UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:
James P. Gleason, Chairman
Frederick J. Shon
Dr. Oscar H. Paris

In the Matter of	)	Docket Nos.
CONSOLIDATED EDISON COMPANY OF NEW YORK, INC. (Indian Point, Unit No. 2)	)	50-247-SP 50-286-SP
	)	
POWER AUTHORITY OF THE STATE OF NEW YORK (Indian Point, Unit. No. 3)	)	January 12, 1983

CON EDISON'S TESTIMONY
OF SAMUEL ROTHSTEIN
AND ARTHUR TUTHILL
CONCERNING BOARD QUESTION 2.2(a)

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My name is Arthur Tuthill. I received a Bachelor of Chemical Engineering degree from the University of Virginia in 1940 and a Masters Degree in Metallurgical Engineering from Carnegie Institute of Technology in 1946. I have worked as a metallurgical and corrosion specialist for Standard Oil Company of New Jersey (now Exxon), E.I. DuPont and International Nickel Company until my retirement on August 1, 1982. Since 1964, at International Nickel, I was responsible for the development and use of nickel-containing alloys, in particular, condenser and heat exchanger tubing applications in saline water. At DuPont my responsibilities included material evaluation and the selection of equipment for use in high purity water systems for the Savannah River project. A detailed statement of my professional qualifications and publications is presented in Attachment BW-1 to this testimony.

My name is Samuel Rothstein. I am the head of the Chemical and Metallurgical Engineering subsection in the Mechanical Studies section at Con Edison. I received a Bachelor's Degree in Chemistry from City College of New York in 1940 and have completed a large number of graduate courses in metallurgy at several universities. I have been employed at Con Edison since 1971. During this time I have been involved in the analysis and evaluation of the fan cooler/service water system, and in the development of an in-service inspection program for the same. A more detailed listing of my background is appended to my testimony on Board Question 2.2.1.

The purpose of this testimony is to address contention 2.2(a) which reads as follow:

> "The cooling system at the plants should be changed so that it no longer uses brackish Hudson River water. This change is needed to combat safety-related corrosion problems."

I. Description of the Indian Point Unit 2 Fan Cooling System

The Indian Point Unit 2 fan cooling system has five air handling units, referred to as the fan cooler units. Each unit consists of a main heat exchanger formed by separate heat exchanger units which cool the air, a fan to draw the air through the heat exchangers and circulate it in containment, a demister to remove condensed moisture droplets from the air, and various filters to clean the air. In addition, each fan motor is cooled by a separate smaller heat exchanger referred to as a motor cooler.

These main air cooling heat exchangers as well as the smaller fan motor cooling heat exchangers (motor coolers) are cooled by Hudson River water provided by the essential service water system. This systems consists of three 5000 gpm service water pumps, each of which has an automatic self-cleaning strainer, that are connected to each of two 24" diameter cement-lined pipes which supply the fan coolers units.

Each fan cooler unit is then serviced by a separate 10" cement lined supply and discharge pipe. Each supply and discharge pipe is provided with motor operated shutoff valves outside containment, which allow each cooler to be isolated.

Each motor cooler is supplied with service water through a 2" pipe and a 2" flexible hose connected directly to the 10" header of its respective fan cooler unit inside the containment building. Water from each of the motor coolers is discharged through separate 2" pipes with shutoff valves outside containment for isolation.

The fan coolers have 3750 5/8" diameter 18 gage (0.049") C70600 alloy (90 copper 10 nickel) "U" tubes with external fins. The external fins provide increased surface to better cool the air passing over the outside. The tubesheets, water boxes and inlet piping are also C70600 alloy. The coolers are subdivided into ten sets, each set with its own inlet and outlet pipe, waterboxes and tube sheets. Figure I is a block type flow diagram which shows the system. The motor coolers are smaller but of similar construction.

II. Corrosiveness of Hudson River Water

Hudson River water at Indian Point is a well aerated estuarine river water of low salinity. The biological oxygen demand (B.O.D.) is low, 4.6 ppm maximum. Dissolved oxygen approaches saturation ranging from 5.5 to 11.5 ppm. PH fluctuates within a narrow range from 7.1 to 7.5. Salinity during the minimum flow period, August, is about 4,000 ppm but did reach 7,020 ppm, 20% of seawater, during the drought year of 1964.

The low B.O.D. indicates minimal organic pollution. The pH is normal, indicating minimal industrial waste pollution. The dissolved oxygen approaches saturation - all indicative of saline water in which copper alloys exhibit very low corrosion rates in the order of 0.001" per year or less.[1] Corrosion rates of 0.001" per year or less translate into upwards of 40 years life for 18 gage tubing, the standard gage and that in use in the fan and motor coolers at Indian Point No. 2.

Carbon steel on the other hand corrodes at low but significant rates in the same saline waters. The corrosion rates increase as the flow velocity increases. These corrosion rates for unprotected carbon steel may approach but would be unlikely to exceed these for sea water, i.e. 0.006 to 0.022 inches per year.[2] Although carbon steel piping will survive for several years at these corrosion rates, such piping is normally cement or epoxy lined for brackish or saline water service, as was done at Indian Point Unit 2. The salinity during the minimum flow period, while low, is still high enough to arouse concern about the possibility of crevice corrosion of stainless steels, which is why copper base alloys are so widely preferred for brackish and other saline waters.

There is nothing unusual about the use of brackish or other saline waters for cooling. In addition to ships, there are numerous industrial plants as well as power plants that sucessfully use brackish and saline waters for cooling provided, as at Indian Point, the proper materials for saline waters are used. We note that 15% of domestic power plants and 33% of domestic nuclear plants are on brackish estuaries or sea coast locations and saline water is routinely used for cooling purposes.

III. Inspections of Fan Cooling System During 1982 Refueling/Maintenace Outage

In September, 1982, Messrs. Tuthill and Rothstein examined four C70600 5/8" tubes removed from the coolers at Indian Point Unit No. 2. Mr. Tuthill reviewed the drawings, general arrangement diagrams, and prior experience, and made recommendations for improvements during the planned outage. These recommendations were for cleaning, improving flow distribution, clean water circulation prior to startup and control of biofouling growth.

In November 1982, Mr. Tuthill visited Indian Point Unit No. 2 during the outage for the purpose of inspecting the intake system, the fan coolers, their piping and the main condensers. We found that the good condition of the copper-nickel piping, waterbox and tubesheet are consistent with the earlier thinking on the low corrosivity of Hudson River water at Indian Point to copper alloys in 2 above. The flush cleaning of the fan coolers and motor coolers had been completed by this time.

The Zurn strainers had been cleaned and overhauled. New distribution plates to improve flow distribution and reduce turbulence were in place in the waterbox. Subsequent to this visit, chemical cleaning to remove the poorly formed corrosion product film and circulation with clean water to reform a good film were completed. Chlorination to reduce biological growth was reinitiated on startup.

IV. Conclusions

Based on the foregoing, it is our opinion and position that:

1) Hudson River water at Indian Point is corrosive to uncoated carbon steel, but not to cement lined steel or copper base alloys, such as those at Indian Point Unit 2, at flow velocities typical of Indian Point Unit 2 operation.

2) Although Hudson River water at Indian Point might well be classified as fresh water for most of the year, the materials in use are those appropriate for saline brackish waters.

3) The inspection ports installed adjacent to the welds in the cement lined pipe during the 1980/81 outage have not only permitted the cement lining in the area of the welds to be repaired but also permit inspection during outages to maintain surveillance on the condition of the cement lining.

4) The corrective measures taken to improve the performance of the fan and motor coolers are those found desirable and recommended to minimize the localized corrosion found in some of the tubing. These should permit C70600 alloy tubing to closely approach the normal long term durability of this alloy in saline waters.

5) The C70600 alloy used in the Indian Point Unit 2 fan coolers is the normal and usual choice for both naval and commercial vessels as well as power and industrial plants for heat exchangers and coolers of the fan cooler type using saline water for cooling.

V. Alternate Cooling Systems

In 1981 Con Edison forwarded to the NRC a report prepared by the Bechtel Power Corporation which provided a feasibility study of various containment cooling system alternatives utilizing both closed and hybrid closed/open system concepts. Con Edison committed at that time to developed a detailed design of the alternative recommended in the study, the so-called "hybrid" closed-loop cooling system and perform further evaluation. By letter dated February 11, 1982 from J.D. O'Toole (Con Edison) to V. Stello (NRC), Con Edison provided its assessment of the "hybrid" system to NRC. We concluded that the "hybrid" system-although possessing the advantages of a closed system during normal plant operation-is complex in comparison with the present fan cooling system.

While Con Edison has decided against the Bechtel alternative system, a review of "hybrid" as well as other alternative systems is continuing and future actions will be guided by the performance of the present fan cooling system and the results of the surveillance program of the fan cooler units and service water piping. However, one must carefully weigh the benefits of an alternative system which does not use river water against the complexities and associated potential for reduced system reliability of such alternatives.

REFERENCE CITED

(1) Marine Corrosion Bulletin No. 1 "The Corrosion Resistance of Wrought 90-10 Copper Nickel Iron Alloy in Marine Environments." Inco Publication A1222, 1975.

(2) Tuthill, A.H., and Schillmoller, C.M. "Guidance for Selection of Marine Materials." Inco Technical Publication A404, 1965.

Block Flow Diagram

Fan Cooling System

Indian Point No 2

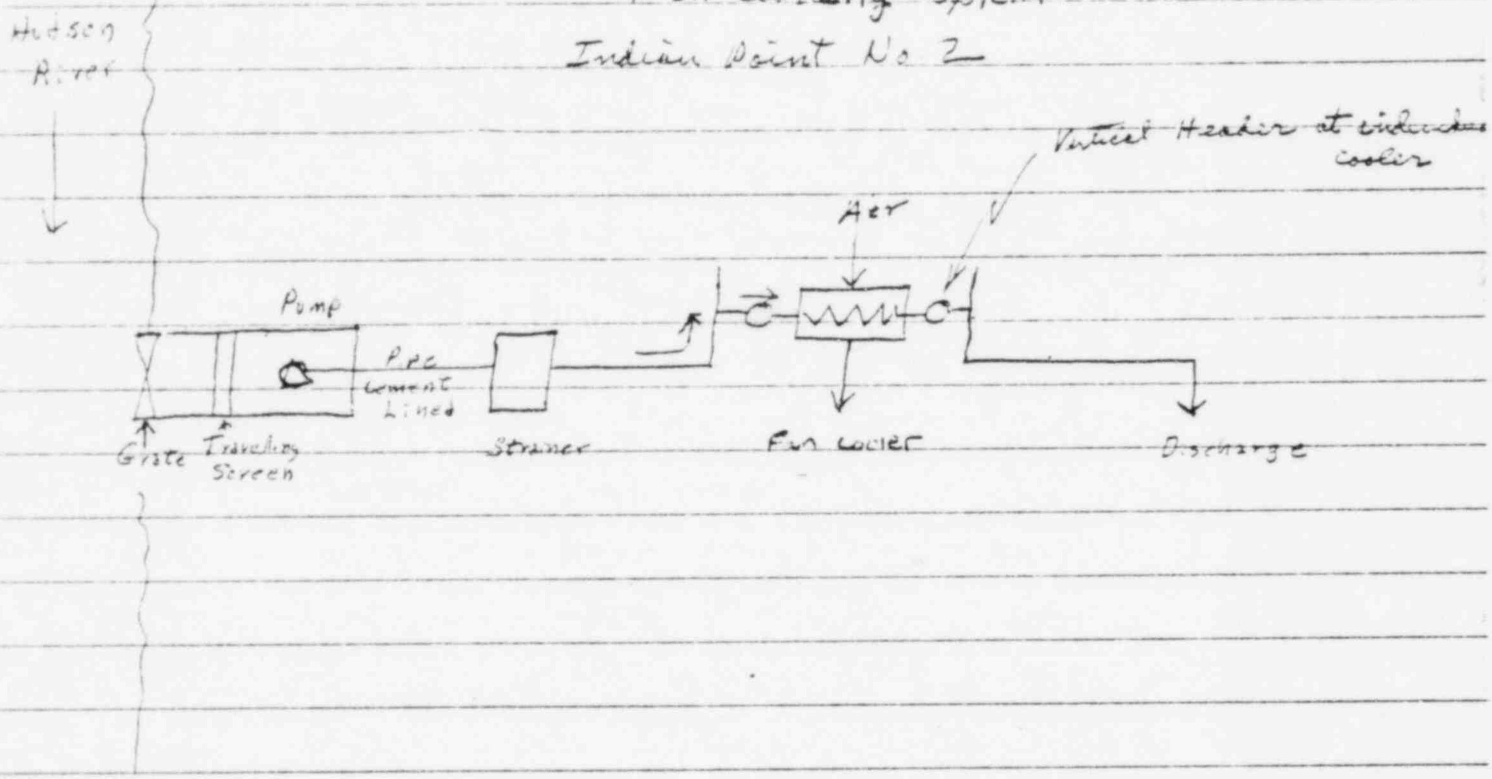

FIGURE I

ARTHUR H. TUTHILL, P.E.
3 CHAPEL LANE
RIVERSIDE, CT 06873

MANAGEMENT EXPERIENCE

Managed group of nationally recognized professional materials and corrosion specialists responsible for developing markets and projects that directly supported sales function and kept nickel markets growing despite aggressive promotion of competitive materials (Inco).

Organized, financed and operated small business enterprise manufacturing high alloy spare parts for refineries, chemical plants and paper mills in Gulf Coast area (Valco Engineering).

Supervised team of engineers and technicians in inspection of safe operating condition of refinery equipment (Exxon).

Commended by Office of Defense Mobilization for excellent services rendered while in charge stainless steel section Iron and Steel Division - procurement of stainless steel to industry and Savannah River Plant (DuPont - Government: National Production Authority).

EMPLOYMENT

1940 - 1941 - Tennessee Eastman Corporation, Kingsport, TN
1941 - 1946 - U.S. Navy, Naval Gun Factory, Cramp Shipyard, Pacific Theater
1946 - 1950 - Standard Oil (NJ), Baton Rouge, LA
1950 - 1954 - E. I. DuPont, Wilmington, DE
1954 - 1959 - Valco Engineering, Baton Rouge, LA
1959 - 1982 - International Nickel Company, Hartford, CT and New York City

EDUCATION

MS. Met. Eng. - Carnegie Tech., 1946
B. ChE. - University of VA, 1940
Numerous AMA Management and Financial Educational Courses

PROFESSIONAL

National Association of Corrosion Engineers
Society of Naval Architects and Marine Engineers
Technical Association of Pulp and Paper Industry
Professional Engineer (Metallurgy), LA License No. 4580
Accomplished public speaker and discussion leader on corrosion and materials

PERSONAL

Born March 27, 1919, Staunton, VA, Married - 5 Children; Health - Excellent
Lt. Cdr. USNR WWII Pacific
Application Mountain Club - White Water and Wilderness Canoeing
Rotary International

PUBLICATIONS

1. LaQue, F.L. and Tuthill, A.H., "Economic Considerations in the Selection of Materials for Marine Applications", Transactions of the Society of Naval Architects and Marine Engineers, Vol. 69, 1961, pp. 619-639.

2. Weldon, B.A. and Tuthill, A.H., "The Cupro-Nickels in Desalination Plant", Proceedings of Conference, "Role of Copper and Its Alloys in Desalination Equipment", London, 1966, Copper Development Association, 1968, Paper #5, pp. 39-47.

3. Tuthill, A.H. and Schillmoller, C.M., "Guidelines for Selection of Marine Materials", Presented at Ocean Science Engineering Conference, Marine Technology, Washington, D.C., June 14-17, 1965.

4. Tuthill, A.H. and Sudrabin, D.A., "Why Copper-Nickel Alloys for Desalination", Metals Engineering Quarterly, Vol. 7, August 1967, pp. 10-26.

5. Tuthill, A.H., "Marine Corrosion", Machine Design, Vol. 40, December 19, 1968, pp. 117-122.

6. Tuthill, A.H., "Future Trends in Tubing for Desalination", Chemical Engineering Symposium Series, Vol. 67, #107, 1970.

7. Todd, B., Tuthill, A.H., Bailie, R.E., "Desalination Lower Cost Water by Proper Materials Selection", Presented at Third European Symposium on Fresh Water from the Sea, Dubrovnik, Yugoslavia, September 14-17, 1970.

8. Tuthill, A.H., "Materials for Sea Water and Brine Recycle Pumps", Inco publication.

9. Tuthill, A.H., "Design and Installation of 90-10 Copper-Nickel Sea Water Piping Systems", Inco publication.

10. Manzolillo, J.L., Thiele, E.W., Tuthill, A.H., "CA706 Copper-Nickel Alloy Hulls: The Copper Mariner's Experience and Economics", Trans., SNAME Vol. 84, 1976, pp. 408-432.

11. Tuthill, A.H., "Progress Report - Corrosion Test Results Phase I Bleach Plant C, D and H Stages", TAPPI Engineering Conference, New Orleans, November 1979, TAPPI Press Report-84.

12. Rushton, J.D., Geisler, J.J., Heasley, R.H., Tuthill, A.H., Edwards, L.L., "Statistical Analysis of Effects of Chloride, Residual Chlorine Temperature and Exposure Period on Corrosion of Bleach Plant Materials", TAPPI Engineering Conference, New Orleans, November 1979, TAPPI Press Report-84.

13. Tuthill, A.H., "Performance of Types 316L and 317L Stainless Steels in C and D Stage Bleach Plant Environments", Third International Symposium on Corrosion in Pulp and Paper Industry Corrosion Problems, Atlanta, May 1980.

14. Tuthill, A.H., Rushton, J.D., Geisler, J.J., Heasley, R.H., Edwards, L.L., "Corrosion Resistance of Alloys to Bleach Plant Environments, TAPPI Journal, Vol. 62, No. 11, November 1979.

15. Tuthill, A.H., "Performance of Types 316 and 317L Stainless Steels in C and D Stage Bleach Plant Environments, Part II TAPPI Engineering Conference, Washington, D.C., September 1980.

16. Tuthill, A.H., "Corrosion of Types 316/316L and 317/317L Specimens in Aggressive Environments Compared to Actual Performance", Presented at Corrosion '81, Houston, Texas.

17. Lee, T.S., Tuthill, A.H., "Guidelines for the Use of Carbon Steel to Mitigate Crevice Corrosion of Stainless Steels in Sea Water", Paper #63, NACE Corrosion '82.

ATTACHMENT BW-1

ARTHUR H. TUTHILL, P.E.
3 CHAPEL LANE
RIVERSIDE, CT 06873

Materials and Corrosion Consultant

Extensive experience in fabrication, use and performance of cast and wrought alloy steels in submarines, naval, commercial and fishing vessels, nuclear and fossil power plants, desalination plants, pumps, offshore oil and waterflood, refineries and sour gas well production, chemical and pulp and paper plants.

Marine

Assisted Naval architects, owners and shipbuilders in evaluation and selection of materials of construction for, and the solution of, troublesome galvanic and other corrosion problems on nuclear submarines, Alvin, deep submergence rescue vessels, aircraft carriers, destroyers, LNG tankers, chemical tankers, deep tanks, offshore oil platforms, fishing vessels and pleasure craft. Organized and led two shipbuilding industry materials seminars.

Authored "Guidelines for Selection of Marine Materials", "Materials for Sea Water and Brine Recycle Pumps" and "CA706 Copper-Nickel Alloy Hulls: The Copper Mariner's Experience and Economics".

Initiated reports from shipowners summarizing experience with materials usage to provide better feedback to marine industry on service experience.

Inspection and quality assurance of naval ordnance-gun mounts, guns and turrets at Naval Gun Factory and assembly and alignment aboard CVLs during construction. Combat experience USS Miami - Pacific.

Desalination

Initiated and coordinated materials test programs and inspection of OSW demonstration plants and operating desalination plants at Freeport, Chula Vista, Key West and Caribbean. Persuaded OSW to fund and undertake the four A.D. Little Surveys of materials usage in actual operating plants to provide this industry with better feedback on service experience.

Assisted domestic, European and Japanese design firms and manufacturers in selection of materials and in solution of corrosion problems on shipboard and land based desalination plants for mid-east and western hemisphere. Co-authored "Desalination, Lower Cost Water by Proper Materials Selection" and other papers on materials for desalination.

Power

Provided design engineering firms, utilities and equipment manufacturers with feedback of overall industry experience, individual case histories and pertinent research data on materials for, and solution to, corrosion problems on condenser tubing, feedwater heaters, cooling towers and other plant components.

Developed and stimulated use of guidelines for designing new condensers to take full advantage of the properties of each different tubing alloy. Guidelines were fundamental to the successful introduction and promotion of Type 304 stainless steel for inland power plants, C70600 alloy for coastal plants and AL6X for severely polluted waters.

Developed practical solutions to galvanic corrosion and biofouling problems in cooling water systems.

Pulp and Paper

Assisted in organizing cooperative alloy producer - pulp and paper mill corrosion test program to identify materials needed to meet more aggressive corrosion conditions arising from current government regulations regulating effluent water quality.

Analyzed and reported data for Metals Subcommittee of TAPPI in five technical papers on bleach plant materials and corrosion.

Organized and conducted two pulp and paper industry corrosion and materials seminars.

Nuclear (DuPont)

Developed welding procedures and evaluated materials for high purity and reactor grade water.

Developed procedures for minimizing and removing contamination (embedded iron) from surface of stainless steel that were the forerunner for ASTM A380.

Evaluated and developed materials for water lubricated bearings and components of machinery for slitting and handling spent fuel elements in submerged processing and storage area.

Chemical (DuPont)

Developed welding procedures for stainless steels and nickel base alloys. Inspected and made initial analysis and reported on stress corrosion cracking of jacketed stainless steel pipe under insulation.

Evaluated materials and corrosion problems in nylon, neoprene, HF and explosives plants.

Refinery (Standard Oil, NJ)

Initiated cathodic protection of pipe coolers, deep well pump casings and heat exchangers and use of tantalum tubes in sulfuric acid reboilers.

Qualified steels for low temperature service - leading to ASTM A300.

In charge welder qualification and refinery weld quality.

Responsible for solution of refinery corrosion and materials problems.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:
James P. Gleason, Chairman
Dr. Oscar H. Paris
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CONSOLIDATED EDISON COMPANY OF NEW YORK, INC. (Indian Point, Unit No. 2)	:	Docket Nos. 50-247-SP 50-286-SP
POWER AUTHORITY OF THE STATE OF NEW YORK, (Indian Point, Unit No. 3)	:	January 12, 1983

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CERTIFICATE OF SERVICE

I certify that I have served copies of CON EDISON'S TESTIMONY OF SAMUEL ROTHSTEIN AND ARTHUR TUTHILL CONCERNING BOARD QUESTION 2.2(a) by deposit in the United States mail, postage prepaid, this 12th day of January, 1983.

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