UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
SOUTH CAROLINA ELECTRIC & GAS COMPANY	)	Docket No. 50-395
	)	
(Virgil C. Summer Nuclear Station, Unit 1)	)	

JOINT AFFIDAVIT OF SANG BO KIM AND JOHN G. SPRAUL REGARDING STRUCTURAL SIGNIFICANCE OF RECENT CADWELD ALLEGATIONS

1. I, Sang Bo Kim, being duly sworn, state as follows:
   I am employed by the U.S. Nuclear Regulatory Commission as a Senior Structural Engineer in the Office of Nuclear Reactor Regulation, Structural Engineering Branch. I am responsible for all but paragraph 14 of this affidavit.

2. I, John G. Spraul, being duly sworn, state as follows:
   I am employed by the U.S. Nuclear Regulatory Commission as a Senior Quality Assurance Engineer in the Office of Nuclear Reactor Regulation, Quality Assurance Branch. I am responsible for paragraph 14 of this affidavit.

3. The purpose of this affidavit is to assess the significance of recent cadwelding allegations raised in an August 1982 Intervenor motion to reopen the record, and NRC Region II inspection of such allegations, upon the structural integrity of the as-built Summer containment.

4. The containment building provides a barrier to prevent the release of radioactive material to the environment in the case of an accident

inside the containment. It also acts as a barrier to protect the safety-related equipment housed therein from the effects of external phenomena.

5. The Summer containment structure is a post-tensioned, reinforced concrete structure with a toruspherical dome, cylindrical wall, a flat foundation and an integral steel liner. The cylinder has an inside diameter of 126 feet, a height of 146 feet and the wall is 4 feet thick. The dome is 3 feet thick and approximately 45 feet high. The concrete walls contain tendons and carbon steel reinforcing bars.

6. Each tendon consists of 170, one-quarter inch diameter stress-relieved high strength wires. There are 265 tendons running vertically and horizontally within the cylindrical wall. The vertical tendons are anchored in the foundation mat. Three way tendons are provided in the dome.

7. A form is erected to initially hold wet concrete. It is later removed after the concrete has settled. Within the form, carbon steel reinforcing bars and tendons are positioned. After removing the form, the tendons are stressed in tension. This is done to maintain a compressive state in the concrete even after internal design pressure is introduced because of the effectiveness of concrete in compression.

8. The Summer containment is designed for 57 psi internal pressure. The source of this internal pressure is the release of high energy pressure from the primary coolant system due to a postulated loss-of-coolant accident. As reported in Section 6.2.1 of the Safety

Evaluation Report, the peak calculated pressure due to a postulated loss-of-coolant accident is approximately 45 psi. Because of the importance of the internal pressure load to the containment design, a structural acceptance test of the containment integrity at 115% of design pressure is required prior to issuance of an operating license. This has been completed satisfactorily by the applicant. The results of this structural acceptance test demonstrate that the containment is capable of containing the internal pressure produced by a loss-of-coolant accident.

9. The intervenor in his August 26, 1982 affidavit noted that there was some minor discrepancy between predicted engineering values (such as deflection and crack size) and the actual measurements during the structural acceptance test. However, we have examined these discrepancies and determined that they are not significant from a structural capability standpoint since the capability of the containment to perform its pressure retaining function has been demonstrated.

10. Cadwelds provide a mechanical splice to connect adjoining carbon steel reinforcing bars. Reinforcing bars are required primarily to resist other types of loadings, namely, earthquake and wind. All reinforcing bars larger than number 14 are required to be mechanically spliced by such means as Cadwelds. Both the inside and outside faces of the concrete containment wall and dome are reinforced by number 14 and number 18 bars. They are spaced at about one foot intervals and run in vertical and horizontal directions.

11. The Cadwelds connecting the vertical bars are questioned by the Jennings allegations. Lateral loads such as earthquake and wind loads are transmitted to the structure as tangential shear forces. These forces are directed on a horizontal plane and tangent to the containment wall. Vertical reinforcing bars are provided to resist this type of shear force.
12. The applicant in calculations documented in a letter from O.W. Dixon, Jr. to H.R. Denton, dated September 3, 1982, stated that approximately 50% of the vertical reinforcing bars are needed to resist the shear forces. This value is based on the assumption that shear forces are transferred from one vertical reinforcing bar to the adjoining bar below through Cadwelds and eventually to the foundation. This is based on elementary engineering principles and the Staff agrees with the applicant's assessment.
13. The applicant, in its evaluation, used 90% of the yield strength of the tendons. This assumption has been accepted by the Staff in the past and also applies to the Summer plant. Since the original design was based on a more conservative value for the tendon strength, the applicant incorporated substantially more rebar in the original design than would currently be required. The net effect of the additional rebar is that none of it is needed to resist the design pressure loads and only 50% of the rebar (in the most critical locations) is needed to resist tangential shear forces caused by lateral loads. This assures that there is no compromise of the containment's capability to resist shear forces since, based on the NRC Region II special inspection into the Jennings'

allegations, there is no concern with the capability of the vertical Cadwelds to meet their design requirements. Region II reports that approximately 100 random production cadwelds were tested to determine the effectiveness of the Cadweld process and that all of the tested Cadwelds exceeded the minimum strength requirements.*

14. On the basis of these tests and the nomograph attached to this affidavit, the Staff reaches the following conclusions:

(a) With 99% confidence, we expect a fraction of cadwelds with strength less than the minimum strength requirement that is no worse than 5%.

(b) With 95% confidence, we expect a fraction of cadwelds with strength less than the minimum strength requirement that is no worse than 3%.

(c) With 90% confidence, we expect a fraction of cadwelds with strength less than the minimum strength requirement that is no worse than 2%.

15. The Staff concludes that containment structural integrity will not be compromised even if there is a small fraction of defective Cadwelds. This is due to the fact that the internal design pressure is resisted exclusively by the tendons and only 50% of the Cadwelds are needed to resist the lateral loads.

16. The applicant has stated that the above analysis which concludes that 50% of the Cadwelds are required is conservative and that a more realistic assessment of the containment integrity shows that no Cadwelds are needed for either lateral loads or internal pressure. Two arguments were provided. The first is that the imbedded reinforcing bars are capable of transmitting shear force in view of their close proximity to each other. In addition, the

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* See page B-12 of the September 9, 1982 affidavit of Joseph Lenahan.

Cadwelds are staggered vertically four feet apart forming a saw tooth shape, thus avoiding a single horizontal plane. This is said to provide a means to transfer the load without Cadwelds. However, the Staff would need supporting experimental data before agreeing with the applicant on this argument.

16. The next argument the applicant presented is that the tendons alone can resist both internal pressure and lateral loads, thus neither vertical reinforcing bars nor their connecting Cadwelds are required. This conclusion is based primarily on a concept of ultimate capacity design where the maximum available strength of the engineering material is utilized in the evaluation. Even though this philosophy has been approved in the past, the Staff would require more information to properly assess its validity in the present situation.

17. In sum, the Staff has considered the allegations and related documents provided by the intervenor and applicant, and the Region II special inspection in this matter, and concludes that there is no reason to doubt the structural integrity of the Summer containment.

Sang Bo Kim

John G. Spraul

Subscribed and sworn to before me
this 10 day of September, 1982.

Notary Public

My Commission expires: July 1, 1986

ATTACHMENT

Nomograph for sample with zero defects

A nomograph of the Poisson frequency distribution can determine the fraction defective and associated confidence level of a population on the basis of a defect free sample.

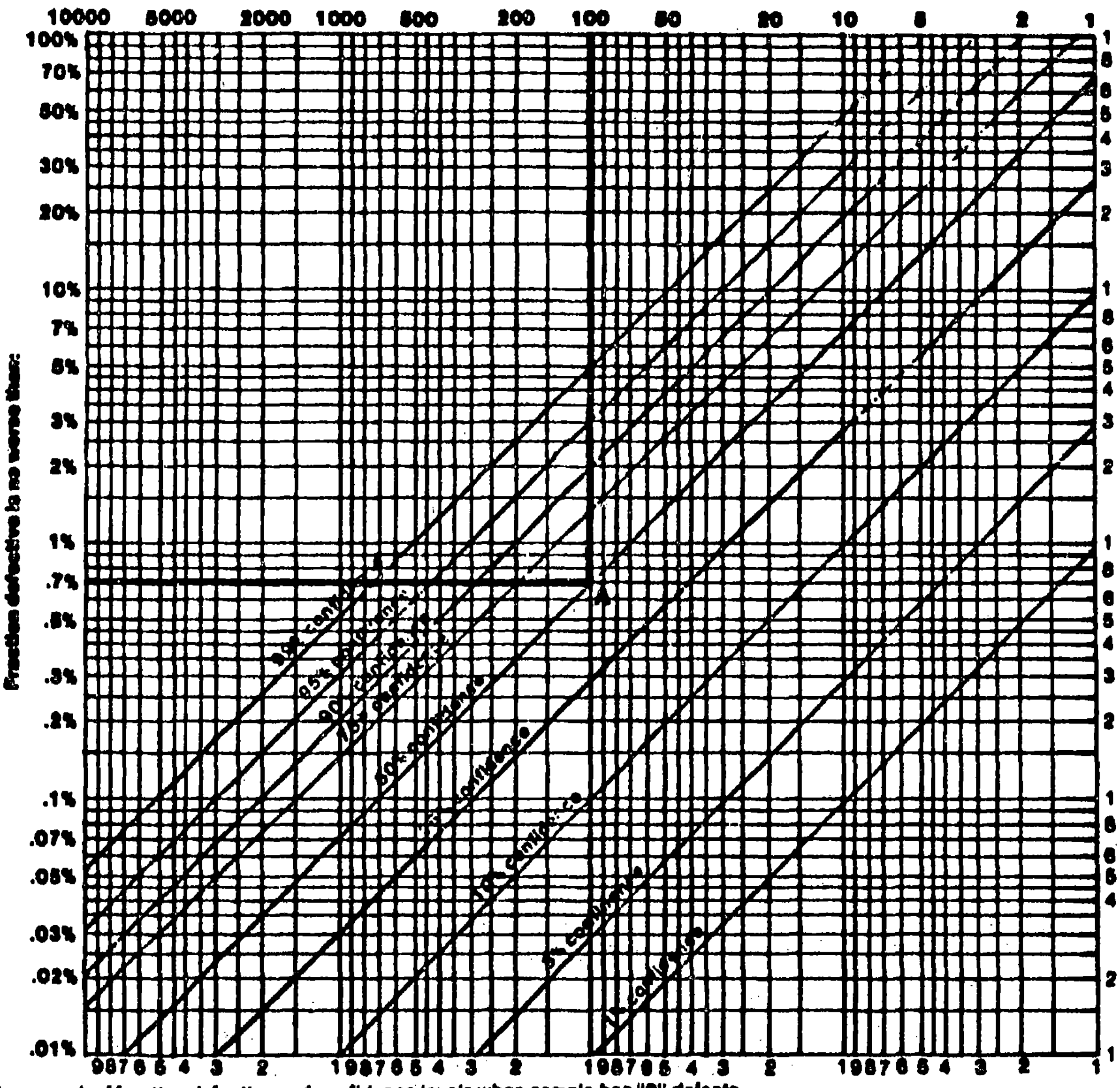
■ Example:

A sample of 100 pieces has been evaluated and there were no defects found. With the aid of the nomograph a variety of statements can be made about the fraction defective lot.

At the top of the nomograph find the vertical line headed 100. To find the percent of defects in the worst case with a 50 percent confidence follow the vertical line downward to the point of intersection with the 50 percent confidence line (Point A). From point A follow the horizontal line to the left until you find its point of intersection with the vertical scale. The intersection is at 0.7 percent. With 50 percent confidence you can expect a fraction defective that is no worse than 0.7 percent. ■

For a copy of this article enter 13 on reader service card. Requests will be honored until supply is exhausted.

Number of pieces in a sample containing "0" defects



Nomograph of fraction defective and confidence levels when sample has "0" defects.

PROFESSIONAL QUALIFICATIONS
SANG BO KIM

My name is Sang Bo Kim. I am a Senior Structural Engineer in the Structural Engineering Branch, Division of Engineering, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission.

I received a B.S. degree in Engineering Mechanics from the University of Illinois in 1960, a M.S. degree in Applied Mechanics from Rensselaer Polytechnic Institute in 1965, and a M.S. in Applied Mathematics from New York University in 1968.

Prior to joing the Nuclear Regulatory Commission, I was a Supervisory Engineer for David Ehrenpreis, Consulting Engineers (1960 - 1963), a Stress Analyst for Combustion Engineering (1963 - 1965); a Senior Engineer for the Singer Company (1965 - 1968), a Senior Engineer for Gulf United Nuclear Fuels Corporation (1968 - 1971), and a Lead Engineer for Nuclear Fuels Service (1971 - 1972).

I joined the NRC in 1972 as a Structural Engineer in the Transportation Branch of the Office of Nuclear Materials Safety and Safeguard. From 1973 to 1979 I was a Reactor Engineer with the Core Performance Branch of the Office of Nuclear Reactor Regulation, from 1979 to the present I have been a Senior Structural Engineer with the Structural Engineering Branch of the Office of Nuclear Reactor Regulation. My present duties include: evaluating the structural and earthquake engineering aspects of safety-related structures, systems and components, as proposed in Safety Analysis Reports, from the standpoint of functional capability and integrity, under normal plant operation, and for safe plant shutdown during normal, transient, accident and environmental conditions; performing independent calculations and engineering analyses to confirm or verify applicants' or vendors' assessment of structural integrity and response under pertinent load combinations, including postulated transient and accident conditions; and performing on-site technical audits of applicants' plant designs for selected structures and systems in the branch's area of responsibility to observe "as built" implementation of NRC Safety criteria.

JOHN G. SPRAUL
PROFESSIONAL QUALIFICATIONS
QUALITY ASSURANCE BRANCH
OFFICE OF NUCLEAR REACTOR REGULATION

I am a Senior Quality Assurance Engineer (Nuclear) in the Quality Assurance Branch in the Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission. In this position, I am responsible for the review and evaluation of applicants' descriptions of quality assurance programs proposed for the design, construction, and operation of nuclear power plants as assigned to me.

I received a Bachelor of Chemical Engineering degree from the Georgia Institute of Technology in 1951. In 1971, I completed the requirements for the Professional Designation in Quality Control at the University of California, Los Angeles. My nuclear experience prior to joining the NRC includes 2 years of engineering work in gaseous diffusion with the Goodyear Atomic Corporation and 12 years of nuclear fuel and nuclear power plant component design, manufacture, and testing with the Atomics International Division of Rockwell International. My quality assurance experience prior to joining the NRC includes 2 years as Chief Inspector and 4 years as Director of Quality Assurance at Atomics International, where I was responsible for managing the entire quality assurance program.

I joined the Quality Assurance Branch of the NRC in 1974. Since joining the NRC, I have reviewed the quality assurance program descriptions for 26 nuclear power plants as well as 19 topical reports on quality assurance submitted by utilities, architect-engineers, NSS suppliers, and constructors.

I am a member of the American Nuclear Society and a senior member of the American Society for Quality Control. In 1972, I was certified as a Quality Engineer by the American Society for Quality Control. This certification was last renewed in 1980, and expires on December 31, 1982.

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CERTIFICATE OF SERVICE

I hereby certify that copies of "NRC STAFF RESPONSE TO INTERVENOR'S MOTION TO REOPEN THE RECORD AND REQUEST FOR A STAY" in the above-captioned proceeding have been served on the following by deposit in the United States mail, first class, or, as indicated by an asterisk, by deposit in the Nuclear Regulatory Commission's internal mail system, this 10th day of September, 1982:

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