to Westvaco Corporation, New York, NY

Research and Training (Current Research)

8/1/80-7/31/81 - Investigation of Lead, Carbon Monoxide and Thiocyanate in Blood Samples from the Third National Health and Nutrition Evaluation Survey (HANES III), Department of Energy - $63,250
9/15/79-9/30/82 -Center for Environmental Epidemiology, Environmental Protection Agency, $1,346,000

Other Activities

Editorial board Environmental Research
Refereeing: New England J Med
Science
Arch Env Health
Environmental Research

Service, University

Departmental Admissions Committee
Curriculum Committee, Graduate School of Public Health

Honors

1943-46 National Scholar, Harvard Medical School
1975-76 Macy Faculty Scholar Award

PUBLICATIONS

1. Radford, EP, Jr. Method for estimating respiratory surface area of mammalian lungs from their physical characteristics. Proc Soc Exp Biol Med 87:58-61, 1954.

2. Radford EP, Jr., Ferris BG, Jr., Kriete BC. Clinical use of a nomogram to estimate proper ventilation during artificial respiration. N Engl J Med 251:877-884, 1954.

3. Radford EP, Jr. Ventilation standards for use in artificial respiration. J Appl Physiol 7:451-460, 1955.

4. Radford EP, Jr., Lefcoe NM. Effect of bronchoconstriction on elastic properties of excised lungs and bronchi. Am J Physiol 180:479-484, 1955.

5. McIlroy MB, Mead J, Selverstone NJ, Radford EP, Jr. Measurement of lung tissue viscous resistance using gases of equal kinematic viscosity. J Appl Physiol 7:485-490, 1955.

6. Otis AB, McKerrow CB, Bartlett RA, Mead J, McIlroy MB, Selverstone NJ, Radford, EP, Jr. Mechanical factors in distribution of pulmonary ventilation. J Appl Physiol 8:427-443, 1955.

7. Radford EP, Jr. Recent studies of mechanical properties of mammalian lungs. In: Tissue Elasticity. JW Remington, ed. Am Physiol Soc., Washington, DC, 1957. pp. 177-190.

8. Mead J, Whittenberger JL, Radford EP, Jr. Surface tension as a factor in pulmonary volume-pressure hysteresis. J Appl Physiol 10:191-196, 1957.

9. Frank NR, Radford EP, Jr., Whittenberger JL. Static volume-pressure interrelations of the lungs and pulmonary blood vessels in excised cats' lungs. J Appl Physiol 14:167-173, 1959.

10. Radford, EP, Jr. Factors modifying water metabolism in rats fed dry diets. Am J Physiol 196:1098-1108, 1959.

11. Brouha L, Radford EP, Jr. The cardiovascular system in muscular activity. In: Science and Medicine of Exercise and Sports. Harper and Brothers, New York, NY, 1960. pp 178-206.

12. Radford EP, Jr. Interrelationships between water and electrolyte metabolism in rats. Am J Cardiol 8:863-869, 1961.

13. Radford EP, Jr., Whittenberger JL. Mechanical methods. In: Artificial Respiration: Theory and Applications. JL Whittenberger, ed. Hoeber Medical Division, Harper and Row, New York, NY, 1962. pp 147-172.

14. Radford EP, Jr. Mechanical stability of the lung. Arch Environ Health 6:134-138, 1963.

15. Radford EP, Jr., Hunt VR, Sherry D. Analysis of teeth and bones for alpha-emitting elements. Radiat Res 19:298-315, 1963.

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19. Little JB, Radford EP, Jr. Bio-assay for antidiuretic activity in blood of undisturbed rats. J Appl Physiol 19:179-186, 1964.

20. Radford, EP, Jr., Hunt VR. Cigarettes and Polonium-210. Science 144:247-249, 1964.

21. Laver MB, Morgan J, Bendixen HH, Radford EP, Jr. Lung volume, compliance and arterial oxygen tensions during controlled ventilation. J Appl Physiol 19: 725-733, 1964.

22. Little JB, Radford EP, Jr. Effects of ionizing radiation and their importance in anesthesiology. Anesthesiology 25:479-489, 1964.

23. Little JB, Radford EP, Jr. Circulating antidiuretic hormone in rats: Effects of dietary electrolytes and protein. Am J Physiol 207-821-825, 1964.

24. Radford EP, Jr. The physics of gases. In: Handbook of Physiology, Sec. 3 Respiration, Vol I. WO Fenn and H R Rahn, eds. Am Physiol Soc, Washington, DC, 1964. pp 125-152.

25. Radford EP, Jr. Static mechanical properties of mammalian lungs. In: Handbook of Physiology, Sec. 3 Respiration, Vol 1. WO Fenn and H Rahn, eds. Am Physiol Soc, Washington, DC, 1964, pp 429-449.

26. Radford EP, Jr., Hunt VR, Little JB. Polonium-210 in cigarette smokers. Science 146:86-87, 1964.

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ATTACHMENT 4

TABLE 1

TYPE OF SHELTER (Shielding Factors)	CHANCES OF RECEIVING HEALTH THREATENING DOSES* AT GIVEN DISTANCES FROM THE PLANT				
	≥30 Rem		≥100 Rem		≥200 Rem
	1-2 mi.	10 mi.	1-2 mi.	10 mi.	1-2 mi.
LILCO Average for Long Island Housing (0.7 cloud, 0.2 ground)	30%	12%	9%	~1%	2%
Wood Frame without Basement (0.9 cloud, 0.4 ground)	30%	15%	20%	1%	2%
Masonry or Brick 1/2 with Basement (0.5 cloud, 0.1 ground)	30%	8%	5%	<1%**	1%
Vehicles (1.0 cloud, 0.7 ground)	35%	15%			<1%

* Calculated for a 12 hour exposure except for vehicles where 2 hrs. exposure was used

** 1% chance of doses exceeding 100 rems at 5 miles