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August 24, 1983<sup>83</sup> AUG 26 10:41

OFFICE OF SECRETARY  
PROTECTIVE ACTIONS DIVISION  
BRANCH

UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
UNION ELECTRIC COMPANY	)	Docket No. STN 50-483 OL
	)	
(Callaway Plant, Unit 1)	)	

APPLICANT'S TESTIMONY OF  
 ROGER E. LINNEMANN, M.D.  
 IN RESPONSE TO REED CONTENTIONS 6 AND 16  
 (PROTECTIVE ACTIONS AGAINST RADIOIODINES  
 AND MESSAGES WITH INSTRUCTIONS FOR  
 LONG-TERM SHELTERING)

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1 Q.1 Please state your name.

2 A.1 Roger E. Linnemann.

3 Q.2 What is your occupation and by whom are you employed?

4 A.2 I am a medical doctor with particular expertise in  
5 the area of radiological health. I am certified by the  
6 American Board of Radiology and the American Board of Nuclear  
7 Medicine. I am Clinical Associate Professor of Radiology at  
8 the University of Pennsylvania School of Medicine and a  
9 visiting Clinical Associate Professor of Radiology at North-  
10 western University School of Medicine. I am also Vice Chairman  
11 of Radiation Management Corporation ("RMC"), a consulting firm  
12 which I established in 1968 to provide emergency medical  
13 expertise and support in the event of an accident involving in-  
14 jury to employees of nuclear power plants, and to provide rou-  
15 tine radiological health consulting on radiation health and  
16 safety to workers in nuclear facilities. Presently, RMC's  
17 Emergency Medical Assistance Program provides 24-hour emergency  
18 support to some 20 nuclear power plant sites throughout the  
19 country. Additionally, we have laboratory capability to  
20 measure radiation in the working environment of a nuclear power  
21 plant as well as in the outside environment. We did extensive  
22 analysis of the environment around Three Mile Island during the  
23 TMI-2 accident. This analysis included, among other things,  
24 iodine concentrations in the food pathway chain. A statement  
25 of my professional qualifications is appended as Attachment 1  
26 to this testimony.

1 Q.3 Please describe the services RMC is providing to the  
2 Union Electric Company.

3 A.3 On behalf of Union Electric Company, RMC is currently  
4 developing a training program for medical personnel who might  
5 be called upon in the event of a radiological emergency at the  
6 Callaway Plant. This program involves the developing of the  
7 proper facilities, supplies, equipment and personnel at the  
8 Callaway Memorial Hospital to enable the hospital to provide  
9 emergency treatment and care of radiation injuries as well as  
10 contaminated and injured patients. In addition, plant person-  
11 nel will be trained in the first aid and rescue of radiation  
12 injuries, and the local ambulance support will be trained in  
13 the transportation of radiation injuries. This will be annual  
14 training combined with an exercise to maintain proficiency at  
15 the Callaway Memorial Hospital in the event of a radiation in-  
16 jury occurring at the site.

17 Q.4 What is the purpose of your testimony?

18 A.4 The purpose of this testimony is to describe the  
19 risks and benefits associated with the ingestion of potassium  
20 iodide ("KI"), and to endorse the policy established by the  
21 State of Missouri for the distribution of KI in the event of a  
22 radiological emergency at the Callaway Plant.

23 Q.5 Could you please describe how KI acts as a thyroid  
24 prophylactic against radioiodines?

1           A.5 Iodine is taken from the blood stream by the thyroid  
2 gland and used in the manufacture of the thyroid hormones,  
3 Thyroxine and Triiodothyronine, which regulate metabolism. Iodine  
4 is normally obtained by an individual through his or her  
5 regular diet, e.g., table salt.

6           If an individual is exposed to radioactive iodine, the  
7 body cannot distinguish it from stable (i.e., nonradioactive)  
8 iodine and, consequently, will concentrate the radioactive iodine  
9 in the thyroid. If a hazardous amount of radioactive iodine  
10 is or may be present in the atmosphere, the hazard can be  
11 minimized through the administration of stable iodine in the  
12 form of KI. The KI will increase the blood pool of available  
13 iodine for the thyroid. If an individual has not yet been  
14 exposed to radioactive iodine, the KI will effectively block  
15 the radioactive iodine from concentrating in the already saturated  
16 thyroid. The "blocked" radioactive iodine is then eliminated  
17 in the urine. Even if an individual has already been  
18 exposed to radioactive iodine, within the first hour after exposure  
19 a 130 mg. tablet of KI will block 90% of the uptake. If  
20 KI is administered within four to six hours after exposure, it  
21 will block the uptake by 40 to 50%. (KI will have little  
22 effect if given more than twelve hours after exposure.) The  
23 effectiveness of KI as a radioactive iodine blocker, then, is  
24 directly related to the time at which it is administered.  
25 Thus, if taken in a timely fashion it is highly effective in

1 reducing radioactive iodine exposures to the thyroid gland;  
2 conversely, if taken at the wrong time, it can have little or  
3 no effect.

4 Q.6 What are the possibilities for adverse reactions?

5 A.6 Adverse reactions to KI are directly related to the  
6 dose and duration of the therapy. KI has been used for the  
7 treatment of bronchial asthma and other pulmonary diseases.  
8 These patients have been administered doses of 300 to 1200 mg.  
9 Cough medication containing over 100 mg. of KI has been given  
10 to children. The toxicity reports on KI are related to chronic  
11 use, e.g., if administered over a period of years, its use has  
12 resulted in the development of hypothyroidism. The risk from a  
13 very small dose, e.g., 130 mg., for an emergency situation is  
14 very small. On the other hand, there has been no experience  
15 with the risks, e.g., allergic reactions, associated with  
16 general distribution of KI to the public. Those who have  
17 received the drug to date have been under direct medical super-  
18 vision.

19 Q.7 What is your medical opinion of federal guidance rec-  
20 ommending administration of KI for exposures of 25 rem or  
21 greater?

22 A.7 Current federal guidance suggests that KI should be  
23 administered to so-called high risk persons in the event of a  
24 radiological emergency at a nuclear facility. Providing KI to  
25 individuals only if they are at risk of receiving a dose of 25

1 rem or greater is sensible, in my view, given what we know  
2 about risks associated with radioactive iodine. Certainly, in  
3 my view, this is a conservative criterion given that thyroid  
4 abnormalities are only associated with much higher doses. This  
5 applies as well to children, infants and pregnant women. For  
6 example, iodine-131 is given to patients in nuclear medicine  
7 departments to obtain functional and morphological information  
8 concerning the thyroid gland. A thyroid uptake study, to de-  
9 termine how well the gland is functioning, will deliver a dose  
10 of 6 to 20 rem to the thyroid. A thyroid scan, used to obtain  
11 morphological information, will deliver a dose of 100 to 200  
12 rem to the thyroid. An overactive thyroid (hyperthyroidism)  
13 may be treated by administering between 6,000 and 10,000 rem of  
14 I-131 to the thyroid. In the numerous follow-up studies that  
15 have been performed to ascertain the biological effects of  
16 these various doses, there is no evidence of increased  
17 leukomogenic or thyroid cancer risk below doses of about 100  
18 rem.

19 Q.8 What is your opinion regarding the State of  
20 Missouri's policy on the administration of KI.

21 A.8 Because of the risks of misuse and loss of KI tab-  
22 lets, the potential for allergic reactions in a large popula-  
23 tion, the problems associated with the distribution of KI  
24 (e.g., shelf life of the drug), and the increasing evidence  
25 that following an accident at a nuclear facility, nascent iodine

1 would be very chemically reactive in a moist environment and  
2 would likely plate out and not be released to the atmosphere,  
3 in my view it is not necessary or prudent to distribute KI to  
4 the general public. However, for individuals at greater risk,  
5 e.g., emergency workers and institutionalized individuals who  
6 are not evacuated, selected distribution of KI is advisable.

7 In conclusion, the Missouri State policy on the distribu-  
8 tion of KI represents a sound approach and conforms to the  
9 national medical and scientific consensus.

CURRICULUM VITAE

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Radiation Management Corporation



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EDUCATION

University of Minnesota, Minneapolis, MN; B.A. (Cum Laude) 1952

University of Minnesota, Minneapolis, MN; B.S., M.D. 1956

Walter Reed Army Hospital, Washington, D.C.; INTERNSHIP 1956-1957

Walter Reed Army Hospital, Washington, D.C.; RESIDENCY (Radiology) 1962-1965

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Certified by American Board of Radiology 1964

Certified by American Board of Nuclear Medicine 1972

Licensed to practice Medicine in 1) Commonwealth of Pennsylvania; 2) Illinois;  
and 3) Minnesota

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Sandia Base, New Mexico; Nuclear Weapons Orientation Course 1961

Walter Reed Army Institute of Research, Washington, D.C.; Medical Aspects of  
Nuclear Warfare 1962

US Department of Agriculture Graduate School (Evening), Washington, D.C.  
Russian Language 1963-1965

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PROFESSIONAL EXPERIENCE

1981-present	Vice Chairman and Chief Medical Officer, Radiation Management Corporation
1969-1981	President/Chief Executive Officer, Radiation Management Corporation
1974-present	Clinical Associate Professor of Radiology, University of Pennsylvania School of Medicine
1977-present	Visiting Associate Professor, Clinical Radiology, Northwestern University Medical School
1969-1974	Assistant Professor, Clinical Radiology, University of Pennsylvania School of Medicine
1968-1969	Nuclear Medicine Consultant, Philadelphia Electric Company

PROFESSIONAL EXPERIENCE (Continued)

Jan-Aug 1968      Assistant Professor, Radiology, University of Minnesota  
School of Medicine (investigated use of isotopes in kidney  
function evaluation)

1957-1968      Employed by United States Army .....

1965-1968:      Commanding Officer, Nuclear Medicine Research Detachment,  
Europe; Radiological Health Consultant, US Army-Europe.  
(responsible for plans, procedures and training of military  
hospitals and personnel in the evaluation, evacuation and  
treatment of radiation casualties. In January, 1966 sent  
to Palomaris, Spain for evaluation of medical and environmental  
aspects of the mid-air collision involving nuclear weapons)

1961-1962:      Research Associate, Department of Radiobiology, Walter Reed  
Army Institute of Research, Washington, D.C. (investigated  
use of anti-radiation drugs in treatment of cancer)

1957-1961:      General Medical Officer, Europe

Languages:      German, Russian

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PROFESSIONAL APPOINTMENTS

1982-present      American Medical Association Council on Scientific Affairs  
Subcommittee on the Management of Radiation Accident Victims

1979-present      Health Physics Society Standards Committee

1978-present      General Dynamics Electric Boat Division Radiological Health  
Consultant

1978-present      Edison Electric Institute Utility Radiation Standards Group

1973-present      University of Pennsylvania Radiation Safety Committee

1973-present      The Atomic Industrial Forum, Inc. Public Affairs & Information  
Committee

1970-present      The American Nuclear Society Subcommittee for Writing Emergency  
Procedures Standards

1969 & 1975      Atomic Energy Commission ad hoc Committee on Medical Aspects  
of Radiation Accidents

1966-present      American College of Radiology .....

1969-present      Commission on Radiologic Units, Standards and Protection

1969-present      Committee on Radiation Exposure of Women

1969-present      Committee on Radiological Aspects of Disaster Planning

1967-1978      International Affairs Committee

1965-1968      U.S. Delegate to NATO Radiation Protection Committee & Medical  
Aspects of Nuclear Warfare Committee

PROFESSIONAL APPOINTMENTS (Continued)

1971-present      Department of Defense & Environmental Protection Agency  
Medical Liaison Officer's Network (MLON)-State of  
Pennsylvania Representative

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PROFESSIONAL MEMBERSHIPS

American College of Radiology  
American Public Health Association  
American Medical Association  
Society of Nuclear Medicine  
Philadelphia Roentgen Ray Society  
Pennsylvania Medical Society  
College of Physicians of Philadelphia  
Radiological Society of North America, Inc.  
American Institute of Physicists/American  
    Association of Physicists in Medicine  
American College of Nuclear Physicians  
American Council on Germany  
Union League of Philadelphia

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AWARDS & HONORS

1978      Association of Medicine & Security, Madrid, Spain  
(Honorary Member)

1968      University of Minnesota Radiological Research Scholar  
(National Research Council)

1968      United States Army Legion of Merit

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PRESENTATIONS

1980      Korea Women's Association (Seoul, Korea)  
presented paper, "Energy: The Basis for Health in Developing  
and Developed Countries", at International Symposium on the  
Expulsion of Environmental Pollution

1980      Korean Association for Radiation Protection (Seoul, Korea)  
presented seminar on emergency management of radiation injuries

1980      Ministry of Health (Madrid, Spain)  
presented paper, "Definitive Treatment of Radiation Injuries",  
at First Seminar on Assistance to Those Wounded by Radioactive  
Elements and Ionizing Radiations

PRESENTATIONS (Continued)

- 1979 Reinisch-Westfalisches Elektrizitätswerk (Essen, Germany)  
presented paper, "Energy: The Basis for Health in Developing  
and Developed Countries", at The Seventh Energy Workshop
- 1978 The Swedish State Power Board (Vallingby, Sweden)  
presented seminar, "Management and Treatment of Radiation  
Injuries", and conducted radiation emergency medical  
exercise at the Ringhals Nuclear Power Plant
- 1978 Deutsche Gesellschaft für Wiederaufarbeitung (Hannover, Germany)  
appeared before the Prime Minister and Parliament of  
Lower Saxony as an International expert to testify on the  
safety of a reprocessing plant at Gorleben, Germany
- 1978 International Atomic Energy Agency (Vienna, Austria)  
presentation at Symposium on Late Effects of Ionizing  
Radiation
- 1978 Asociación de Medicina y Seguridad en el Trabajo de  
Unesa para la Industria Eléctrica (Madrid, Spain)  
presented one-day seminar entitled, "Primary Management  
of Radiation Injury"
- 1977 International Atomic Energy Agency (Vienna, Austria)  
presented paper, "Emergency Medical Assistance Programs  
for Nuclear Power Reactors", at Symposium on Handling of  
Radiation Accidents
- 1967 University of Freiburg Institute of Radiobiology (Freiburg,  
Germany); presented seminar on diagnosis and treatment of  
radiation injuries

## PUBLICATIONS

1. Linnemann, Roger E. "Berlin: The Young-Old City". Senior Citizen (September 1961)
2. Linnemann, Roger E. "This Way to Berlin". The American Benedictine Review:14, No. 4 (December 1963)
3. Linnemann, Roger E. "The Acute Radiation Syndrome and its Impact on the Chain of Evacuation". Medical Bulletin, U.S. Army Europe:22, No. 12 (December 1965)
4. Linnemann, Roger E. and Robert T. Wangemann. "Medical Support of Nuclear Weapons Accidents". Medical Bulletin, U.S. Army Europe (November 1967)
5. Linnemann, Roger E. and O. Messerschmidt. "Erholungsvorgaenge bei Grosstieren nach Ganzkoerperbestrahlung", :dem 6, Jahrbuch von der vereinigung Duetscher Strahlenschutzaeerzte (1968)
6. Linnemann, Roger E. "Command Radiation Guidance". Military Medicine: 33, pp. 771-716 (September 1968)
7. Loken, Merle K., Linnemann, Roger E. and George S. Kush. "Evaluation of Renal Function Using a Scintillation Camera and Computer". Radiology: 93, No. 1, pp. 85-94 (July 1969)
8. Linnemann, Roger E., Loken, Merle K. and Colin Markland. "Computerized Compartmental Renograms to Study Kidney Function". Journal of Urology: 103, pp. 533-537 (May 1970)
9. Linnemann, Roger E. and J.W. Thiessen. "Regional Approach to the Management of Radiation Accidents". Journal of the American Public Health Association: 61, No. 6, pp. 1229-1235 (June 1971)
10. Linnemann, Roger E. and Robert H. Holmes. "Nuclear Accidents and Their Management". Emergency Medical Care, pp. 281-292, Spitzer, Stanley and Wilbur W. Oaks (eds.) New York: Bruner and Stratton, Inc. (1971)
11. Linnemann, Roger E., Rasmussen, N.C. and F.K. Pittman. Nuclear Energy: Issues and Answers. Atomic Industrial Forum, Inc. in cooperation with Pennsylvania Power & Light Company (April 1973)
12. Linnemann, Roger E. "Accentuate the Positive". Trial: 10, No. 4, p. 13 (July/August 1974)
13. Linnemann, Roger E. "Accentuate the Positive". Congressional Record: 109, pp. 4964-4967. Washington, D.C." United States of America Proceedings and Debates of the 93rd Congress, Second Session (July 23, 1974)
14. Linnemann, Roger E. and J.W. Thiessen. Editorial, "In Defense of Radiation and Cells". The New York Times (May 23, 1974)

(Continued)



Roger E. Linnemann - Publications

15. Linnemann, Roger E. Nuclear Radiation and Health. Springville, NY Nuclear Fuel Services, Inc. (September 23, 1974)
16. Linnemann, Roger E. Editorial, "In Defense of Nuclear Power Plants", The Philadelphia Inquirer, p. 11A (March 6, 1975)
17. Linnemann, Roger E. "Nuclear Power Plants Pose Minimal Health Risks", Perspective. News Bureau of the University of Pennsylvania, Philadelphia, PA (February 1975)
18. Linnemann, Roger E. "Medical Aspects of Power Generation". Impulse. Massachusetts: Electrical Council of New England (June 1975)
19. Linnemann, Roger E. "Bugs in the Nuclear Fuel Cycle". Spectrum, p. 59, Gadi Kaplan (ed.) Piscataway, NJ: The Institute of Electrical and Electronic Engineers, Inc. (September 1975)
20. Linnemann, Roger E. and Fred A. Mettler, Jr. "Emergency Medical Assistance Programs for Nuclear Power Reactors". International Atomic Energy Agency Symposium on the Handling of Radiation Accidents, IAEA-SM-215/22, Vienna Austria (1977)
21. Linnemann, Roger E. "Why ALARA?" Transactions of 1979 American Nuclear Society Conference, Atlanta, GA (June 3-7, 1979), Vol. 32, TANS AO 32 1 832 ISSN 0003-018x (1979)
22. Linnemann, Roger E., Hackbarth, C.J. and Ray Crandall. "The Contaminated and Injured Patient". Proceedings of Twenty-fourth Annual Meeting of the Health Physics Society, July 9-13, 1979 (Philadelphia, PA)
23. Linnemann, Roger E. "The Three Mile Island Incident in 1979: The Utility Response". The Medical Basis for Radiation Accident Preparedness, K.F. Hubner and S.A. Fry (eds.), Elsevier/North-Holland, pp. 501-509 (1980)
24. Linnemann, Roger E. "Initial Management of Radiation Injuries". Journal of Radiation Protection, 5, No. 1, pp. 11-25 (December 1980)
25. Linnemann, Roger E. "Facilities for Handling the Contaminated Patient". Radiation Accident Preparedness: Medical and Managerial Aspects, Science-Thru-Media Company: New York (1980)
26. Linnemann, Roger E. "A Systems Approach to the Initial Management of Radiation Injuries". Systems Approach to Emergency Medical Care, Appleton-Century-Crofts: New York (1980)
27. Linnemann, Roger E., Stephen M. Kim and Frazier L. Bronson. "Three Mile Island: Medical and Public Health Aspects of a Radiation Accident". Journal of Radiation Protection, 6, No. 1, pp. 45-52 (October 1981)

PROFESSIONAL TESTIMONY

in progress Union Electric Company Emergency Planning/Licensing Hearings for Callaway Nuclear Power Plant

in progress Long Island Lighting Company Emergency Planning Hearings for the Shoreham Nuclear Power Station

in progress Texas Utilities Generating Company Emergency Planning Hearings for the Comanche Peak Steam Electric Station

in progress Pennsylvania Power & Light Company Susquehanna Steam Electric Operating License Hearings

in progress Florida Power & Light Company Turkey Point Steam Generator Repair Hearings

in progress John Benek v. Pennsylvania Power Company et al. #199 of 1977 Eminent Domain

1981 Southern California Edison Company Emergency Planning Hearings for the San Onofre Nuclear Generating Station

1979 Gorleben Nuclear Fuels Reprocessing Plant Hearings before the Prime Minister and Parliament of Lower Saxony, Hanover, Germany

1979 Florida Power & Light Company Turkey Point Nuclear Station Operating License Hearings

1971 Long Island Lighting Company Shoreham Nuclear Power Station Operating License Hearings

1970 Baltimore Gas & Electric Company Calvert Cliffs Nuclear Power Plant Operating License Hearings

1970 Northeast Utilities Service Company Millstone Nuclear Power Station Operating License Hearings