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LILCO, December 3, 1984

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
LONG ISLAND LIGHTING COMPANY	)	Docket No. 50-322-OL
	)	
(Shoreham Nuclear Power Station Unit 1)	)	
	)	

LILCO'S REPLY TO SUFFOLK COUNTY AND STATE OF NEW YORK PROPOSED FINDINGS OF FACT

HUNTON & WILLIAMS
P. O. Box 109
Raleigh, North Carolina 27602

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I. INTRODUCTION

1. These reply findings address the findings proposed by Suffolk County and New York State (Joint Proposed Findings). For convenience, this reply follows the format of the Joint Proposed Findings.[1/] LILCO does not propose that the Board adopt these reply findings. Rather, the reply findings demonstrate that the findings proposed by the Intervenors should be rejected. A surprising number of the findings are wholly unsupported by citations to the evidentiary record. (See, e.g., Joint Proposed Findings 18, 28, 29, 34, 39, 42, 46, 50, 51, 55, 77, 86, 96, and 104-106). Others misrepresent or omit pertinent testimony. The Joint Proposed Findings also largely ignore the cross-examination of witnesses for the County and the Staff and the direct testimony of LILCO's witnesses.

2. Joint Proposed Findings 1-17 are not proposed findings of fact but rather are summary conclusions in the form of a proposed decision and are not supported by citations to the record. LILCO disagrees with the conclusions in Section I of

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1/ LILCO disagrees with some of the findings proposed by the NRC Staff, although LILCO agrees with many of the Staff's Proposed Findings. To avoid repetition, LILCO does not separately discuss the Staff Proposed Findings with which it disagrees, except in certain isolated instances.

the Joint Proposed Findings. However, because this Section merely contains unsupported conclusions, LILCO will not specifically address each paragraph of Section I of the Joint Proposed Findings.

II. DISCUSSION

A. Compliance with the Rules of Classification Societies

1. Relevance of Classification Societies' Rules

3. Joint Proposed Findings 19-27 argue that the rules of various marine classification societies (Lloyd's, ABS and IACS) are relevant in determining whether the replacement crankshafts in the Shoreham EDGs are adequate. These proposed findings are argumentative and conclusory and are often unsupported by any citation to the transcript. In addition, they ignore the fact that current Nuclear Regulatory Guides provide that standby emergency diesel generators need only comply with DEMA. (LILCO Proposed Finding 9; Staff Proposed Finding 17).

4. Joint Proposed Finding 23 concludes that if a crankshaft in a diesel generator at a nuclear plant does not

comply with the rules of the classification societies, the crankshaft does not satisfy NRC regulations. There is no transcript citation for this conclusion nor is there any indication which NRC regulations the Intervenors claim the crankshafts fail to meet.

5. Joint Proposed Findings 24-27 discuss the alleged similarities between marine diesels and diesels in nuclear standby service. These proposed findings are misleading for several reasons. First, the findings ignore testimony by LILCO and the Staff that operating conditions for marine diesels are more severe than operating conditions for nuclear standby diesels. (LILCO Proposed Finding 15). Second, even if marine diesel generators (as opposed to main propulsion diesel engines) are not subjected to more severe operating conditions than land based diesels, the rules of the classification societies for designing crankshafts make no distinction between main propulsion diesel engines and diesel engines used for electrical generation. (Joint Proposed Finding 27). While the service seen by a marine diesel generator may be similar to the service seen by a land based diesel, marine diesel generators are designed to the same standards as main propulsion diesel engines. The County's witnesses concede that main propulsion engines are subject to more severe stresses than land

based diesels. (Joint Proposed Finding 26; Tr. 23,984-85 Eley). It is clear that the design standards of the classification societies are intended to apply to engines subject to more severe operating conditions than the Shoreham EDGs. It is not appropriate to evaluate a land based diesel according to these standards. The fact that marine generators may be subject to similar operating conditions as land based diesels is irrelevant.

2. Compliance with the Rules of Classification Societies

(a) Lloyd's

6. Joint Proposed Findings 29-33 discuss the County's horsepower calculations under Lloyd's rules. These proposed findings completely ignore the extensive cross-examination of the County's witnesses. Proposed Finding 29, which is unsupported by any transcript citation, states that LILCO did not contest the accuracy or validity of the County's Lloyd's calculations. Contrary to this assertion, LILCO extensively cross-examined the County concerning the Lloyd's calculations. (Tr. 23,976-24,056). Furthermore, there is no requirement in Lloyd's for an overload calculation. (Lilco Reply Finding 10).

7. Little if any weight should be given to the County's Lloyd's calculations. Professor Christensen described the

Lloyd's horsepower calculations as a very, very simple "chug and plug" formula. (Tr. 24,011 Christensen). This type of formula is commonly used in the initial design of a crankshaft. (Id.) It is not appropriate to conclude, however, that an existing crankshaft is inadequate because it does not comply with this simple horsepower formula. As Dr. Pischinger noted, design formulas (such as Lloyd's), which do not require any thought during the design process, have been criticized for not being in complete accord with physical laws. (Tr. 22,789 Pischinger).

8. Notwithstanding that the County's witnesses described the Lloyd's formula as very simple, they were unable to state whether their calculated horsepower rating at full load was approximately 5% less than the actual horsepower of the EDGs. (Tr. 23,977-79 Christensen). They were also unable to state what effect an increase of 25% in the Zed factor in the calculation would have on the allowable horsepower. (Tr. 24,040-49 Christensen, Eley).

9. In addition, when asked if the allowable horsepower at 3300 kW could be obtained by ratioing the calculation that was made at 3500 kW, Professor Christensen stated that the "chug and plug" horsepower formula was "complicated." He was unable to say whether the allowable horsepower at 3300 kW could

be obtained by ratioing without "spending a lot of time thinking about it." (Tr. 24,054-56 Christensen, Eley).

10. Joint Proposed Finding 31 discusses the County's horsepower calculation at 3900 kW. There is no requirement in Lloyd's for an overload calculation. (Tr. 24,005-06 Christensen, Eley). According to the County's calculations, the replacement crankshafts would have to be capable of operation at 4290 kW in order to meet Lloyd's requirements. (Tr. 24,016-20 Christensen, Eley).

11. Joint Proposed Finding 31 also incorrectly states that the acutal measured peak firing pressure in the EDGs is 1720 psi at full load. This representation is misleading because 1720 psi is the single highest peak firing pressure ever measured in any cylinder on the Shoreham EDGs at full load. (Tr. 22,081 Pischinger). It was measured from one cylinder at one point in time and is by no means a representative number. The peak value for one individual cycle is not the important value in performing a fatigue analysis. The significant value is the peak firing pressure that is representative of the millions of fatigue cycles to be experienced by the engine, or in other words, the average peak for a large number of cycles. (Tr. 22,075; 22,081-82 McCarthy). The significant value is neither the highest nor the lowest pressure measured at any one

time and, therefore, is certainly not the 1720 psi represented by the Intervenors.

12. In addition to the fact that the 1720 psi is the highest peak firing pressure ever recorded on the Shoreham EDGs, this measurement was recorded by a Kiene guage, which, in and of itself, is designed to record "the maximum of the maximum values of different cycles." (Tr. 22,562-63 Pischinger). The Kiene guage overemphasizes the higher peak firing pressures and is not as accurate as other measurement devices that reflect a more representative peak firing pressure. (Tr. 22,113-15, 22,562-63 Pischinger).

13. A more accurate measurement of the average or representative peak firing presure can be obtained from a quartz Piezo electric transducer. (Tr. 22,113 Pischinger). FaAA measured the peak firing pressures from cylinder number seven in the Shoreham EDG 103 with a Piezo electric transducer. The Intervenors totally fail to give these measurements the proper credit. The measurements using the quartz Piezo electric tranducer gave the whole pressure trace (Tr. 22,113-15 Pischinger), reporting pressures from 800 individual cycles of the engine as opposed to just the maximum pressure of 1720 psi from one cycle measured by the Kiene guage. (Tr. 22,537 Swanger). The highest peak firing pressure obtained from the

measurements (adjusted for the turbocharger boost) for 250 seconds using the more accurate quartz Piezo electric transducer at 100% load was 1668 psi, and the average value was 1604 psi. (Tr. 22,461-62; 22,534-35 McCarthy). The Piezo tranducer measurements are more accurate than the Kiene guage measurements and nothing in the record contradicts this. The County attempted to discredit the accuracy of the Piezo electric tranducer measurements, but the entire record, and not just the portions extracted by the Intervenors, does not support their attempt

14. In sum, little weight should be given to the County's Lloyd's calculations. These formulas are intended to be used as initial design guidelines. The fact that the crankshafts may not comply with these formulas does not mean the crankshafts are inadequate. The horsepower calculations were developed at a time when engineers did not know how to calculate torsional stresses. (Tr. 24,203-04 Christensen). Cross-examination established that the County's witnesses did not fully understand even the simple Lloyd's horsepower calculations, one of the few they actually performed.

15. An additional reason cited by the County for their belief that compliance with Lloyd's is important is the fact that Lloyd's has a staff of experienced surveyors who inspect

and evaluate engines after they have been in operation. The purpose of these inspections is to ensure continued safe operation. As an example of the type of inspections Lloyd's surveyors are capable of performing, the County's witnesses cited the testing of bottom-end bolts. The testing procedure is to remove the bolts, hang them on a piece of string, give them a blow with a hammer and see if they ring. If the ring is doubtful, the bolt may be tested further. There is, however, no specific rule covering bolt ringing in Lloyd's. (Tr. 24,215-17 Christensen, Eley). Obviously, this type of testing procedure could provide no assurance of the adequacy of any component in the Shoreham EDGs and provides no support for the County's contention.

(b) IACS

16. Joint Proposed Findings 34-38 discuss the crankshafts' alleged non-compliance with the CIMAC rules. These findings should not be adopted because the record demonstrates that the County's witnesses had little or no understanding of the CIMAC rules and their testimony should be entitled to little weight.

17. Joint Proposed Finding 35 correctly states at footnote 10 that the CIMAC rules are based on the conservative assumption that the maximum bending and torsional stresses

occur simultaneously and at the same location. However, when asked if this is what the CIMAC rules said, Professor Christensen said no. When he was shown a copy of the CIMAC rules (County Exhibit 38), he said the translation was poor. (Tr. 24,106-07 Christensen). Furthermore, Professor Christensen did not know "without thinking about it" whether the actual maximum bending and torsional stresses in the Shoreham crankshafts occured simultaneously and at the same location. (Tr. 24,109 Christensen). The uncontradicted evidence showed that the maximum bending and torsional stresses do not occur simultaneously or at the same location. (LILCO Proposed Finding 63).

18. Joint Proposed Finding 36 states that the County reviewed TDI's CIMAC calculations and determined that the replacement crankshafts do not comply with the CIMAC rules. This statement is misleading. Cross-examination of the County's witnesses established that they did little more than check TDI's math. (Tr. 24,138-39 Eley). One of the important inputs to a CIMAC calculation is torsional stress. The County's witnesses made no attempt to check the accuracy of TDI's torsional calculation. (Tr. 24,137-39 Christensen, Eley). Indeed, Mr. Eley freely admitted that he was incapable of calculating torsional vibratory stresses. (Tr. 23,968 Eley). Professor Christensen claimed to be capable of performing forced

torsional vibratory calculations, but admitted he had not performed such calculations for this case. (Tr. 23,965-66 Christensen). When questioned further, Professor Christensen revealed that he did not know how to sum orders or how to calculate the phase relationship between two orders. Indeed, all Professor Christensen knew how to do was a Holzer tabulation. (Tr. 23,965-70 Christensen). The opinion of these witnesses concerning the accuracy of TDI's CIMAC calculation should be given no weight.

19. Joint Proposed Finding 36 also states that the firing pressure of 1720 psi should have been used in the CIMAC calculation, rather than the 1650 psi used by TDI. There is no basis for this statement. For purposes of calculating torsional stress, a representative rather than a maximum peak firing pressure is desired. (LILCO Proposed Finding 57). 1720 psi is not a representative peak firing pressure. (LILCO Reply Findings 11-13). The TDI test logs, which are part of County Exhibit 46, show average peak firing pressures at full load no higher than 1647 psi. The figure of 1650 psi used by TDI was a conservative average.

20. Joint Proposed Findings 37 and 38 discuss an ABS calculation that shows compliance with the CIMAC rules. The Intervenors assert this calculation is insufficient evidence to

support LILCO Proposed Finding 11. The Intervenors' assertion in this regard is entitled to no weight. First, the calculation in question was part of an exhibit offered into evidence by the County. (County Exhibit 43 at 29). Second, the fact that the County's witnesses had not previously reviewed the calculation does not support Joint Proposed Finding 38. Instead, this fact supports a finding that the County's witnesses were ill-prepared, unfamiliar with even their own exhibits and generally uninformed about the areas in which they were offered as expert witnesses.

(c) ABS Rules on Torsional Vibration

21. Joint Proposed Findings 39-50 urge the Board to find that the crankshafts do not comply with the ABS rules on torsional vibration. The Intervenors essentially ask the Board to overrule ABS's approval of the crankshaft and to determine that ABS is incapable of performing its own job. The fact remains, however, that ABS approved the torsional critical speed arrangement of the crankshafts (LILCO Exhibit C-13) and, despite an invitation by counsel for Suffolk County to reconsider (County Exhibit 46), ABS has not withdrawn its approval of the crankshafts. ABS approval on this issue is dispositive.

22. Joint Proposed Finding 40 and 41 state that the Staff and the County both conclude that the torsional stresses

exceed ABS limits. There is no basis for a finding that the torsional stresses in the crankshafts exceed ABS limits. First, the County's witnesses have no ability to calculate torsional stresses (LILCO Reply Finding 18) and were merely inappropriately comparing FaAA's calculations to the ABS limits. Second, both the Staff and County compared a calculation that summed 24 orders. There is no evidence whatsoever that ABS requires or even contemplates a 24 order calculation. Indeed, the only evidence in the record is that ABS sums two orders. (Joint Proposed Finding 41, n. 12). There is no basis for a finding that ABS requires more information concerning torsional stress that was submitted by TDI. The statements by Professor Sarsten in footnote 12 of the Joint Proposed Findings are sheer speculation on his part.

23. Witnesses for both the Staff and County argued that the crankshafts should be evaluated by the rules of various clasification societies. The classification societies are in the best position to interpret their own rules. ABS interpreted its rules to approve the torsional stress levels in the replacement crankshafts. Furthermore, the last sentence in footnote 12 is just plain wrong. The ABS calculations showed that the stresses, as determined by ABS, clearly met the allowable limits of the 1984 rules. (County Exhibit 43 at 26-28).

The stresses did not meet the limits of the 1983 rules. The limits were increased by approximately 400 psi in 1984. The Intervenors' statement in footnote 12 is blatantly misleading.

24. Joint Proposed Findings 42-50 argue that the ABS approval is entitled to no weight because TDI submitted inaccurate information to ABS concerning shotpeening. The Intervenors again distort the record in an attempt to provide a completely one-sided view of the ABS approval. The Intervenors suggest that ABS approved the crankshafts only because TDI attributed a 20% increase in the fatigue life to shotpeening. (See, e.g. Joint Proposed Findings 44, 49). There is however, nothing in the record to support this assertion. The information TDI submitted to ABS is contained in County Exhibit 45. The information includes a torsional analysis by TDI, data concerning the mass elastic system for a number of DSR-48 engines, results of the torsiograph tests on EDG 103 in January, 1984, information on the physical properties of the crankshafts, results of the strain guage tests on EDG 103 and a log of operating hours for other DSR-48 engines. The Intervenors would have the Board believe, incorrectly, that the sole factor that lead to ABS approval was shotpeening. The record supports no such finding.

25. The Intervenors also suggest that ABS would not have attributed a 20% increase in fatigue life to shotpeening were it not for TDI's representation. The Intervenors again fail to reveal facts that do not support their version of events. For example, County Exhibit 43 contains, among others, pages 93, 98 and 99 of the ABS deposition. Page 93 of the deposition contains the statement that ABS accepted TDI's representations concerning shotpeening. The County intentionally excluded pages 94-97 of the ABS deposition from County Exhibit 43. This is not surprising. On page 94 the ABS representatives stated that they had no reason to disagree with the 20% value because that value was established by the literature and ABS had seen that value quoted most often. Indeed, they said some people actually claimed credit for a much higher increase in the fatigue limit as a result of shot peening. In addition, at page 97 the ABS representatives said they had reviewed literature on shotpeening and for that reason did not question the 20% figure reported by TDI. Therefore, contrary to the Intervenors' mischaracterization, ABS gave credit for the shotpeening because ABS believed 20% was a reasonable figure, not because ABS was mislead by TDI.[2/]

2/ LILCO recognizes that pages 94-97 of the ABS deposition are not part of the record and could not be the basis of a

(Continued)

26. It would be entirely inappropriate for the Board to overrule the ABS approval of the replacement crankshafts. The Intervenors argue they are in a better position to interpret and apply the ABS rules than ABS. The record is clear that according to ABS the crankshafts comply with the ABS rules. No further inquiry is necessary or appropriate.

(d) ABS Web Dimensions

27. Joint Proposed Findings 51-55 argue that the replacement crankshafts do not comply with the ABS rules on web dimensions. The record does not support these proposed finding.

28. Joint Proposed Finding 52 discusses Professor Christensen's web calculations. Even his calculation shows compliance with ABS rules at full load. Professor Christensen's web calculations show that the maximum allowable firing pressure at full load is 1746 psi. Even assuming that the correct peak firing pressure at full load is 1720 psi, the crankshafts pass.

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finding by the Board. LILCO merely brings this information to the Board's attention to assist in fairly evaluating the Joint Proposed Findings relating to ABS.

29. Joint Proposed Finding 55 states that there is insufficient evidence to support a finding that ABS has approved the web dimensions of the replacement crankshafts. The fact remains, however, that the testimony of Mr. Montgomery was uncontradicted concerning ABS approval of the web dimensions. (LILCO Proposed Finding 45). Despite the fact that Professor Christensen thinks the webs do not meet ABS rules, ABS has approved the webs.

(e) The Crankshafts are Adequate Under the Kritzer-Stahl Criteria

30. Joint Proposed Findings 56-63 attempt to discredit the analysis performed by Dr. Pischinger under the Kritzer-Stahl criteria. These proposed findings are based on a tortured reading of the record and distort Dr. Pischinger's testimony.

31. Joint Proposed Finding 58 states that the replacement crankshafts are "just on the boundary" of the Kritzer-Stahl criteria at full load. The support for this statement is a reference to Dr. Pischinger's deposition on June 21, 1984. This proposed finding completely ignores Dr. Pischinger's testimony at the hearings. Dr. Pischinger performed additional work after his deposition which allowed him to state unequivocally that the replacement crankshafts have a

factor of safety at full load of 1.24. (Tr. 23,026). The Intervenors simply ignore the further analyses Dr. Pischinger performed. There is no basis for a finding that the crankshafts are "just on the boundary" at full load.

32. Footnote 17 to Joint Proposed Finding 58 and Joint Proposed Finding 63 draw a totally unsupported conclusion concerning the significance of the ultimate tensile strength (U.T.S.) values used by Dr. Pischinger in his calculations. Dr. Pischinger used a U.T.S. value of 700 Newtons per square millimeter in his calculations. The actual U.T.S. for two of the replacement crankshafts is 695 Newtons per square millimeter. Dr. Pischinger contacted Krupp, the manufacturer of the crankshafts, and asked them what U.T.S. value he should use. Krupp supplied 700 Newtons as the appropriate figure. (Tr. 22,993 Pischinger). In addition, the difference between 700 Newtons and 695 Newtons is less than 1% and is not significant. (Tr. 22,993 Pischinger). The Intervenors argue this is unsettling because minor refinements to Dr. Pischinger's calculations can substantially change the results. Dr. Pischinger testified without contradiction, however, that the difference in U.T.S. values was of no significance.

33. Joint Proposed Findings 59 and 60 are merely conclusions that are unsupported by the record.

34. Joint Proposed Finding 62 distorts the record in an attempt to discredit Dr. Pischinger's calculations. The Intervenors argue that if failure is defined as the time a crack initiates, rather than the time a crankshaft severs, Dr. Pischinger's calculations accurately predict the lifetime of the original crankshafts. The results of any calculation may be altered if the assumptions on which the calculation is based are changed. It is clear, however, that all of Dr. Pischinger's calculations, as well as the S-N curve he used, were based on hours of operation until the crankshafts actually severed. (Tr. 22,778, 23,007-08 Pischinger). Dr. Pischinger's calculation of the lifetime of the original crankshaft predicts 150 hours of life at full load until severance. He did not predict 150 hours of life until crack initiation. The original crankshaft on EDG 102 actually operated for 273 hours at full load before it severed, almost twice the life predicted by Dr. Pischinger. (LILCO Proposed Finding 84). The discussion of when failure occurs was totally theoretical. (Tr. 23,008-09 Pischinger). Only by ignoring what Dr. Pischinger actually did and making an entirely unfounded comparison can the Intervenors argue that his calculations do not provide assurance of the adequacy of the replacement crankshafts.

35. Footnote 20 to Joint Proposed Finding 63 completely distorts Dr. Pischinger's testimony concerning the adequacy of the webs of the replacement crankshafts. While the statements attributed to Dr. Pischinger in footnote 20 are correct, the Intervenors fail to mention one critical fact. Although Dr. Pischinger said he might make the webs 1/2 inch thicker if he were designing the crankshafts, this fact had nothing to do with his assessment of the crankshafts under the Kritzer-Stahl criteria or his conclusion that the crankshafts have an adequate safety factor. (Tr. 23,024-25 Pischinger). Web dimensions are merely an input to the Kritzer-Stahl calculations. (Tr. 22,783 Pischinger).

B. DEMA

1. DEMA is an Appropriate Standard

36. Joint Proposed Findings 64-76 present the County's view that DEMA is an inadequate standard by which to judge the adequacy of the replacement crankshafts. For example, Joint Proposed Findings 64, 67, 68, 70 and 76 all conclude, without any transcript citation, that LILCO has failed to establish that DEMA constitutes an acceptable criteria to judge the adequacy of the replacement crankshafts. These proposed findings ignore one critical fact: the adequacy of DEMA as a standard

is not within the scope of the admitted contention. (See Joint Proposed Finding 3). The Intervenors were well aware that the purchase specifications required the diesels to comply with DEMA. (LILCO Proposed Finding 8). At no point, however, did the Intervenors propose a contention that challenged the adequacy of DEMA as a standard. Therefore, LILCO did not have the burden of proving that DEMA was an appropriate standard. LILCO merely had to prove the crankshafts met the DEMA recommendations. The Joint Proposed Findings also ignore the fact that DEMA is the only standard referenced in NRC Reg. Guide 1.9, Rev. 2, which addresses the design of standby diesel generators at nuclear power plants. (See LILCO Proposed Finding 9; Staff Proposed Findings 15-21).

37. Joint Proposed Finding 66 cites only a portion of Dr. Chen's testimony and does not accurately reflect the record.[3/] Dr. Chen specifically stated that while he thought the DEMA rules were older rules and conservative, he did not think they were out-of-date or obsolete. (Tr. 23,015 Chen). In addition, Dr. Chen considers DEMA a valid and reasonable method for evaluating torsional stresses on a crankshaft. (Tr. 23,015-16 Chen).

3/ The selective use of the record by the Intervenors is particularly inappropriate in this instance. While Dr. Chen's early testimony after arriving late on September 17, 1984, was somewhat unclear, he later corrected himself. The Intervenors have chosen to ignore Dr. Chen's corrections.

38. Joint Proposed Finding 67 makes the unsupported leap from the fact that DEMA is not a design code, which LILCO does not dispute (LILCO Proposed Finding 10), to the conclusion that DEMA does not provide standards to measure the adequacy of a crankshaft. Suffolk County, and to some extent the Staff, have lost sight of the fact that the issue in this proceeding is not which organization or society provides the best rules for designing crankshafts. Rather, the issue is whether the existing replacement crankshafts are adequate for their intended service. Therefore, the fact that DEMA cannot be used to design a crankshaft is irrelevant. DEMA can plainly be used to evaluate a crankshaft. (Tr. 23,015 Chen).

39. Joint Proposed Findings 68-75 deal with the question of how the DEMA recommendations should be interpreted. These findings urge, as do Staff Findings 25-28, that the DEMA allowable stresses should be calculated according to the most sophisticated computational techniques, which permit the summation of 24 orders of vibration. These proposed findings are based exclusively on the testimony of Professor Sarsten. The County's witnesses were unable to perform torsional vibration calculations, had no prior experience with DEMA and were able to shed no light whatsoever on this question. (LILCO Reply Finding 18; Tr. 23,975-76 Christensen, Eley).

40. Both the County and the Staff urge the Board to adopt Professor Sarsten's interpretation of DEMA and reject Dr. Chen's interpretation. Professor Sarsten's interpretation of DEMA is entitled to little, if any, weight. Professor Sarsten freely admitted that he had no way of knowing what methodology DEMA intended to be used for the calculation of vibratory stresses. (Tr. 23,239 Sarsten). He had no knowledge of how American diesel manufacturers sum orders for purposes of DEMA compliance or how those firms interpret DEMA. (Tr. 23,246-47, 23,250 Sarsten). Professor Sarsten had no experience with DEMA prior to his invovlvement in this case (Tr. 23,255 Sarsten), he made no inquiry of DEMA members concerning the number of orders typically summed for a DEMA calculation (Tr. 23,254 Sarsten), and he based his interpretation of DEMA solely on his own reading of DEMA. (Tr. 23,247 Sarsten).

41. Dr. Chen, on the other hand, has worked in the American diesel industry since 1952, worked for Fairbanks-Morse (which is a member of DEMA) from 1969-1973, and was chairman of the DEMA Technical Committee from 1971-1973. (Chen, ff Tr. 22,610 at 4, 30; Tr. 22,695). Dr. Chen's testimony was uncontradicted that it is standard practice in the American diesel engine industry to sum only the four or six largest orders of vibration for purposes of comparing stresses against the DEMA allowables. (LILCO Proposed Finding 21).

42. Joint Proposed Finding 68 implies that DEMA is inadequate because it does not specify any method to be used for calculating torsional vibratory stresses. However, it should be noted that of the three classification societies supported by the Intervenors (Lloyd's, ABS and IACS) only the IACS calculation (CIMAC) specifies the number of orders to be used in calculating torsional stress. (Tr. 23,286 Sarsten). Neither ABS nor Lloyd's specifies the number of orders to be used in calculating torsional stress, but rely on the calculations submitted by the manufacturer. (Tr. 23,286 Sarsten).

43. Joint Proposed Finding 69 is riddled with internal inconsistencies. The Intervenors first criticize LILCO for not seeking an interpretation from DEMA. They then criticize DEMA for having no procedure for obtaining an interpretation of the recommendations. If no procedure exists for obtaining an interpretation of DEMA, LILCO can hardly be criticized for failing to seek such an interpretation. Finally, they recognize that Dr. Chen did contact several members of DEMA in formulating his opinions.

44. Joint Proposed Finding 71 and 72 state that calculational methods such as modal superposition have been conventionally used since 1972. This is only partially accurate. Both Professor Sarsten and Dr. Pischinger testified that such

methods were conventional in Europe. (Tr. 23,283-84 Sarsten; Tr. 22,989-90 Pischinger). There was no evidence that such methods were or are conventionally used in the United States.

45. Joint Proposed Finding 72 concludes, totally without support from the record, that DEMA would not continue to publish its recommendations if it did not believe current analytical techniques should be used. There is no basis for this conclusion. Indeed, the only fair conclusion that may be drawn from the record is that analytical techniques similar to those available at the time the DEMA recommendations were adopted should be used for comparison with the DEMA allowables. Witnesses for LILCO, the Staff and the County all testified that prior to the development of digital computers in the mid-1960s it was very difficult to sum more than two or three orders. (Tr. 22,742 Pischinger; Tr. 23,282 Sarsten; Tr. 24,200-04 Christensen). It is uncontradicted that at the time the DEMA torsional vibration limits were established in 1958, the summation of 24 orders was not possible. It is further uncontradicted that DEMA only calls for the summation of "major" orders and that the DEMA stress levels have not changed since 1958. (LILCO Proposed Finding 19). Professor Sarsten's testimony on this matter is entitled to little weight because has has no experience with DEMA. (LILCO Reply Finding 40).

46. Joint Proposed Findings 73-74, and Staff Findings 27-28, state that Professor Sarsten's interpretation of DEMA should be accepted because Dr. Pischinger and FaAA also sum 24 orders. These proposed findings misinterpret the significance of FEV's and FaAA's calculations. First, Joint Proposed Finding 74 distorts Dr. Pischinger's testimony. Dr. Pischinger's statement concerning the number of orders he would sum was made specifically in the context of the calculations he would perform for the Kritzer-Stahl criteria. It was not a general statement concerning all calculations of torsional stress. (Tr. 22,798 Pischinger). Second, both FEV and FaAA calculated torsional stresses using 24 orders to determine an input to a fatigue calculation. Neither FEV nor FaAA were calculating nominal torsional stresses for purposes of comparison to the DEMA limits. Indeed, both Dr. Pischinger and Dr. Johnston stated that they did not believe their 24 order torsional stress calculations should be compared to DEMA. (Tr. 22,801, 22,809 Pischinger; 22,851-53 Johnston). Only Professor Sarsten summed 24 orders solely for the purpose of comparing his results to the DEMA allowables, and even he recognized that his calculation of nominal stresses should more appropriately be used as an input to a factor of safety calculation. (Tr. 23,384 Sarsten).

47. Joint Proposed Finding 75 incorrectly asserts that Dr. Chen stated experts could reasonably disagree over which orders were major. Nowhere on the page of the transcript cited by the Intervenors is there a statement resembling the one attributed to Dr. Chen. In fact, the record reflected that there was remarkable agreement among the experts about what the term major orders meant. (Tr. 23,085-87 Chen, Johnston, Pischinger; Tr. 22,747-50 Chen, Johnston).

2. The Crankshafts Comply with DEMA

48. Joint Proposed Findings 77-85 discuss the torsional calculations performed by various witnesses. The entire discussion in this section is based on the incorrect assumption that the appropriate torsional stress calculation for purposes of comparison with DEMA is one that sums 24 orders.

49. Joint Proposed Finding 77 is a conclusion that is unsupported by any transcript citation.

50. Joint Proposed Finding 79 incorrectly states that the analyses by FaAA and Dr. Pischinger show noncompliance with DEMA. Both Dr. Johnston and Dr. Pischinger specifically stated that it was not appropriate to compare the results of their analyses with DEMA. (Tr. 22,801, 22,809 Pischinger; 22,851-53 Johnston). Nominal torsional stresses exist only hypothetically. The stresses may be computed in different ways for

different purposes. It is appropriate to use a 24 order summation as an input to a fatigue calculation to calculate a safety margin or a true stress, rather than a nominal stress. It is not appropriate to use a 24 order summation to make a comparison with DEMA. The appropriate calculation for a DEMA comparison is a four or six order summation or a reduction of torsiograph test data. (Tr. 22,851 Johnston).

51. Joint Proposed Findings 80 and 81 state that Professor Sarsten's calculations are "the most accurate of the methods used by the expert witnesses in this case." Although the record supports a finding that there are some slight differences in the computational methods and results obtained by the different experts, the record does not support a finding that Professor Sarsten's calculations are "more accurate." (Tr. 23,050-54 Johnston, Pischinger). The Intervenors emphasize the fact that Professor Sarsten's prediction of free end amplitude was in closer agreement with the free end amplitude measured by Stone & Webster than the values calculated by FaAA and Dr. Pischinger. There is no significance to this fact. The test measurements are only accurate to within $\pm$ 5%. (LILCO Exhibit C-16 at 7-3; County Exhibit 49). Professor Sarsten's, FaAA's and Dr. Pischinger's predicted free end values are all within 5% of each other. This fact shows a rather remarkable

agreement among the results and in no manner establishes that one calculation is more accurate than another.

52. The primary basis for the proposed finding that Professor Sarsten's calculations are "more accurate" is that Professor Sarsten used a larger dynamic magnifier in his calculations than did FaAA. However, under cross-examination by the Board, Professor Sarsten was unable to explain why the dynamic magnifier he used (40) more accurately represented the real world condition of the engines than the dynamic magnifier used by FaAA (20). (Tr. 23,437-40 Sarsten). Professor Sarsten also admitted that at the engine speeds in question, the stresses were not very much influenced by the damping. (Tr. 23,440 Sarsten). The question of which method is "more accurate" is largely theoretical. (Tr. 23,441 Sarsten). Professor Sarsten's assertions that in theory his method is more accurate do not support Joint Proposed Findings 80 and 81. Interestingly, the Staff makes no such claims for Professor Sarsten's calculations. (See Staff Proposed Findings 31-33).

53. Footnote 35 in Joint Proposed Finding 81 incorrectly states that FaAA used a one node vibratory form as the basis for calculating stresses. The record is clear that in its modal superposition analysis, which is the calculation being discussed by the Intervenors in Joint Proposed Finding

81, FaAA calculated the multi-modal response of the crankshaft. (Tr. 23,050-53 Johnston). FaAA did assume a one node vibratory form when it converted the torsiograph data into stresses. (LILCO Proposed Findings 38-41). FaAA's torsiograph conversion is not, however, discussed in Joint Proposed Finding 81.

54. Joint Proposed Findings 83-85 state that the stresses calculated by Professor Sarsten, Dr. Pischinger and FaAA are too low, because FaAA's Tn values are too low, because the pressure measurements taken from cylinder No. 7 on EDG 103 are too low. The record supports none of these proposed findings. First, nowhere in the record is there testimony that the stresses should be higher, which is evident from the fact that there is no transcript reference in support of the statement. Second, Professor Sarsten's testimony about alleged inaccuracies in FaAA's Tn values was, like his discussion of damping, largely theoretical. Professor Sarsten could not say with certainty that there was any error in the Tn values, and to the extent there was any error, it was not large and was not significant enough for him to address in his direct testimony. (Tr. 23,412 Sarsten). Further, it was not even possible to calculate what error might exist. (Tr. 23,415 Sarsten). Finally, to the extent there was any error, it was not unacceptable and the Tn values were more accurate than tabulated Tn values.

(Tr. 23,418-19 Sarsten). In sum, there is no evidence to support a finding that FaAA's Tn values are too low. Dr. Pischinger also calculated Tn values from the pressure measurements taken on EDG 103. There was good agreement between Dr. Pischinger's Tn values and FaAA's Tn values. (Tr. 22,811-16 Pischinger).

55. Joint Proposed Finding 85 and footnote 36 assert that the pressure measurements are too low. The accuracy of pressure measurements is a theme repeated frequently by the Intervenors. (See e.g., Joint Proposed Findings 31 n. 8, 36, 49 n. 15 and 52). However, as before, the Intervenors have no evidence to support their assertions. The Intervenors represent that the transducer pressure measurements are too low because the indicated mean effective pressure (IMEP) calculated from the pressures does not correspond to the break mean effective presure (BMEP) of the Shoreham EDGs. The Intervenors cite testimony by Mr. Henriksen to support this idea. Contrary to this implication, however, Dr. Sarsten stated unequivocally just two pages before those cited by the Intervenors that the difference need not be attributed to an error in the maximum firing pressures, but probably was due to the shift in the top dead center, which changes the mechanical efficiency. Moreover, at another point in his testimony, Mr. Henriksen agreed with Dr.

Sarsten that the difference between the IMEP and BMEP was more likely attributable to the top dead center location. (Tr. 23,727-728 Henriksen). The Intervenors, however, do not quote this portion of Mr. Henriksen's testimony and attempt to convey the impression that he attributed the difference in IMEP and BMEP to the fact that the peak firing measurements should be higher. Mr. Henriksen, in fact, made it very clear by his entire testimony that this was not the case. In addition, LILCO Exhibit C-16 (the results of the field test on EDG 103 in January, 1984) contains a detailed discussion of the pressure measurements taken by the Piezo electric transducers and the procedures used to calibrate the transducers. The Intervenors presented absolutely no evidence to show that the transducers were improperly calibrated or that the pressure measurements were too low. Indeed, the County's witnesses did not even know how to calibrate the transducers. (Tr. 24,220-24 Christensen, Eley).

56. The Intervenors state as a fact in footnote 36 that cylinder number 7 was not developing full power when the measurements were taken. There is absolutely no evidence to support this finding. All of Mr. Eley's calculations, which are discussed in footnote 36, were based on the asumption that cylinder number 7 was not developing full power. The

Intervenors attempt to parly Mr. Eley's assumption into a fact. There is, however, no evidence to support Mr. Eley's assumption.

C. FaAA's Fatique Analysis

57. Joint Proposed Findings 86-95 argue that the 1.48 factor of safety calculated by FaAA is insufficient proof that the replacement crankshafts are adequate. There is, however, no evidence in the record that challenges the methods used or the conclusions reached by FaAA in its fatigue analysis. Neither the County nor the Staff presented any evidence challenging the validity of FaAA's fatigue analysis, nor was FaAA's analysis successfully challenged on cross-examination. The Staff agrees that FaAA's analysis is proper and that the factor of safety is accurate. (Staff Proposed Finding 61). FaAA's actual factor of safety for the replacement crankshafts of 1.48 stands uncontradicted.

58. The Intervenors rely almost exclusively on the testimony of Professor Sarsten to support Joint Proposed Findings 86-95. This is not surprising due to the inability of the County's witnesses to evaluate the adequacy of a crankshaft based on a fatigue analysis. For example, Mr. Eley admitted that he was incapable of calculating the actual stresses in the crankshaft fillets. (Tr. 23,847-48 Eley). Professor

Christensen stated that he could calculate the stresses in the fillets. He then described his method, which was a simplification that actually eliminated the fillets. (Tr. 23,848-49 Christensen). In addition, the County's witnesses did not have sufficient training or experience to evaluate the test data taken from EDG 103. Neither of the County's witnesses knew the degree of accuracy of pressure measurements taken by Piezo electric transducers. (Tr. 24,220-24 Christensen, Eley). Professor Christensen believed that a crack of several microns in the replacement crankshafts would propagate. However, he was unable to describe the stress field such a crack would need in order to propagate nor had he performed any calculations to show that such a crack would propagate. (Tr. 24,224-25 Christensen).

59. Notwithstanding Professor Sarsten's [illegible]ious ability to evaluate FaAA's fatigue analysis, he did not do so. Professor Sarsten had no opinion about the adequacy of the replacement crankshafts because he made no attempt to determine whether the crankshafts were adequate. (Tr. 23,352-53, 23,383-84 Sarsten). Indeed, Professor Sarsten stated that his only concern was whether the nominal torsional stresses exceeded 7000 psi. (Tr. 23,352-53 Sarsten). He did not review the results of the tests on EDG 103 and he made no calculations

of the stresses in the original 13 inch x 11 inch crankshafts for purposes of comparison with the replacement crankshafts. (Tr. 23,385, 23,389 Sarsten). Professor Sarsten admitted that the calculation of torsional stress was merely one of the inputs required to evaluate the adequacy of the crankshafts. (Tr. 23,384 Sarsten).

60. Joint Proposed Finding 89 states that FaAA's factor of safety is not sufficient proof that the replacement crankshafts are adequate. The record does not support this proposed finding. Professor Sarsten's opinion (upon which this proposed fining is premised) is not based upon any criticism of FaAA's methods or conclusions. (See Staff Proposed Finding 61). Rather, it is simply based on the fact that Professor Sarsten wants to see the crankshafts tested for 10^7 cycles, and feels more comfortable with classification societies' guidelines. (Tr. 23,528-29 Sarsten).

61. The record is uncontradicted, however, that the degree of knowledge about the replacement crankshafts is more than sufficient to provide confidence in FaAA's fatigue analysis. Dr. McCarthy testified that FaAA had more knowledge about the design of the replacement crankshafts than any other part he had ever confronted in his entire professional experience, and he did not expect to have this kind of information again for a long, long time. (Tr. 23,027 McCarthy).

62. Furthermore, Joint Proposed Finding 89 incorrectly suggests that FaAA's approach to analyzing the crankshaft was solely to compare a calculated endurance limit with the measured stresses. First, FaAA did not calculate the endurance limit of the replacement crankshafts in the sense suggested by the Intervenors. The actual endurance limit was established by tests and analyses of the original and replacement crankshafts. (LILCO Proposed Findings 69-71). Second, FaAA's assessment of the crankshaft was based upon a three-tiered approach of testing, inspections and analyses, all of which confirmed that the replacement crankshafts were adequate. (See LILCO Proposed Findings 49-81).

63. Joint Proposed Finding 91 incorrectly attempts to compare the actual endurance limit determined by FaAA with the endurance limit calculated by Dr. Pischinger. The Intervenors imply that FaAA should have used Dr. Pischinger's endurance limit in its fatigue analysis. It would be totally improper, however, to use an endurance limit that was calculated according to a specific criteria (Kritzer-Stahl) in a fatigue analysis that is based upon actual tests and measurements. Dr. Pischinger specifically noted that the Kritzer-Stahl criteria was extremely accurate at predicting stresses because the predicted stresses were very close to the actual measured

stresses. (Tr. 23,006 Pischinger). Dr. Pischinger believed, however, that the endurance limit calculated by the Kritzer-Stahl criteria was extremely conservative and was too low. (Tr. 23,005-07, 23,045-46 Pischinger). There is no evidence to indicate that the actual endurance limit determined by FaAA is inaccurate.

64. Joint Proposed Findings 92 and 93 discuss the forging process of the crankshafts. There is no evidence that the factor of safety determined by FaAA is effected in any manner by the facts discussed in Joint Proposed Findings 92 and 93.

65. Joint Proposed Finding 94 discusses the various safety factors that have been calculated for the replacement crankshafts. It is significant to note that of the ten safety factor calculations made for these crankshafts (seven by ABS, one by TDI, one by Dr. Pischinger and one by FaAA), none yield a factor of safety of less than 1.0. (County Exhibit 39 at 6; County Exhibit 43 at 29, 32; LILCO Proposed Findings 72 and 87). Of tnese ten, only two are below 1.1, and only three are below 1.15. (County Exhibit 39 at 6; County Exhibit 43 and 32). Six of the safety factors exceed 1.22 and four exceed 1.3. (County Exhibit 43 at 32; LILCO Proposed Findings 72 and 87). Dr. Pischinger testified that an accepted range of safety

factors was between 1.15 and 1.3. (LILCO Proposed Finding 89). Professor Sarsten testified that a factor of safety of 1.1 was adequate under certain circumstances. (Tr. 23,509 Sarsten).

66. FaAA determined that the actual factor of safety for the replacement crankshafts was 1.48. This factor of safety was not based upon a predetermined criteria. It was based upon an extensive engineering analysis to determine a true margin of safety. There is more than adequate assurance that the replacement crankshafts are adequate for their intended service.

D. Shotpeening

67. Joint Proposed Findings 96-106 discuss the issue of shotpeening. It is apparent from the proposed findings that the Intervenors have abandoned their contention that the original shotpeening damaged the crankshafts. (See Joint Proposed Findings 3, 106 n. 41). The Intervenors now merely argue that it is impossible to precisely quantify the increase in the fatigue endurance limit attributable to shotpeening. Because the Intervenors have abandoned their shotpeening contention, LILCO will not specifically address Joint Proposed Findings 96-106. However, this should not be interpreted to mean that LILCO agrees with Joint Proposed Findings 95-106. The record supports a finding that shotpeening increased the fatigue

endurance limit by ten percent (10%) to twenty percent (20%). (LILCO Proposed Finding 109).

Respectfully Submitted,

LONG ISLAND LIGHTING COMPANY

BY David Dreifus /ecg
Counsel

E. Milton Farley, III
John Jay Range
Hunton & Williams
2000 Pennsylvania Ave., N.W.
P. O. Box 19230
Washington, D.C. 20036

T. S. Ellis, III
Anthony F. Earley, Jr.
Hunton & Williams
707 East Main Street
P. O. Box 1535
Richmond, Virginia 23212

Odes L. Stroupe, Jr.
David Dreifus
Hunton & Williams
333 Fayetteville Street
P. O. Box 109
Raleigh, North Carolina 27602

DATED: December 3, 1984

WITNESSES IN ALPHABETICAL ORDER

Witness	Following Transcript Page
Anderson, Robert N.	23,826
"Joint Direct Testimony of Dr. Robert N. Anderson, Professor Stanley G. Christensen, G. Dennis Eley, Dale G. Bridenbaugh and Richard B. Hubbard regarding Suffolk County's Emergency Diesel Generator Contentions"	
Bridenbaugh, Dale G.	23,826
"Joint Direct Testimony of Dr. Robert N. Anderson, Professor Stanley G. Christensen, G. Dennis Eley, Dale G. Bridenbaugh and Richard B. Hubbard regarding Suffolk County's Emergency Diesel Generator Contentions"	
Burrell, N. Ken	23,122
"Testimony of Clifford H. Wells, Duane P. Johnson, Harry F. Wachob, Craig Seaman, Dominic Cimino and N. Ken Burrell on behalf of Long Island Lighting Company Concerning Shotpeening of the Replacement Crankshafts"	
Bush, Spencer H.	23,126
"Joint Testimony of Carl H. Berlinger, Spencer H. Bush, Adam J. Henriksen, Walter W. Laity, and Professor Arthur Sarsten on Contentions Concerning TDI Emergency Diesel Generators at the Shoreham Nuclear Power Station"	

Witness	Following Transcript Page
Chen, Simon K.	22,610
"Testimony of Roger L. McCarthy, Paul R. Johnston, Eugene F. Montgomery and Simon K. Chen on behalf of Long Island Lighting Company on Suffolk County's Contention Regarding Replacement Crankshafts on Diesel Generators at Shoreham"	
Christensen, Stanley G.	23,826
"Joint Direct Testimony of Dr. Robert N. Anderson, Professor Stanley G. Christensen, G. Dennis Eley, Dale G. Bridenbaugh and Richard B. Hubbard regarding Suffolk County's Emergency Diesel Generator Contentions"	
Cimino, Dominic	23,122
"Testimony of Clifford H. Wells, Duane P. Johnson, Harry F. Wachob, Craig Seaman, Dominic Cimino and N. Ken Burrell on behalf of Long Island Lighting Company Concerning Shotpeening of the Replacement Crankshafts"	
Eley, G. Dennis	23,826
"Joint Direct Testimony of Dr. Robert N. Anderson, Professor Stanley G. Christensen, G. Dennis Eley, Dale G. Bridenbaugh and Richard B. Hubbard regarding Suffolk County's Emergency Diesel Generator Contentions"	

Witness	Following Transcript Page
Henriksen, Adam J.	23,126
"Joint Testimony of Carl H. Berlinger, Spencer H. Bush, Adam J. Henriksen, Walter W. Laity, and Professor Arthur Sarsten on Contentions Concerning TDI Emergency Diesel Generators at the Shoreham Nuclear Po er Station"	
Hubbard, Richard B.	23,826
"Joint Direct Testimony of Dr. Robert N. Anderson, Professor Stanley G. Christensen, G. Dennis Eley, Dale G. Bridenbaugh and Richard B. Hubbard regarding Suffolk County's Emergency Diesel Generator Contentions"	
Johnson, Duane P.	23,122
"Testimony of Clifford H. Wells, Duane P. Johnson, Harry F. Wachob, Craig Seaman, Dominic Cimino and N. Ken Burrell on behalf of Long Island Lighting Company Concerning Shotpeening of the Replacement Crankshafts"	
Johnston, Paul R.	22,610
"Testimony of Roger L. McCarthy, Paul R. Johnston, Eugene F. Montgomery and Simon K. Chen on behalf of Long Island Lighting Company on Suffolk County's Contention Regarding Replacement Crankshafts on Diesel Generators at Shoreham"	

Witness	Following Transcript Page
McCarthy, Roger L.	22,610
"Testimony of Roger L. McCarthy, Paul R. Johnston, Eugene F. Montgomery and Simon K. Chen on behalf of Long Island Lighting Company on Suffolk County's Contention Regarding Replacement Crankshafts on Diesel Generators at Shoreham"	
Montgomery, Eugene F.	22,610
"Testimony of Roger L. McCarthy, Paul R. Johnston, Eugene F. Montgomery and Simon K. Chen on behalf of Long Island Lighting Company on Suffolk County's Contention Regarding Replacement Crankshafts on Diesel Generators at Shoreham"	
Pischinger, Franz F.	22,610
"Testimony of Edward J. Youngling and Franz F. Pischinger on behalf of Long Island Lighting Company on Suffolk County's Contention Regarding Replacement Crankshafts on Diesel Generators at Shoreham"	
Sarsten, Arthur	23,126
"Joint Testimony of Carl H. Berlinger, Spencer H. Bush, Adam J. Henriksen, Walter W. Laity, and Professor Arthur Sarsten on Contentions Concerning TDI Emergency Diesel	

Witness	Following Transcript Page
Generators at the Shoreham Nuclear Power Station"	
Seaman, Craig	23,122
"Testimony of Clifford H. Wells, Duane P. Johnson, Harry F. Wachob, Craig Seaman, Dominic Cimino and N. Ken Burrell on behalf of Long Island Lighting Company Concerning Shotpeening of the Replacement Crankshafts"	
Wachob, Harry F.	23,122
"Testimony of Clifford H. Wells, Duane P. Johnson, Harry F. Wachob, Craig Seaman, Dominic Cimino and N. Ken Burrell on behalf of Long Island Lighting Company Concerning Shotpeening of the Replacement Crankshafts"	
Wells, Clifford H.	23,122
"Testimony of Clifford H. Wells, Duane P. Johnson, Harry F. Wachob, Craig Seaman, Dominic Cimino and N. Ken Burrell on behalf of Long Island Lighting Company Concerning Shotpeening of the Replacement Crankshafts"	

Witness	Following Transcript Page
Youngling, Edward J.	22,610
"Testimony of Edward J. Youngling and Franz F. Pischinger on behalf of Long Island Lighting Company on Suffolk County's Contention Regarding Replacement Crankshafts on Diesel Generators at Shoreham"	

SEQUENCE OF CRANKSHAFT TESTIMONY

Witness (Party)	Date	Transcript Page Where Witness Sworn
Chen (LILCO)	9/17/84	22.664
Johnston (LILCO)	9/17/84	22,605
Montgomery (LILCO)	9/17/84	22,605
McCarthy (LILCO)	9/17/84	22,605
Pischinger (LILCO)	9/17/84	22,605
Youngling (LILCO)	9/17/84	22,605
Burrell (LILCO)	9/20/84	23,118
Cimino (LILCO)	9/20/84	23,118
Johnson (LILCO)	9/20/84	23,118
Seaman (LILCO)	9/20/84	23,118
Wachob (LILCO)	9/20/84	23,118
Wells (LILCO)	9/20/84	23,118
Bush (NRC)	9/20/84	23,118
Henriksen (NRC)	9/24/84	23,234
Sarsten (NRC)	9/24/84	23,234
Anderson (SC)	10/1/84	23,812
Bridenbaugh (SC)	10/1/84	23,812
Christensen (SC)	10/1/84	23,812
Eley (SC)	10/1/84	23,812
Hubbard (SC)	10/1/84	23,812

EXHIBITS BY PARTY AND NUMBER

Exhibit Number	Description	Identified at Transcript Page	Admitted at Transcript Page
LILCO Ex. C-1	Evaluation of Emergency Diesel Generator Crankshafts at Shoreham and Grand Gulf Nuclear Power Stations prepared for TDI Diesel Generator Owners Group dated May 22, 1984 (hereinafter "Owners Group Crankshaft Report"), Figure 3-4.	22,610	22 610
LILCO Ex. C-2	Specification for Diesel Generator Sets, Shoreham Nuclear Power Station - Unit 1, Spec. No. SH1-89, Revision 2, January 26, 1983, page 1-20.	22,610	22,610
LILCO Ex. C-3	U.S. Nuclear Regulatory Commission Regulatory Guide 1.9, Revision 2, December 1979.	22,610	22,610
LILCO Ex. C-4	IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations, Std 387-1977.	22,610	22,610

Exhibit Number	Description	Identified at Transcript Page	Admitted at Transcript Page
LILCO Ex. C-5	Transcript of July 11, 1984 meeting of the TDI Diesel Generator Owners Group, pages 124-25.	22,610	22,610
LILCO Ex. C-6	Available Logged Hours of Operation of DSR-48, Rated 3500 KW at 450 RPM.	22,610	22,673 (Rejected)
LILCO Ex. C-7	TDI Diesel Generator Run History - Shoreham Nuclear Power Station - Unit 1 - August 6, 1984.	22,610	22,610
LILCO Ex. C-8	Results of non-destructive examinations of replacement crankshafts at Shoreham after 100 hours of operation at full load or greater.	22,610	22,610
LILCO Ex. C-9	American Bureau of Shipping, Rules for Building and Classing Steel Vessels (1983), § 37.17.1.	22,610	22,610
LILCC Ex. C-10	American Bureau of Shipping, Rules for Building and Classing Steel Vessels (1983), Table 34.3.	22,610	22,610

Exhibit Number	Description	Identified at Transcript Page	Admitted at Transcript Page
LILCO Ex. C-11	TDI Crankshaft Drawing Number 03-310-05-AC.	Withdrawn	
LILCO Ex. C-12	American Bureau of Shipping Reports on Castings or Forgings of Replacement Crankshafts.	22,610	22,610
LILCO Ex. C-13	American Bureau of Shipping letter to TDI dated May 3, 1984.	22,610	22,610
LILCO EX. C-14	Diesel Engine Manufacturers Association Standard Practices for Low and Medium Speed Stationary Diesel and Gas Engines (1972 ed.), pages 53-56.	22,610	22,610
LILCO Ex. C-15	TDI Proposed Torsional and Lateral Critical Speed Analysis, August 22, 1983.	22,610	22,610
LILCO Ex. C-16	Field Test of Emergency Diesel Generator 103 with 13 x 12 Crankshaft, April, 1984.	22,610	22,610

Exhibit Number	Description	Identified at Transcript Page	Admitted at Transcript Page
LILCO Ex. C-17	Owners Group Crankshaft Report.	22,610	22,610
LILCO Ex. C-18	Crankshaft Torsional Stress Calculations for 8L 17 x 21 Engine-Generator Set, July 19, 1984.	22,610	22,610
LILCO Ex. C-19	Table 2.2 from Owners Group Crankshaft Report showing natural frequencies from TDI analysis.	22,610	22,610
LILCO Ex. C-20	Table 2.4 from Owners Group Crankshaft Report showing single order nominal stresses from TDI analysis.	22,610	22,610
LILCO Ex. C-21	Table 2.5 from Owners Group Crankshaft Report showing nominal stresses calculated from torsiograph.	22,610	22,610
LILCO Ex. C-22	Crankshaft Torsional Stress Calculations for 8L 17 x 21 Engine-Generator Set, July 19, 1984, page 11.	22,610	22,610

Exhibit Number	Description	Identified at Transcript Page	Admitted at Transcript Page
LILCO Ex. C-23	Figure 3-3 from Owners Group Report showing comparison of measured and calculated torque.	22,610	22,610
LILCO Ex. C-24	Tables 3.6 and 3.7 from Owners Group Crankshaft Report showing comparison between analytical and test results.	22,610	22,610
LILCO Ex. C-25	Figure 3-13 from Owners Group Crankshaft Report showing fatigue endurance limit of replacement crankshafts on Goodman diagram.	22,610	22,610
LILCO Ex. C-26	Oberg and Jones, Machinery's Handbook (18th Ed.) pages 352-53; Shigley, Mechanical Engineering Design (McGraw-Hill) pages 212-13; Rothbart (editor), Mechanical Design and Systems Handbook (McGraw-Hill) page 18-4.	22,610	22,610
LILCO Ex. C-27	Engineering and Design Coordination Report No. F-46109G.	23,121	23,122

Exhibit Number	Description	Identified at Transcript Page	Admitted at Transcript Page
LILCO Ex. C-28	Military Specification No. 13165B, Amendment 2, June 25, 1979.	23,121	23,122
LILCO Ex. C-29	LILCO Operational Quality Assurance Reports (EDG 102 and 103 Crankshafts).	23,121	23,122
LILCO Ex. C-30	Metal Improvement Company Certificate of Shot Peening (EDG 102 and 103 Crank-shafts).	23,121	23,122
LILCO Ex. C-31	Certificate of Non-Destructive Testing Issued by Krupp Stahl AG (EDG 102 and 103 Crankshafts).	23,121	23,122
LILCO Ex. C-32	LILCO Magnetic Particle Testing and Liquid Penetrant Testing Records (EDG 102 and 103 Crank-shafts).	23,121	23,122
LILCO Ex. C-33	LILCO Ultra Sonic Test-ing Records (EDG 102 and 103 Crankshafts).	23,121	23,122

Exhibit Number	Description	Identified at Transcript Page	Admitted at Transcript Page
LILCO Ex. C-34	H. Fuchs and R. Stevens, Metal Fatique in Engineering (1980) at pages 226-227; H. Uhlig, Corrosion and Corrosion Control at pages 132-133.	23,121	23,122
LILCO Ex. C-35	Metal Improvement Company Certificate of Shot Peening (EDG 101 Crankshaft).	23,121	23,122
LILCO Ex. C-36	LILCO Operational Quality Assurance Reports (EDG 101 Crankshaft).	23,121	23,122
LILCO Ex. C-37	Certificates of Non-Destructive Testing Issued by Krupp Stahl AG (EDG 101 Crankshaft).	23,121	23,122
LILCO Ex. C-38	LILCO Magnetic Particle Testing, Liquid Penetrant Testing and Ultra Sonic Testing Records (EDG 101 Crankshaft).	23,121	23,122

Exhibit Number	Description	Identified at Transcript Page	Admitted at Transcript Page
LILCO Ex. C-39	Kirk, Behavior of Peen-Formed Steel Strip on Isochronal Annealing, Proceedings of the Second International Conference on Shot Peening at page 231, (May, 1984).	23,121	23,122
LILCO Ex. C-40	Pages 70 and 71 from the May 10, 1984 Deposition of Dr. Robert N. Anderson	23,881	24,333
LILCO Ex. C-41	Rules and Regulations for the Classification of Ships, Lloyd's Register of Shipping, Part 5, Chapter 2 (July, 1982) and Part 5, Chapter 1 (January, 1983)	24,010	24,333
LILCO Ex. C-42	Pages 129 and 130 from the July 18, 1984 Deposition of Woytowich, Blanding and Giuffra (ABS)	24,143	24,333
Staff Ex. 1	PNL Evaluation of Crankshaft Dimensions	23,236	23,236 (Bound in)

Exhibit Number	Description	Identified at Transcript Page	Admitted at Transcript Page
Staff Ex. 2	PNL Analysis of Torsional Stresses for Sum of 24 Orders of Vibration	23,236	23,236 (Bound in)
Staff Ex. 3	PNL Analysis of Stress Levels for Single Orders	23,236	23,236 (Bound in)
Staff Ex. 4	American Bureau of Shipping letter to TDI dated May 3, 1984	23,236	23,236 (Bound in)
Staff Ex. 5	Kohls, et al., Effects of Multiple Shot-Peening/ Cadmium-Plating Cycles on High-Strength Steel	23,124	23,128 (Bound in)
County Ex. 7	Design Review of TDI R-4 and RV-4 Series Emergency Generator Cylinder Blocks and Liners, June 1984	23,824	23,827
County Ex. 10	Deposition testimony of Gerald Edgar Trussell, pages 62, 45-48, 107, 111-113	23,824	23,827
County Ex. 24	Deposition testimony of Maurice H. Lowrey, dated May 10, 1984, pages 1, 15-16, 62	23,824	23,827

Exhibit Number	Description	Identified at Transcript Page	Admitted at Transcript Page
County Ex. 35	Board Notification 84-101; Evaluation of Diesel Generator Failure at Shoreham Unit 1, Franklin Research Center, pages 1-6, 33-34, 59-62, 63-68	23,824	23,827
County Ex. 36	Calculations for 12" x 13" Crankshafts under Lloyd's Register Rules by Professor Christensen	23,824	23,827
County Ex. 37	Calculations for 12" x 13" Crankshafts under Lloyd's Register Rules by Mr. Eley	23,824	23,827
County Ex. 38	IACS-CIMAC Rules for the Calculation of Crankshafts for Diesel Engines	23,824	23,827
County Ex. 39	TDI Calculations under IACS-CIMAC Rules on R-48 Crankshaft	23,824	23,827
County Ex. 40	Calculations under ABS Rules for Crankshafts with Solid Webs, by Professor Christensen	23,824	23,827
County Ex. 41	Deposition testimony of Franz F. Pischinger, dated June 21, 1984, pages 1, 94, 97-98, 100-101, 108, 110, 185-187	23,824	23,827

Exhibit Number	Description	Identified at Transcript Page	Admitted at Transcript Page
County Ex. 43	Deposition testimony of Messrs. Woytowich, Blanding and Giuffra (ABS), dated July 18, 1984, pages 1, 80-81, 93, 98-99, 112, 163-165, 167-168 and exhibit 3 to the deposition	23,824	23,827
County Ex. 44	May 3, 1984 letter from ABS to TDI	23,824	23,827
County Ex. 45	TDI submission to ABS entitled "Report on Crankshaft Torsional Stresses, Transamerica Delaval Model DRS-48, Serial No. 74010/12 for Long Island Lighting Company, by Roland Yang, April 4, 1984	23,824	23,827
County Ex. 46	July 25, 1984 letter to Howard C. Blanding (ABS) from Alan Roy Dynner, and documents 1-12 attached	23,824	23,827
County Ex. 47	ABS Check Calculations (Exhibit 3 to ABS deposition) dated July 18, 1984	23,824	23,827
County Ex. 48	Letter dated February 17, 1984 to Gregory M. Beshouri (TDI) from Shinpei Denoh (Kobe Steel Ltd.)	23,824	23,827

Exhibit Number	Description	Identified at Transcript Page	Admitted at Transcript Page
County Ex. 49	Field Test of Emergency Diesel Generator 103 With 13 x 12 Crankshaft, April 1984, pages 1 and 7-3	23,824	23,827
County Ex. 50	Field Test of Emergency Diesel Generator 101, October 1983, pages 1 and 7-2	23,824	23,827
County Ex. 51	Stone & Webster Engineering Corporation Engineering & Design Coordination Report No. F-46109G	23,824	23,827
County Ex. 52	Deposition testimony of Paul R. Johnston, May 9, 1984, pages 1, 39-40	23,824	23,827
County Ex. 53	Stone & Webster Engineering Corporation Interoffice Memorandum dated September 20, 1983.	23,824	23,827
County Ex. 72	Deposition testimony of Messrs. Woytowich, Blanding and Giuffra (ABS) dated July 18, 1984, pages 114-130	24,272-74	24,333

LILCO, December 3, 1984

CERTIFICATE OF SERVICE

In the Matter of
LONG ISLAND LIGHTING COMPANY
(Shoreham Nuclear Power Station, Unit 1)
Docket No. 50-322 (OL)

I hereby certify that copies of LILCO'S REPLY TO SUFFOLK COUNTY AND STATE OF NEW YORK PROPOSED FINDINGS OF FACT were served this date upon the following by first-class mail, postage prepaid, or (as indicated by asterisk) by hand.

Judge Lawrence Brenner, Esq.*
Chairman
Atomic Safety and Licensing
Board, United States
Nuclear Regulatory Commission
4350 East-West Highway
Fourth Floor (North Tower)
Bethesda, Maryland 20814

Dr. Peter A. Morris*
Administrative Judge
Atomic Safety and Licensing
Board, United States
Nuclear Regulatory Commission
4350 East-West Highway
Fourth Floor (North Tower)
Bethesda, Maryland 20814

Dr. George A. Ferguson*
Administrative Judge
Atomic Safety and Licensing
Board Panel
School of Engineering
Howard University
2300 6th Street, N.W.
Washington, D.C. 20059

Atomic Safety and Licensing
Appeal Board Panel
U.S. Nuclear Regulatory
Commission
Washington, D.C. 20555

Martin Bradley Ashare, Esq.
Att: Patricia A. Dempsey, Esq.
County Attorney
Suffolk County Dept. of Law
Veterans Memorial Highway
Hauppauge, New York 11787

Richard J. Goodard, Esq.*
Office of the Executive
Legal Director
U.S. Nuclear Regulatory
Commission
7735 Old Georgetown Road
Bethesda, Maryland 20814

Alan Roy Dynner, Esq.*
Kirkpatrick, Lockhart,
Hill, Christopher &
Phillips
1900 M. Street, N.W.
8th Floor
Washington, D.C. 20036

Secretary of Commission*
U.S. Nuclear Regulatory
Commission
Washington, D.C. 20555

MHB Technical Associates
1723 Hamilton Avenue
Suite K
San Jose, California 95125

Mr. Jay Dunkleberger
New York State Energy Office
Agency Building 2
Empire State Building
Albany, New York 12223

Stephen B. Latham, Esq.
Twomey, Latham & Shea
33 West Second Street
P. O. Box 398
Riverhead, New York 11901

James B. Dougherty, Esq.
3045 Porter Street
Washington, D.C. 20008

Ralph Shapiro, Esq.
Cammer and Shapiro, P.C.
9 East 40th Street
New York, New York 10016

Mr. March W. Goldsmith
Energy Research Group
4001 Totten Pond Road
Waltham, Massachusetts 02154

Fabian G. Palomino, Esq.
Special Counsel to the
Governor
Executive Chamber, Rm 229
State Capitol
Albany, New York 12224

Jonathan D. Feinberg, Esq.
New York State
Depart. of Public Service
Three Empire State Plaza
Albany, New York 12223

Robert E. Smith, Esq.
Guggenheimer & Untermyer
80 Pine Street
New York, New York 10005

Howard L. Blau
217 Newbridge Road
Hicksville, New York 11801

David Dreifus /mcj

HUNTON & WILLIAMS
P. O. Box 109
Raleigh, North Carolina 27602

DATED: December 3, 1984