

UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of )  
 )  
COMMONWEALTH EDISON COMPANY ) Docket Nos. 50-295  
 ) and 50-304  
(Zion Station, Units 1 and 2) )

NRC Staff Testimony on  
Contentions 2(e)(3), 2(e)(4), 2(h),  
2(i), 2(j), and 2(k)

By Frank M. Almeter  
and  
Edward Lantz

In this testimony, we address the above listed contentions. The following discussion regarding the experimental data, operational experience, and surveillance provides material facts to show that whatever corrosion occurs will have no significant effect on spent fuel pool components.

The spent fuel pool components of the Zion facility that are exposed to the pool water are:

1. Pool liner (stainless steel);
2. Spent fuel assemblies (Zircaloy clad fuel rods, stainless steel tie plates, and Inconel spacers);
3. Storage rack base (stainless steel); and
4. Storage racks (Square tubes of inner and outer shrouds of stainless steel completely encapsulating Boral neutron absorber plates. Boral is a composite panel of  $B_4C$ /aluminum matrix clad with 1100 aluminum alloy).

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The Zion spent fuel storage pool environment is typical of PWR plant systems (i.e., oxygen-saturated high purity demineralized water containing boron as Boric acid, normally at a temperature range of 79°F to 150°F and a pH range of 4.5 to 6).

Contention 2(e)(3) and 2(e)(4)

The amendment request and supporting documentation do not adequately discuss monitoring procedures. In the light of the proposed modification and long term storage of nuclear spent fuel the Applicant should clarify the following:

- (e)(3) Methods for detecting the loss of neutron absorber material and/or swelling of stainless steel tubes in storage racks.
- (e)(4) Details of a corrosion test program to monitor performance of materials used in the construction of the racks.

Commonwealth Edison has committed to an in-pool neutron absorber surveillance program to verify the ability of a neutron absorber material employed in the high density fuel racks to withstand the long-term environment.<sup>(1)</sup> The test conditions represent a restricted flow of water over the neutron absorber material. Samples will be supported adjacent to and suspended from the fuel racks. Eighteen vented test samples of Boral enclosed in stainless steel are to be fabricated and installed in the pool when the racks are installed. The test samples are representative of materials used in the construction of the storage racks. The program is designed to evaluate the long-term effects of galvanic corrosion between dissimilar metals with a large electrical potential difference and the integrity and

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<sup>(1)</sup> Letter from W. F. Naughton to H. R. Denton, dated January 24, 1979.

the capability of Boral as a neutron absorber material in spent fuel pools. The welded seams of the stainless steel covering on the Boral will test the resistance of welded stainless steel to stress corrosion cracking in the spent fuel pool environment. The test samples will be examined every 90 days for the first year of exposure, then every 5 years up to 20 years, and after 20 years every 10 years up to 40 years.

Since the rate of loss of boron due to corrosion will be small in any event and this rate generally decreases with time in the pool, we find that this program is satisfactory for monitoring the condition of the Boral plates and the continued presence of the boron.

Also in its January 24, 1979 submittal, CEC stated that it will vent the Boral containing components and allow pool water to enter and exist without restriction. It is our finding that this venting will eliminate the potential for any significant amount of swelling of the stainless steel tubes.

Contention 2(h)

The amendment request and supporting documentation have not analyzed the long term\* electrolytic corrosion effects of using dissimilar alloys for the pool liners, pipes, storage racks and storage rack bases, such as the galvanic corrosion between unanodized aluminum, as is used in Brooks and Perkins storage racks, and the stainless steel pool liner.

\*"Long term" storage would include storage during the life of the reactor.

Contention 2(h) assumes the electrolytic corrosion will affect the long term integrity of dissimilar alloys, such as the galvanic corrosion between unanodized aluminum and stainless steel in the pool water environment.

Corrosion is the deterioration that occurs in metals because of either a chemical or electrochemical reaction with its environment. Metallic corrosion, in water, is a combination of anodic and cathodic reactions (electrochemical oxidation/reduction) which involves the development of protective films. Acceleration of the corrosion reaction in high purity water requires either: (1) an increase in aqueous temperature, (2) a change in the electrolytic nature of the anodic and cathodic reactions by metals that have a large electrical potential differential or an electrical current flow in the aqueous environment, (3) a change in the ionic concentration of the aqueous electrolyte, or (4) coupling of dissimilar metals by direct contact or an electrical conductor (galvanic corrosion). Significant galvanic corrosion can occur only when one metal is more noble than the other (i.e., where there is a major difference in electrical potential).

The Zircaloy, stainless steel, and Inconel in the spent fuel assemblies removed from the reactor vessel would have an initial protective oxide layer which would decrease the corrosion rate once the assemblies were placed in the pool water environment. Zircaloy and Inconel have greater corrosion

resistance than stainless steel. According to B. Cox, Atomic Energy of Canada<sup>(2)</sup>, C. Breden, Argonne National Labs, and E. T. Hayes<sup>(3)</sup>, Bureau of Mines<sup>(3)</sup>, the initial corrosion kinetics for Zircaloy increase at a quasi-cubic rate and, after formation of an initial protection  $ZrO_2$  layer of  $2.42 \times 10^{-3}$  inches after 1,250 days at 600°F, become linear at a corrosion rate of  $1.4 \times 10^{-5}$  inches/year. A. B. Johnson has noted that the corrosion rate of Zircaloy is much less at 195°F to 212°F, (i.e.,  $1.18 \times 10^{-7}$  to  $3.54 \times 10^{-7}$  inches/year)<sup>(4)</sup>. In the absence of neutron irradiation, Zircaloy is quite resistant to oxygen in aqueous environments and the passivity will remain in either weak acid or weak alkaline solutions. If one assumes that the corrosion rates at the temperature range cited by Johnson would be the extreme case for extended periods in the Zion spent fuel pool, the additional linear growth of the  $ZrO_2$  layer should be not more than  $4 \times 10^{-5}$  inches after 100 years, which is minute relative to the initial thickness.

Stainless steel has performed satisfactorily in the reactor water environment as fuel cladding and in spent fuel pools without significant deterioration being detected over a 15-year period. Based on the corrosion data published for stainless steel in more aggressive environments than in spent fuel storage pools, the corrosion rate of the stainless steel pool liner and the

<sup>(2)</sup>B. Cox, J. Nuclear Materials, 25, 310 (1968).

<sup>(3)</sup>D. E. Thomas, Proc. International Conference on the Peaceful Uses of Atomic Energy, Geneva 1955, Vol. 9, p. 407, United Nations, N.Y. (1956).

<sup>(4)</sup>Battelle Pacific Northwest Lab. Report (BNWL-2256, September 1977).

stainless steel storage racks in pool environments should not exceed  $5.90 \times 10^{-7}$  inches per year during the expected plant life.

Unanodized 1100 aluminum also forms an initial protective film within the first 5 days of immersion in distilled water before the corrosion rate becomes linear. J. E. Draley and W. E. Ruther, Argonne National Laboratory<sup>(5)</sup>, have reported that the corrosion rate in distilled water (pH7) ranges from  $1.1 \times 10^{-5}$  inches/year at 122°F to about  $7.0 \times 10^{-5}$  inches/year at 212°F. In dilute acid (pH5), the corrosion rate at 212°F is  $3.7 \times 10^{-5}$  inches/year and decreases to  $3.57 \times 10^{-5}$  inches/year at 122°F. The corrosion rates in slightly alkaline solution (pH 8.5) at 212°F were observed to be approximately the same as in distilled water, but they are generally higher at 122°F ( $5.83 \times 10^{-5}$  inches/year). This indicates that the corrosion rate of aluminum in aqueous solutions in a range of pH 5-8.5 decreases with decreasing temperature and becomes relatively minute at temperatures below 122°F.

The electrolytic potential of stainless steel and Inconel are about the same, and they can be coupled without experiencing significant electrolytic corrosion or galvanic effects. Zircaloy is very resistant to electrolytic corrosion and galvanic effects because of its nonconducting  $ZrO_2$  protective layer. However, there is a major difference in electrical potential between aluminum and stainless steel. The aluminum cladding of the Boral neutron absorber plates in contact with the stainless steel tubes encapsulating the Boral is more reactive and it will experience galvanic corrosion upon exposure to the pool water environment.

<sup>(5)</sup> Proc. International Conference on the Peaceful Uses of Atomic Energy, Geneva 1955, Vol. 9, p. 391, United Nations, N.Y. (1956).

R. A. U. Huddle, AERE-Harwell<sup>(6)</sup>, states that in a pH 4-8 range the dissolution of the protective film on aluminum is negligible and the slight acidity or alkalinity reduces the resistance of the aluminum to anodic attack in the adjacent area of the galvanic couple, resulting in pitting corrosion (a highly localized penetration at only a few spots). Oak Ridge National Laboratory tests<sup>(7)</sup> on 1100 Aluminum in contact with stainless steel in an oxygenated demineralized water at a pH5 and at 194°F also show that galvanic corrosion between dissimilar metals results in pitting corrosion of the anodic material (aluminum) and no attack of the cathodic material (stainless steel). The corrosion process on the aluminum not in contact with the stainless steel was typical of 1100 aluminum in distilled water (i.e., a rapid increase in corrosion rate prior to a lower stable linear corrosion rate. This indicates that galvanic coupling between stainless steel and aluminum does not accelerate general corrosion of aluminum).

Exxon Nuclear has conducted tests on samples of vented spent fuel storage cells in a borated deionized water (pH5) at 146°F and in an alkalinated deionized water (pH9.6) at 153.4°F for periods up to one year<sup>(8)</sup>. The deterioration was in the form of pitting of the aluminum cladding on the Boral plates and edge attack confined to the area of the leak path. The frequency of pitting did not increase with longer exposure time. Pitting had

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(6) Proc. International Conference on the Peaceful Uses of Atomic Energy, Geneva 1955, Vol. 9, p. 403, United Nations, N.Y. (1956).

(7) Report No. ORNL-TM-1030, September 1966.

(8) Exxon Nuclear Company, Inc. Report No. XN-NS-TP-000/NP, March 1979.

no effect on the dislodgement of the  $B_4C$  particles in the Boral core. In fact, the cermet  $B_4C$  particles are inert to pool water environment and galvanic corrosion and became embedded in the aluminum corrosion product which forms on the edges of the Boral plate. The more noble stainless steel showed no attack by the galvanic coupling. The tests also indicated that galvanic coupling does not accelerate the general corrosion of the aluminum cladding on the Boral nor the aluminum in the Boral matrix.

Although galvanic corrosion does occur in the unanodized aluminum of the Boral plates, it should not have any significant effect on the neutron absorption capability of the Boral, and certainly no effect on storage rack structural integrity for a period far in excess of 40 years.

The stainless steel pool liner would not be affected by interaction with the aluminum in the Boral plates for the following reasons:

1. Stainless steel is more noble than aluminum and will not suffer galvanic or electrolytic corrosion,
2. The Boral plates are completely encapsulated in the stainless steel tubes of the storage rack module, thus isolating them from the pool liner. The stainless steel storage rack base forms a further protective layer between the Boral plates and the floor of the pool.



3. The spacing between the storage racks (containing the Boral) and the pool liner is sufficient to cause electrical discontinuity.

Contention 2(i)

The Applicant has not discussed whether the proposed modification and long term storage may cause the following effects on the stored fuel: accelerated corrosion, micro-structural changes, alterations in mechanical properties, stress corrosion cracking, intergranular corrosion, and hydrogen absorption and precipitation by the zirconium alloys.

As discussed in the response to contention 2(h), accelerated corrosion of Zircaloy at spent fuel pool temperatures is not expected to occur for two reasons: (1) the fuel removed from the reactor has an initial  $ZrO_2$  layer which retards the corrosion rate, (2) the corrosion rate at pool temperatures is several orders of magnitude less than that at reactor temperatures. Reactor irradiation (fast neutron fluxes  $> 10^{13}$  n/cm<sup>2</sup>-sec and gamma  $10^9$  Rhr<sup>-1</sup> doses) can produce minor accelerated corrosion (e.g., fuel that remained in the Shippingport reactor for 12 years resulted in less than  $2 \times 10^{-4}$  inch penetration of the cladding). According to R. C. Asher<sup>(9)</sup> gamma doses of  $6 \times 10^6$  Rhr<sup>-1</sup> and beta doses of  $7 \times 10^8$  Rhr<sup>-1</sup> have no effect on the corrosion rate of fuel cladding. The maximum gamma doses ( $10^4 - 10$  Rhr<sup>-1</sup>) expected in the spent fuel pool are many order of magnitudes lower which should not affect the fuel during storage up to 40 years.

Zircaloy is quite resistant to general corrosion in aqueous solutions containing chloride (e.g., less than  $4 \times 10^{-6}$  inches/year in 20,000 ppm chloride at 200°F). In order for pitting corrosion, intergranular corrosion,

<sup>(9)</sup> Corrosion Science, Vol. 10 (1970).

or stress corrosion cracking to occur in aqueous solutions containing 0.15 ppm chloride, generally specified in PWR storage pools, Zircaloy must be polarized anodically to break down the protective  $ZrO_2$  layer. To achieve this, there must be galvanic coupling to a cathodic material with a large electro-potential differential or/and applied current. Since the stainless steel and Inconel in the fuel bundle have about the same electrical potential as Zircaloy and stray current potential in pool water is minute, accelerated general corrosion, pitting intergranular corrosion, and stress corrosion cracking of fuel cladding should not occur in the Zion spent fuel pool for at least 40 years.

Alterations in the microstructure and mechanical/physical properties of metal is achieved by metallurgical processes (viz., heat treating, welding, alloying, fabrication, etc.) or by irradiation. High levels of fast neutron fluxes such as those occurring in the reactor vessel,  $>10^{10}$  n/cm<sup>2</sup>-sec ( $E > 1$  MeV), are required to cause such additional changes in the yield strength, ductility, or residual stresses of the fuel assembly bundle. Furthermore, irradiation creep causes relaxation of residual stresses and the high fracture toughness of irradiated Zircaloy would minimize the potential for brittle fracture.

Galvanic coupling of Zircaloy to aluminum will cause cathodic polarization of the Zircaloy, which makes it sensitive to hydrogen absorption at temperatures below 212°F. However, the only aluminum in the spent fuel pool is that in the Boral neutron absorber plates which are enclosed in stainless

steel isolating the aluminum from the Zircaloy. Therefore, this eliminates the probability of progressive hydriding (precipitation) and embrittlement of the fuel cladding during long-term pool storage.

Recent surveys by G. Versterlund and T. Olsson in Sweden<sup>(10)</sup>, A. B. Johnson of Battelle Northwest Laboratories<sup>(11)</sup>, and J. R. Weeks at Brookhaven National Laboratories<sup>(12)</sup>, reveal that Zircaloy or stainless steel cladding, stainless steel tie plates, and Inconel spacers in BWR and PWR fuel bundle assemblies have been stored in water pools for the past 12 years without evidence of accelerated corrosion. Defective fuel placed in the water pools at Windscale (England) and examined after 9 years storage showed no indication of accelerated corrosion, metallurgical changes, hydrogenation and crack propagation of the Zircaloy cladding, or oxidation of the UO<sub>2</sub> fuel. Release of fission products from the high burn-up fuel decreased rapidly to a relatively low and steady rate after 100 days. The detection of only 1 microcurie of Cs-137 and less than 10 ppb iodine in the pool water further indicates no degradation during water pool storage of high burn-up fuel.

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<sup>(10)</sup> ASEA-Atom Preprint No. RB 78-29 (January 18, 1978)

<sup>(11)</sup> Battelle Pacific Northwest Lab. Report (BNWL-2256, September 1977)

<sup>(12)</sup> NRC Report (BNL-NUREG-23021, July 1977)

Contention 2(j)

The amendment request and supporting documentation do not give sufficient data to fully assess the durability and performance of the Boral-stainless steel tubes which form the spent fuel storage racks:

- (1) there is inadequate analysis of the corrosion rate of the tubes,
- (2) there is no calculation of the effect of water chemistry on the Boral within the stainless steel,
- (3) there is no mention of the possible swelling of the Boral within the stainless steel tubes, a condition which could affect, among other things, removal of fuel assemblies from the racks.

Exxon Nuclear has conducted tests of samples of vented spent fuel storage cells in a borated water (pH5) at 146°F and in an alkalinated water (pH9.6) at 153.4°F for periods up to one year<sup>(13)</sup>. The deterioration was in the form of pitting of the aluminum cladding on the Boral plates and edge attack confined to the area of the leak path. The frequency of pitting did not increase with longer exposure time. Pitting had no effect on the dislodgement of the B<sub>4</sub>C particles in the Boral core. In fact, the B<sub>4</sub>C particles are inert to pool water environment and galvanic corrosion and became embedded in the aluminum corrosion product which forms on the edges of the Boral plate. The more noble stainless steel showed no attack by the galvanic coupling. The tests also indicated that galvanic coupling does not accelerate the general corrosion of the aluminum cladding on the Boral nor the aluminum in the Boral matrix.

Upon exposure of Boral to the spent fuel pool environment gas generation will occur within the first 5 days due to the rapid initial corrosion of the aluminum, after which there is a minute excess gas evolved during the slow

<sup>(13)</sup> Exxon Nuclear Company, Inc. Report No. XN-NS-TP-009/NP, March 1979.

steady state corrosion rate of the aluminum. However, the Zion storage racks will be vented at the top allowing the gas to escape, thus minimizing the probability of swelling and any effect on the removal of fuel assemblies. The Exxon Nuclear tests on vented storage cells indicated that the possibility of small bulging in the Boral plates would be rare, random, and self-limiting in size minimizing severe deformation of the stainless steel covering.

Boral has been exposed to the reactor coolant water of the Brookhaven Medical Research Reactor for 20 years without experiencing significant deterioration<sup>(14)</sup>. The Boral plates are the typical  $B_4C$ /aluminum core with an aluminum cladding, but not covered with stainless steel. The reactor water is high-purity demineralized water at a temperature range of 75°F to 115°F. Boral samples examined in September 1978 showed the characteristic protective film on the aluminum cladding and a slight corrosion product on the edges where the aluminum in the Boral core was exposed to the water. The samples showed no loss of the inert  $B_4C$ . Neutron attenuation tests on five samples showed no loss in neutron absorption properties, indicating that no boron was lost from the Boral core during the 20 years exposure.

Contention 2(k)

The amendment request and supporting documentation do not consider possible degeneration of the Boral density due either to generic defects or to mechanical failure which would diminish the effectiveness of Boral as neutron absorber, thus leading to criticality in the spent fuel pool.

<sup>(14)</sup> NRC Report (BNL-NUREG-25582, January 1979).

As stated in Section 2.1 of the Safety Evaluation, the criticality calculations for the modification were made using the stated minimum value of 0.02 grams of the boron - 10 isotope per square centimeter of Boral plate. During our review of the application we asked the Commonwealth Edison Company how the minimum value would be verified for all of the Boral plate area. Its response, which was transmitted to us by letter dated January 24, 1979, is as follows:

The manufacture of Boral and fabrication into plates is controlled by the Brooks and Perkins Quality Assurance Program, which includes detailed procedures for the inspection and verification of boron-ten loading in each Boral plate. The inspection plan for these activities will include the following:

1. Documented laboratory analysis for chemical boron content and isotopic boron-ten content of each lot of boron carbide powder.
2. Inspector's verification of the weighing and mixing of boron carbide and aluminum powder into a batch, according to the production plan, and the assembly of this batch into one or several ingots, all identified and traceable to the batch.
3. Documented laboratory analysis of a selected sample of batch mixes to verify boron carbide content.
4. The rolling of the ingot into a sheet, and the subsequent blanking of a sheet into two or three plates, each identified and traceable to the ingot and batch.
5. Visual inspection of the perimeter of each plate to verify that the core extends to the edge (the aluminum edge filler has been completely sheared away), and a check of plate thickness at several points.
6. Documented laboratory analysis, according to a sampling plan, of the boron carbide content of coupons cut from each end of each plate.

7. Documented neutron transmission tests over the surface of a selected sample of plates to verify the uniformity of boron-ten loading across the entire plate area.

The detailed sampling plans will be established prior to manufacturing, based on the specific production lot sizes to be used, in order to establish a 95 percent confidence that the minimum areal density of 0.02 grams of boron-ten per square centimeter is present over the entire area of each plate.

It is estimated that the nominal level of boron-ten areal density will be  $0.0220 \pm 0.0012$  grams per square centimeter, to provide an assured minimum level of 0.02. The exact range will be established in the detailed production plans.

From this reponse we concluded that there will indeed initially be at least 0.02 grams of boron-ten per square centimeter of Boral plate.

From the physical facts and experimental results presented in this testimony we conclude that the areal density of boron-ten in the Boral plates will not be reduced by chemical means below 0.02 grams of boron-ten per square centimeter of Boral plate over the life of the racks.

In regard to a possible mechanical failure which could diminish the effectiveness of Boral as a neutron absorber, Commonwealth Edison in their April 26, 1978 submittal stated that only the outer stainless steel tubes are welded together, and they form the load-carrying, structural part of the rack. These outer stainless steel tubes are designed to carry the mechanical loads imposed during a Safe Shutdown Earthquake (SSE). Thus the mechanical strength of the Boral plates is not relied on in the design. Also, the inner stainless steel tubes are designed to hold the Boral in place. Thus the mechanical strength

of the Boral is not used in any way in this design. Since the strength of the stainless steel is expected to deteriorate by only a minute, insignificant amount over the life of the racks, there should be no mechanical failures which would diminish the Boral density.

The only other effect which could possibly diminish the Boral density in the spent fuel pool is radiation. However, the boron carbide in the Boral is very resistant to the types of radiation in the spent fuel pool, where the neutron flux is very low. The neutron flux is the product of the subcritical neutron multiplication and whatever neutron source is present in the pool. For a  $K_{eff}=0.95$  the subcritical neutron multiplication is a factor of 20; so the neutron flux in the pool will be twenty times whatever source is present. Since even the strongest, non-reactor sources emit only about  $10^8$  neutrons per second, the neutron flux in the pool will be many orders of magnitude below the level where boron depletion effects would be significant in forty years of full time use. The gamma flux in a spent fuel pool is also much less than in an operating reactor. And boron carbide, even in a reactor, is relatively unaffected by either gamma or beta radiation. Thus, experience has shown that the radiation in the spent fuel pool will not diminish the Boral density.

From all of the above, we conclude that the areal density of boron in the Boral plates will not be reduced below 0.02 g/cm<sup>2</sup> of boron - 10 per square centimeter of Boral plate throughout the life of the racks in the spent fuel pool.



PROFESSIONAL QUALIFICATIONS OF FRANK M. ALMETER

I joined the Commission in October, 1974 as a Materials Engineer and I am presently a Senior Materials Engineer in the Engineering Branch, Engineering and Projects, Division of Operating Reactors, Office of Nuclear Reactor Regulation. Since October, 1974 my duties and responsibilities have involved the review and evaluation of materials application in nuclear power plants with specific emphasis on corrosion and water chemistry in PWR and BWR systems. I have been appointed to the Electrical Power Research Institute (EPRI) Corrosion Advisory Committee and the NRC Corrosion Review Group for Reactor Systems. I have the primary responsibility for the safety evaluation regarding the corrosion problems of PWR steam generator tubing, spent fuel storage pools, BWR and PWR piping systems, and snubbers.

I also have the responsibility for the evaluation of reactor coolant chemistry in both Pressurized Water Reactors and Boiling Water Reactors. I have provided the Division of Regulatory Standards with the technical bases required for the revision of Regulatory Guide 1.56, "Maintenance of Water Purity in Boiling Water Reactors."

I presented testimony on "Steam Generator Tube Integrity" at the Beaver Valley Unit 1, Pilgrim Station Unit 2, Jamesport Station Units 1 and 2, Byron/Braidwood Stations Units 1 and 2, and Prairie Island public hearings. I also assisted in the preparation of testimony on this same subject for the South Texas Project Units 1/2 and the Washington Nuclear Project One public hearings.

I have a Ph.D. in metallurgy from the University of London (1959) and a D.I.C. degree in metallurgy from the Imperial College (London 1956). I received a B.Sc. degree in Metallurgical Engineering from the University of Missouri at Rolla in 1953.

From June, 1973 to October, 1974, I was associated with the U.S. Consumer Projects Safety Commission as a metallurgist responsible for the evaluation of engineering, manufacturing and quality control procedures within the consumer product industry to insure production of non-hazardous products. I developed safety tests and basic engineering factors relative to the modification of product safety standards.

In 1971 I joined the Office of Saline Waters, Department of the Interior, as Assistant to the Chief, Materials Division. My duties and responsibilities were the planning and directing of contracts for the development, testing, and evaluation of materials utilized in the various desalination processes. I prepared contracts for the development of economic materials to reduce the capital and maintenance costs of desalination plants and increase their reliability. I also conducted inspections to evaluate the corrosion performance of materials in operating plants. I performed highly technical studies of the corrosion, mechanical, physical, and fabrication properties of a wide range of materials.

From 1968 to 1971 I was Chief Metallurgist of corporate materials technology for the Burndy Corporation with duties and responsibilities for the technical/administrative management of materials pertinent to process and product development. As manager of the metallurgical R & D laboratory, I was responsible for program planning, cost estimates, budget control and recruiting. I established, staffed and managed a new Metallurgical Service Center to support Engineering, Manufacturing, Purchasing, and Sales/Marketing Departments.

Before I became Chief Metallurgist with the Burndy Corporation, I was a research scientist for 10 years in the aerospace industry where I conducted basic and applied research in the areas of surface science, precious metal coatings, corrosion of metals, mechanical/physical metallurgy, fibrous composite materials, simulated high altitude environmental effects on materials, fracture and surface damage in metals, alloy development, heat treating, ferrous and nonferrous alloys, ceramic/dielectric materials, and HERF forming of metals.

From 1955 to 1958 I was a Consulting Metallurgist in the United Kingdom. I specialized in the areas of precipitation-hardening, fatigue and tensile properties of Beryllium Bronzes.

I am listed in the American Men of Science, 12th edition and Who's Who in America, 14th edition. I was Guest Lecturer, Fairleigh Dickinson University course on "Desalination Operations," Dec. 1972. I was invited by the Electrical Power Research Institute (EPRI) to be secretary to the "First U.S. - Japan Joint Symposium on Light Water Reactors" (May 29 - June 2, 1978).

I have authored 17 publications in my professional field.

Current Publication: "An Overview of Water Chemistry for Nuclear Power Plant Safety by F. M. Almeter, Vol 28, pp 582-583, 1978 Transactions of the American Nuclear Society.

I am a member of the American Society for Metals, AIME Metallurgical Society, and National Association of Corrosion Engineers.

EDWARD LANTZ

DIVISION OF OPERATING REACTORS

U.S. NUCLEAR REGULATORY COMMISSION

PROFESSIONAL QUALIFICATIONS

As an Engineering Systems Analyst in the Plant Systems Branch I am responsible for technical reviews and evaluations of component and system designs and operating characteristics of licensed nuclear power reactors.

I have a Bachelor of Science degree in Engineering Physics from the Case Institute of Technology and a Masters of Science degree in Physics from Union College and a total of 28 years of professional experience, with over 20 years in the nuclear field. My experience includes work on reactor transients and safeguards analysis, nuclear reactor analysis and design, research and development on nuclear reactor and reactor control concepts and investigations of their operational and safety aspects.

I have held my present position with the Commission since December 1975. My previous position, which I held for about two and one half years, was Project Manager in the Gas Cooled Reactors Branch, Division of Reactor Licensing, U. S. Nuclear Regulatory Commission, where I was responsible for the technical review, analysis, and evaluation of the nuclear safety aspects of applications for construction and operation of nuclear power plants. For about ten years prior to that I was Head of the Nuclear Reactor Section in NASA. My section was responsible for the development and verification of nuclear reactor analysis computer programs, conceptual design engineering, and development engineering contracting. Prior to my employment with NASA, I was a nuclear engineer at the Knolls Atomic Power Laboratory for about six years, where I worked on the safeguards and nuclear design of the S3G reactors and the initial development of the nuclear design of the S5G reactors. Previous experience includes system engineering and electrical engineering with the General Electric Company and electronic development engineering with the Victoreen Instrument Company.