RELATED CORRESPONDENCE

November 7, 1984

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

REBUTTAL TESTIMONY OF
DR. ROBERT N. ANDERSON,
PROFESSOR STANLEY G. CHRISTENSEN,
AND G. DENNIS ELEY

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1.Q. Dr. Anderson, based on FaAA's description of the samples it took from the cylinder blocks of EDG's 101 and 102, do you believe that FaAA has an adequate basis for concluding that those blocks do not contain quantities of Widmanstaetton graphite similar to the quantity found in the old EDG 103 block?

A. (Anderson) No. As I understand FaAA's testimony, they took two small specimens and about ten replications from each block. Based on the FaAA witnesses' descriptions of the sampling performed, they evaluated less than 100 grams of material from each block, and each block weighs 24,000 pounds. Therefore, they have based their conclusions on analysis of approximately 10 parts per million, and that is hardly sufficient to warrant a high degree of scientific certainty about the composition of the EDG 101 and 102 blocks. The fact that FaAA did observe areas in the EDG 102 block samples that had characteristics similar to Widmanstaetton graphite (Tr. 24,754 (Wachob)) underscores my concern about the thoroughness of their sampling in this particular.

2.Q. Could residual stress create tensile forces in the block top and cam gallery areas of the cylinder blocks?

A. (Anderson) Yes, and those forces could be substantial because of the complex geometry of the casting in both of those areas.

3.Q. Do you believe it is possible to predict the existence and amount of residual stress in those areas using any analytical methods short of actual testing?

A. No, and no one can do that with any reasonable degree of scientific certainty. The preferred way to evaluate the amount of residual stress in a structure with any degree of scientific certainty is to undertake strain gage testing of the surface in its existing state and compare those results to strain gage readings of the same surface after a piece has been removed from the vicinity.

4.Q. Dr. Anderson, Dr. Rau testified that he did not observe the "multiple small disconnected cracks branching out into the cast iron material" below the tip of the 3/8-inch circumferential crack reported in your Supplemental Testimony (Answer to Question 18, pp. 11-12), and suggested that you may have confused artifact of Widmanstaetton graphite for the cracks you described. Is it possible that you confused artifact of Widmanstaetton graphite for cracks?

A. (Anderson) No. I viewed the particular specimen under a microscope with power varying from 20X to 60X. I did observe random artifact in the area, and I assumed that to be Widmanstaetton graphite. However, the branch-like cracks I described in the cited testimony were quite different. The cracks I observed and described in the cited testimony had an organized appearance consistent with the orientation of the larger crack above them and were not random as I would expect artifact from Widmanstaetton graphite to be.

5.Q. Dr. Wells testified that he considered the risk of structural failure from circumferential cracks to be highly unlikely because one-third of the circumference of the liner landing area consists of stud bosses. Tr. 25,100-01 (Wells). Do you agree?

A. (Eley, Christensen) No. We cannot be sure that a circumferential crack in the cylinder liner landing area is likely to extend deeply enough to cause a structural failure, but it is clearly possible and cannot fairly be characterized as unlikely. A more serious concern is, as described in our Supplemental Testimony (Answer to Question 20 at p. 13), that such a crack could cause the liner landing to flex under the force created by the 1600-1700 pounds of firing pressure, causing movement of the cylinder liner and leakage of combustion gases outside the cylinder into the cylinder liner landing area. In that event, and if the circumferential crack extends through the 1-inch depth of the liner landing area that does not consist of stud bosses (about two-thirds of the circumference), then gases would enter the cooling jacket water system. Such gases in the cooling jacket water could cause overheating and require engine shut-down. The alternative to engine shut-down would be to risk the same consequences of overheating due to loss of coolant described at pp. 152-53 of our Revised Joint Testimony, dated October 29, 1984.

6.A. Dr. Anderson, Dr. Rau testified that there is no way you can conclude that the weld material in the cam gallery crack

sectioned by FaAA from the old EDG 103 block pulled free from the crack surface due to operating stresses and not due to heat shrinkage as you testified in your Supplemental Testimony (Answer to Question 11 at p. 8). Do you stand by your testimony?

A. (Anderson) Yes. Based on my examination of the crack samples sectioned by FaAA, it appeared that the weld material had been simply "puddled" into the crack after it was widened by grinding or arcing. It did not appear that the crack site had been subjected to any pre- or post-heat treatment as part of the welding operation. If these premises are correct, then the weld material would adhere to the cast iron relatively uniformly and would break cleanly from that base metal if the moving force were tensile stress resulting from weld shirkage. The fact that some cast iron was still adhering to the weld material that had separated from one side of the crack therefore makes it more likely that the separation was caused by operating stress and not weld shrinkage.

7.Q. Aside from that analysis, do you have any reason to question Dr. Rau's conclusion that the separation of the weld material from the cast iron in the crack which was sectioned by FaAA from the old EDG 103 block had been caused by tensile stress from shrinkage of the weld material itself?

A. (Anderson) Yes. I understand that the weld material is a nickel-iron alloy. The characteristics of nickel-iron weld material are such that they minimize shrinkage and therefore

minimize the likelihood of tensile stress caused by post-cooling shrinkage.

8.Q. Dr. Rau testified that, because of the general shape of the cracks in the old EDG 103 block, even if such a cam gallery crack did propagate, its deepest extension through the 1-1/4 inch cam gallery wall could cause only a pinhole leak at the inner wall. Tr. 25,249-50 (Rau). Do you agree, Dr. Anderson?

A. (Anderson) No, there is no scientific basis for assuming that a cam gallery crack which propagates through the wall in that area would be limited to a pinhole at the inner wall based on the shape of the crack indications that I observed. Although it is conceivable that the initial extension through the inner wall would begin as a pinhole leak, I would expect it to expand very rapidly once the initial penetration occurs so that the crack surface along the inner wall could extend up to a couple of inches in length.

9.Q. Professor Christensen and Mr. Eley, Dr. Wells testified that even if a cam gallery crack were to penetrate through the wall, there is a horizontal channel and perhaps other pieces of metal in the cam gallery area sufficient to provide support for the camshaft bearing. Tr. 25,254-55 (Wells). Do you agree?

A. (Christensen, Eley) Yes, provided that Dr. Wells intended his conclusion to be limited to the vertical support for the crankshaft bearing. Our concern in this area as discussed in our Revised Joint Direct Testimony dated October 29, 1984, at p. 176 relates to flexing of the crankshaft horizontally

along the plane of the cam gallery wall, not vertically as suggested by Dr. Wells' testimony. We continue to believe that such horizontal flexing is a concern that is not eliminated by the structural support discussed by Dr. Wells in his testimony.

10.Q. Dr. Rau and/or Dr. Wachob testified that they did not believe that the relatively low temperature environment of the engine when it is not operating would cause the volume of oxidation present on the samples of the cracks removed from the old EDG 103 block -- Dr. Anderson, do you agree?

A. (Anderson) No. As I understand it, the old EDG 103 block was manufactured in the mid-1970s and was maintained during a substantial part of the period after that time in a room temperature of 70°F. It is also my understanding that the jacket water temperature in the engine when it is not in operation is maintained at approximately 140°F and I would therefore expect the cast iron in the cam gallery wall to be approximately that temperature. Those temperatures are sufficient to cause oxidation in the quantities measured on the cam gallery crack samples (0.2-0.5 mm) over a period of a few years depending, of course, on other conditions.

11.Q. Mr. Schuster testified that the entire shaded region depicted on Suffolk County Diesel Exhibit 77 was "arced and perhaps subsequently ground out" before the weld metal was puddled in. Tr. 25,456 (Schuster). Do you agree with Mr.

Schuster based upon your examination of the samples and photographs, Dr. Anderson?

A. (Anderson) I have no basis for agreeing or disagreeing based upon my review of the samples or photographs -- the appearance of the repaired cracks is consistent with either arcing or grinding preparatory to welding. However, I visited TDI and observed that in making weld repairs to engine components, TDI followed the practice of grinding cracks, not arcing them. Of course, I cannot state that they followed the same procedures in 1975 but that is a reasonable assumption.

12.Q. Dr. Anderson, assuming that the oxide discovered on the cam gallery crack specimen removed from the old EDG 103 block was formed during the casting process and assuming that TDI attempted to repair those cracks subsequently, in your opinion is it reasonable to believe that there would be as much as 0.5 mm of oxide still adhering to the side of the crack to which the weld material had been applied but from which it is now separated?

A. (Anderson) No. The crack specimens which I examined definitely showed evidence of having been either arced or ground out in preparation for welding. Regardless of whether the cracks were widened by arcing or grinding, I would expect any oxide that had been adhering to the crack surface to be removed in the normal course of arcing or grinding. Neither process is so precise that the surface of both sides of the crack would be undisturbed in the course of it. Moreover, it

would make no sense to attempt to avoid disturbing one particular side of the crack because it is normal welding preparation to remove any oxide adhering to the surface to be welded in order to permit better weld adhesion.

12.Q. Dr. Wachob testified that FaAA did not perform any tests to determine whether the oxide on the cam gallery crack surface removed from the old EDG 103 block is a wustite, a hematite or a magnetite oxide. Tr. 25,414 (Wachob). Dr. Anderson, in your opinion would such a test be useful in determining the origin of the oxide?

A. (Anderson) Yes. If the oxide were a wustite it would tend to confirm FaAA's theory because wustite only forms at very high temperatures. On the other hand, if the oxide were hematite or magnetite, it would disprove FaAA's hypothesis concerning its formation because those oxides form only at much lower temperatures.

13.Q. Is there an accepted method for testing oxide to determine whether it is wustite, hematite or magnetite?

A. (Anderson) Yes. The method is by x-ray diffraction. It is not a very complicated procedure.

14.A. Dr. McCurthy testified that the addition of 20 gallons of water to the engine lubricating oil would not compromise the lubricating systems of the Shoreham EDGs. Tr. 25,273 (McCurthy). Mr. Eley do you agree?

A. (Eley) Absolutely not. It is normal operating procedure to regularly test the lubrication oil in large diesel

engines for the existence of water. The reason for that practice is that relatively small amounts of water in the lubricating oil can have catastrophic effects on the engine, particularly piston seizure and bearing failure. The amount of water that would be a problem depends on the type of oil. The lube oil system capacity for each Shoreham EDG is 700 gallons so that 20 gallons would amount to almost three percent. Regardless of the type of oil used, that volume of water in the lube oil of a diesel engine would be dangerous. We have checked with Mobil Oil Company to determine how much water they believe is permissible in the Mobil Delvac 40 oil used in the Shoreham EDGs during engine operation. Mobil's chief engineer responded that when the water reaches 0.15 percent, the Delvac 40 oil should be discarded. He also advised that he would be "concerned" about operating the engine with as little as 0.2 percent water in Delvac.

15.Q. Professor Christensen, do you agree with Mr. Eley's testimony concerning operation of a diesel engine with water in the lube oil?

A. (Christensen) Yes, I do, but I had no communications with Mobil Oil Company on the subject.

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CERTIFICATE OF SERVICE

I hereby certify that copies of SUFFOLK COUNTY'S REBUTTAL TESTIMONY OF DR. ROBERT N. ANDERSON, PROFESSOR STANLEY G. CHRISTENSEN, AND G. DENNIS ELEY, dated November 7, 1984, have been served on the following this 7th day of November 1984 by U.S. mail, first class, except as otherwise noted.

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