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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)	)	

LONG ISLAND LIGHTING COMPANY'S REPLY FINDINGS OF FACT CONCERNING EMERGENCY DIESEL GENERATOR CONTENTIONS

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LILCO'S DIESEL GENERATOR REPLY FINDINGS 1/

RL-1. SC L-5 misrepresents the record. SC wants the Board to find that the Shoreham testing does not demonstrate the capability to handle loads greater than the qualified load. This is an unjustified inference from testimony by Dr. Berlinger in which he simply stated that operation at a specific load for 10E7 cycles would not allow the assumption of an overload rating greater than that load. Tr. 27989 (Berlinger). SC ignores additional testimony by Dr. Berlinger that during the 10E7 cycle confirmatory test at Shoreham, the diesel generator was run at loads exceeding the qualified load and this operation can be used to demonstrate its capability beyond the qualified load. Tr. 27999-28000, 28011, 28204-05 (Berlinger); LILCO L-58.

RL-2. SC L-6 and -8 are misleading in suggesting MESL loads are not known with sufficient precision. SC ignores the record which demonstrates that a significant portion of the load on each EDG has been measured, and the remaining loads with one exception are small loads. Compare LILCO L-9 to -11 with SC L-6 and -8. Significantly, SC's consultant conceded that no problems had been identified for any of the individual loads measured by LILCO. Tr. 27575 (Bridenbaugh). Further, cumulative load on each EDG has been demonstrated by the integrated electrical test. LILCO L-29 to -34.

RL-3. Numerous misrepresentations and errors exist in SC's findings alleging inaccuracies in estimating the MESLs. Contrary to SC L-8, loads measured as input to the MESL calculation were measured with a meter having an accuracy of approximately ± 1%, not ± 2.5%. Tr. 27214 (Youngling). 2/ SC L-9 states that

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1/ For convenience, these Reply Findings refer only to Suffolk County (SC) in discussing evidence, positions and findings jointly sponsored by SC and New York State. Also for convenience, SC findings are referred to by the prefixes "SC L-___," "SC B-___" and "SC C-___" for load, block and crankshaft findings, respectively. LILCO's Reply Findings are prefixed "RL-___," "RB-___" and "RC-___" for load, block and crankshaft findings, respectively.

2/ SC's own findings are inconsistent on this point. SC L-9 n.7 contradicts, and demonstrates the inaccuracy of, SC L-8 in this regard. Thus, n.7 states

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operation of equipment with a complicated system such as an EDG increases opportunity for error in nameplate ratings, but the testimony cited is not related to the EDG. It discusses parameters of fluid systems such as pressure drop and flow.3/ Tr. 27606-07 (Bridenbaugh). SC L-10 states LILCO relies primarily on its measurement of loads to find that nameplates are more accurate than ± 5%, but LILCO's testimony was that this was but one positive observation. Tr. 27214-16 (Youngling). More importantly, SC L-8, -9 and -10 ignore the record on design conservatisms which result in conservative component nameplate ratings. LILCO L-14. SC L-10 asserts that the use of measured loads to establish diesel generator loading is contrary to industry practice, but ignores evidence that the Staff concurs with LILCO that combining measured and nameplate loads is an appropriate methodology. Tr. 27795-96 (Knox); LILCO L-10.

RL-4. SC L-12 misrepresents the record. Contrary to SC L-12, LILCO clearly explained that a conservatism in the MESL calculation was the assumption of simultaneous operation of all those loads, i.e., those identified in FSAR

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that the MESLs could be increased approximately 11 KW or 22 KW due to instrument error effect on measured loads. These values represent approximately 1% of the measured load in the MESL, and could not increase an MESL above the qualified load. LILCO L-12.

3/ Several SC findings address matters contained in excluded sections (a)(v) and (a)(vi) of the SC load contention. Memorandum and Order Ruling on Admissibility of EDG Load Contention, January 18, 1985. For example, SC L-4 and -7 attack the MESLs as nonconservative for unspecified reasons beyond intermittent/cyclic loads and operator error loads. SC L-8 similarly attacks the accuracy of nameplate ratings used in the MESL. These unspecified nonconservatisms seem to be further identified by SC L-9 which discusses modeling questions (e.g., system complications, voltage variations). These areas were specifically excluded by the Board from the scope of the contention, which focuses solely on whether the qualified load is adequate in view of intermittent/cyclic loads, instrument accuracy, the ± 100 test band and operator error load. Particularly flawed is SC's discussion in SC L-9 n.7 of conditions and adjustments during load measurements. Indeed, the record demonstrates that the service water pump load was not measured, and that the system configuration in question would not have significantly affected pump load in any event. Compare Tr. 27221-24 (Dawe) with Bridenbaugh and Minor, ff. Tr. 27500, at 18-19.

Table 8.3.1-1A, that are included in the MESL. LILCO did not testify that any other equipment was included in either the MESL or the explanation of this conservatism. Dawe et al., ff. Tr. 27153, at 9, 19; LILCO L-13, -18, -19. Given the definition of the MESL, exclusion of intermittent/cyclic loads has no bearing on the conservatism in the MESL which results from the assumption of simultaneous operation of all MESL equipment.

RL-5. SC L-11, -13 and -14 inaccurately reflect the record by asserting that the IET does not support the conclusion that the MESLs are conservative.4/ It does. The LILCO witnesses explained, in detail, MESL conservatisms that accounted for a large portion of the differences between IET results and the calculated MESL values. LILCO L-29, -33, -34. SC L-13 emphasizes Dr. Berlinger's recollection of conversations with LILCO personnel, but incorrectly characterizes the record. A fair reading of the record indicates that he had not conducted a detailed review of the IET, he did not need to rely on it, and he believed the IET was a better estimate of loads than the MESL. Further, Dr. Berlinger agreed that in response to his inquiry as to whether the IET should be used to define the MESL, LILCO's position was that the IET was a reasonable estimate of EDG load following a LOOP/LOCA, but it was better practice to calculate the MESLs from measured and nameplate values. We agree with Dr. Berlinger that the MESL calculation was conservative.5/ Tr. 28155-56, 28272-73

4/ Staff L-22 adopts the position that there is no need to rely on the results of the IET to evaluate the MESLs. In asserting this position, Staff L-22 contains errors similar to those found in SC L-11, -13 and -14. Thus, RL-5 applies to Staff L-22 as well. In any event, Staff L-22 notwithstanding, the Staff concludes the MESLs are conservative. E.g., Staff L-12. Thus, unlike Staff L-13, -15, -17 and -23, we can conclude that EDG 101 will not experience loads in excess of 3300 KW, by 31 KW or less, for even short periods of time as a result of intermittent/cyclic loads. Tr. 28281-82 (Berlinger). This would be true even if we chose not to consider the results of the IET.

5/ Staff L-5 asserts that the Staff concluded that the FSAR loads were an "accurate representation" of anticipated LOOP or LOOP/LOCA loads. This ignores Dr. Berlinger's clarifying testimony that they were actually a "conservative estimate" of the loads. Tr. 27756 (Berlinger).

(Berlinger); LILCO L-32. The IET results provide confirmation that the MESLs are conservative. LILCO L-34. The entire difference need not be accounted for in detail to demonstrate this.6/

RL-6. SC L-15 to -18 argue that the qualified load does not encompass cyclic and intermittent loads. These findings contain a number of significant inaccuracies, and ignore the substantial record on the ability of the EDGs to accommodate the intermittent and cyclic loads within the qualified load, e.g., LILCO L-35. SC L-15 incorrectly concludes that nonoperating MOVs are intermittent/cyclic loads. Contrary to SC L-15, SC's witnesses acknowledge that these valves do not operate upon a LOCA. The SC witnesses included these valves only because they are not locked out and the SC witnesses believed they may have to move. Bridenbaugh and Minor, ff. Tr. 27500, at 11 n.*. Testimony of SC, LILCO and NRC witnesses confirms that nonoperating MOVs are not intermittent/cyclic loads.7/ LILCO L-22. SC L-16 fails to reflect the testimony of Staff witness Knox that intermittent/cyclic loads should be considered as they would actually sequence when determining design load. Tr. 27996 (Knox). Contrary to SC L-17, the SC testimony cited says "some," not "most," intermittent/cyclic loads will continue to operate. Bridenbaugh and Minor, ff. Tr. 27500, at 11. The record shows that (1) not all automatically actuated MOVs8/ will indeed operate, and those that do operate generally do so only once, LILCO L-23, (2) diesel

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6/ SC's finding that the primary purpose of the IET was not to determine actual load on the EDGs does not alter the fact that the IET does just that. See LILCO L-29 n.1.

7/ SC L-17 n.11 attempts to defend the classification of nonoperating MOVs as intermittent loads, but the record demonstrates that the SC witnesses' testimony was speculative, Tr. 27526 (Bridenbaugh), and not based on any analysis, Tr. 27555 (Bridenbaugh).

8/ The record shows that "nonoperating MOVs" are manually operated from the control room. Tr. 27305-07 (Dawe). Thus SC L-17, which states intermittent/cyclic loads are automatically applied, contradicts SC L-15, which identifies nonoperating MOVs as intermittent/cyclic loads.

generator air compressors operate only once, LILCO L-26, and (3) fuel oil transfer pumps operate periodically but are only 0.2 KW per pump, LILCO L-25.

RL-7. SC L-18 and n.12 suggest that the Staff was forced to exclude intermittent/cyclic loads from the MESL because LILCO chose to test the engine at 3300 KW. This inference is not supported by the record, which confirms that the Staff intended the MESL to reflect a continuous load, and therefore chose to define the MESL to exclude intermittent/cyclic loads. Tr. 27967, 28004 (Berlinger); see also Staff L-14. In any event, contrary to SC L-18 n.12, the record demonstrates that the conservatisms in the MESL ensure that the design load is accommodated within the qualified load. LILCO L-35.9/

RL-8. Contrary to the record, SC L-20 asserts that the Staff's standard practice has been to confirm that EDG short-time ratings encompass operator error loads. SC then argues that this so-called standard practice is better evidence that GDC-17 requires EDGs to accommodate operator error load than are the Staff's position and testimony to the contrary.10/ The record as a whole, however, does not substantiate this so-called standard practice. Rather, it supports the conclusion that EDG ratings are not required to accommodate operator error loads.11/ LILCO L-54, -55. SC misuses the evidence to support its view.

9/ In any event, SC concedes that the intermittent/cyclic loads are de minimis in their effect on the qualified load, absent the operator error load and so-called nonconservatisms in the MESL. SC L-18, n.13. The operator error load should not be included in the qualified load, LILCO L-54, -55, RL-8, and the MESL is conservative, LILCO L-6 to -19. Thus, the intermittent/cyclic loads are, at worst, de minimis in their impact on the qualified load.

10/ Findings SC L-3 and -4 are essentially identical to SC L-20 in their argument and citation to the record. Thus, they are similarly flawed. Further, SC's findings never actually state, nor could they, that this "standard practice," even if it exists, is required to comply with GDC-17, or that the qualified load is precluded as a licensing basis by GDC-17. See LILCO L-1.

11/ SC and the Staff do not address LILCO's request for reconsideration of the Board's ruling on the admissibility of Contention (a)(iv) as a challenge to the Single Failure Criterion. LILCO Proposed Findings at 19, n.4. Staff findings, however, demonstrate that (1) operator error is included in single failure anal-

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Neither the testimony of Mr. Knox at Tr. 27998 nor that of Dr. Berlinger at Tr. 27980 refers to operator error load. The testimony of Dr. Berlinger at Tr. 27952-53, in fact, makes clear that he was not sure whether all cases in the past assumed an operator error load. Tr. 27953 (Berlinger). More importantly, SC L-20 does not properly reflect subsequent testimony of Dr. Berlinger, directly clarifying the testimony at Tr. 27952-53, that ratings do not have to accommodate design loads plus the operator error load and that it has not been past Staff practice to require that they do so.12/ Tr. 28277-81 (Berlinger). The only evidence supporting SC's view of past Staff practice is the prefiled testimony of Staff witness Knox that the Staff normally ensures that an EDG has a short-term overload capability which encompasses operator error load. Knox, ff. Tr. 27735, at 9. During cross-examination, however, Mr. Knox clearly testified that NRC Regulatory Guide 1.9 does not require that the operator error load be accommodated in the short-term rating of the diesel. Tr. 28174 (Knox). Knox also testified that, although he was not aware of any specific case, he could

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ysis to the extent it can be the cause of failure, (2) operator error need not be included in design load and, insofar as it is applicable to the single failure criterion, they are adequately accounted for at Shoreham, and (3) GDC-17 only requires that the EDGs have sufficient capacity and capability to supply the design load and that they withstand a single failure from any cause. Staff L-40, -41, -44. We believe that these Staff findings support LILCO's position that Contention (a)(iv) is a challenge to the Single Failure Criterion. In light of these findings, we believe that the Staff's assertion that, as a general matter, operator errors are not applicable to the Single Failure Criterion, Staff L-39, means only that single failure analysis does not contribute to operator reliability in the same way it contributes to system reliability. See Hodges, ff. Tr. 27729, at 4, 5.

12/ SC L-20 n.16 attempts to avoid this subsequent testimony by arguing that the testimony merely states that it is not the inclusion of operator error load in the short-term rating that determines the capacity and capability of an EDG, but rather it is testing at this rating that does so. This is a disingenuous play on words. The language describing capacity, capability and ratings at Tr. 28277-81, which SC attempts to explain away, is essentially the same as that at Tr. 27952-53 upon which it chooses to rely. Indeed, both portions of the record confirm that operator error load is not required to be included in EDG ratings.

probably find some cases among operating plants where the addition of an operator error load would result in exceeding the short-term rating of an EDG. Tr. 27956, 28200 (Knox). SC is particularly disingenuous in stating that the Staff knows of no instance in which the short-time rating of an EDG does not encompass the maximum continuous load plus the operator error load. The testimony of Mr. Hodges and Mr. Buzy cited by SC L-20 states only that these witnesses know of no such case. Tr. 27957 (Hodges); Tr. 27960, 28036 (Buzy). SC ignores subsequent testimony by these witnesses that they do not know one way or the other whether such cases exist. Tr. 28196-200 (Hodges, Buzy).13/ Indeed, this was the case for all six NRC witnesses. LILCO L-54 n.5. Finally, the fact that the Staff chose in this instance to consider the ability of the EDGs to support loads up to 3900 KW for short periods of time in no way establishes a requirement under GDC-17 that the EDGs must be sized to accommodate operator error load.14/

RL-9. SC L-21 and n.18 misrepresent the record in asserting that the operators may give low priority to maintaining EDG load within the qualified load, and violate procedures if they deem it necessary. Staff witness Clifford, on whose testimony SC largely relies for this finding, testified that the Staff believes operators will stay within the procedures and not add loads on their own outside the scope of the procedures. Tr. 28217, 28306 (Clifford). Mr. Clifford rejected the characterization of his testimony as being that operators might

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13/ SC L-20 n.17 is unpersuasive in arguing that the original EDG 103 short-term rating does not counter SC's view of past practice and the requirements of GDC-17. Undeniably, the previously accepted short-term rating of EDG 103 did not encompass operator error loads. Tr. 27455-56 (Dawe). The testimony relied on by SC in n.17, to claim that the former EDG 103 short-term rating was inadequate, does not address operator error. Rather, it questions whether the second service water pump would be needed. Anderson et al., ff. Tr. 23826, at 17-18. But as LILCO demonstrated, even with a single failure, that service water pump need not be operated. Tr. 27230-31 (Dawe).

14/ The Staff has identified incorrect KW values for the worst case load resulting from a LOOP followed by operator error. Compare LILCO L-56 with Staff L-40 (Staff did not consider errata).

give lower priority to maintaining EDG loads within the qualified load.15/ Compare Tr. 28074-75 (Clifford) with Tr. 27842 (Clifford). Departure from the 3300 KW technical specification limit, addressed in SC L-21 as a violation of procedures, is unrelated to the operator error load. By regulation, departure from a technical specification can be approved by a senior licensed operator, but only if it is deemed immediately needed to protect the health and safety of the public. 10 CFR § 50.54(x), (y).

RL-10. SC L-22 does not fairly reflect the record in its assertion that the operator's ability to deal with an accident would be reduced because procedures and training would inherently entail less flexibility. The ability to accomplish required safety functions is unaffected by establishment of the qualified load. LILCO L-7. SC testimony on operator flexibility was speculation with no basis in analysis. See Tr. 27542-43, 27556 (Bridenbaugh). SC, in citing testimony of NRC witness Clifford on reduced flexibility, fails to consider subsequent testimony in which Mr. Clifford states his opinion that there is sufficient flexibility, that the equipment needed to respond to a LOOP/LOCA is included in the MESL, and that plant safety functions can be maintained within the capacity of the EDGs. Tr. 28295-96, 28311-12, 28356-57 (Clifford).

RL-11. SC L-23 and n.20 constitute a superficial summary of an extensive record on procedures and training. SC ignores LILCO testimony demonstrating that procedures and training do minimize the likelihood of operator error. LILCO L-65 to -78. Further, except to acknowledge LILCO's commitment to perform a job task analysis, SC fails to address the testimony of the Staff witnesses following their mid-hearing visit to the Shoreham site. The Staff's concerns

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15/ In addition, SC's inference that priority will be given to maintaining core cooling at the expense of EDG loading is a misrepresentation of the evidence. All ECCS pumps are included in the MESL and thus accommodated by the qualified load, see, e.g., LILCO L-7, -17, and there is a team of operators in the control room, each with different assigned duties and priorities, Tr. 27269-75 (Notaro).

were the result of incomplete information and many were resolved to the Staff's satisfaction. LILCO L-78 to -81.

RL-12. SC L-25 argues that the endurance testing of EDG 103 for 525 hours should have been run at a higher load value to account for cyclic and intermittent loads, operator error loads, instrument accuracy and uncertainties in the MESLs.16/ As shown by the findings and reply findings of LILCO and the NRC Staff, none of these items invalidate the 3300 KW qualified load. Thus, no higher test load was necessary. In addition, SC L-25 fails to acknowledge the fact that a significant portion (221 hours) of the total 10E7 cycle confirmatory test of EDG 103 was at loads of 3500 KW or above. Bush and Henriksen, ff. Tr. 28503, at 16.

RB-1. SC B-15 mistakenly asserts that the Staff did not agree with LILCO's GDC-17 compliance standard. To the contrary, the Staff and LILCO agree that GDC-17 is met where the EDGs are shown to be capable of performing their safety functions throughout a single LOOP/LOCA, which is the limiting design basis accident. Tr. 26234, 28130-37, 28141, 28281-82 (Berlinger).17/ Shoreham's EDGs more than meet this standard. The crankshafts have been shown

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16/ Again, SC refers to unspecified "uncertainties" which LILCO believes refer to areas excluded from the contention by the Board. See n.3, supra.

17/ Dr. Berlinger testified that an acceptable means of demonstrating GDC-17 compliance involves analyzing postulated events to determine which is the most limiting from the standpoint of functional requirements that have to be met by the EDGs and then to determine whether the EDGs can meet these functional requirements. Tr. 28130-37. He specifically agreed with the statement that GDC-17 compliance is shown by reliable operation through one limiting event, and that the Staff's evaluation assumed a one-week duration for this limiting event, the LOOP/LOCA. Tr. 26234, 28136-37, 28141, 28148-49 (Berlinger). SC B-15 also fails to reflect that Dr. Berlinger stated that the Staff had made a careful study of this approach and that it was the Staff position that this approach satisfied GDC-17. Tr. 28136-37. Finally, SC misconstrues the testimony concerning multiple LOOP/LOCAs. In essence, Dr. Berlinger testified that it is immaterial whether the EDGs can withstand more than one LOOP/LOCA and the Staff does not look to see how many LOOP/LOCAs the EDGs can survive. Rather, the assumption is that at any one point in time, required maintenance, inspections and surveillance assure the capacity and capability of the EDGs to perform their intended functions in any subsequent LOOP/LOCA. Tr. 28148-49 (Berlinger).

to have unlimited life at the qualified load (and at 3500 KW/3900 KW), and the blocks can also function indefinitely so long as inspections continually show no stud-to-stud cracks. LILCO C-5, C-8 to -13; B-30.18/ Even if a 1.5" deep stud-to-stud crack were to develop, the blocks can perform their intended function with more than sufficient margin, i.e., 50 consecutive LOOP/LOCAs. LILCO B-30.

RB-2. SC B-11 to -19 ask the Board to find that GDC-17 compliance can only be demonstrated by having EDGs capable of operating 8760 hours at a continuous rating and two hours of every 24 hours at a short-term rating. SC misinterprets the regulations and confuses a design criterion with a regulatory requirement. The design criterion of continuous operation for 8760 hours is but one acceptable means of demonstrating compliance; it is not the exclusive means. LILCO L-1. Indeed, there is no regulatory requirement that the EDGs run continuously for a year; rather, the regulatory requirement is that the EDGs have the capacity and capability to perform their safety functions during transients or accidents. No EDG safety function requires continuous operation for one year. Given that GDC-17 is expressed in terms of safety function performance during transients and accidents, it is clear that demonstration of EDG capacity and capability to perform safety functions reliably during the limiting event (LOOP/LOCA) is an appropriate GDC-17 compliance standard. Tr. 26234 (Berlinger); LILCO B-67; Staff B-61.

RB-3. SC B-25 and -34 confuse ligament cracks with stud-to-end and

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18/ Staff attaches to its proposed findings draft technical specifications for the EDGs. Staff Attachment 2. LILCO had not previously seen this document or reviewed its contents with the Staff. Preliminary review suggests that some of the requirements are ambiguous, unnecessary or impractical. Technical specifications are joint products of the Staff and applicant, with the customary process for their development involving an initial proposal by the applicant, followed by consultations between the Staff and the applicant. See In the Matter of Virginia Electric and Power Co. (North Anna Nuclear Power Station, Units 1 & 2), ALAB 578, 11 NRC 189, 211 n.62 (1980); see also SER (Aug. 1984) at 10. The customary process should be followed here and technical specifications finalized after the Board's ruling has established any appropriate inspection criteria from the record.

stud-to-stud cracks, and erroneously argue that propagation of any block top crack beyond a depth of 1.5" is contrary to LILCO's "theory of crack behavior."19/ Propagation of stud-to-end and stud-to-stud cracks beyond a depth of 1.5" is irrelevant to and does not contradict LILCO's testimony that ligament cracks arrest at the cylinder liner landing. Moreover, no ligament crack extended beyond the liner landing on the original EDG 103 block despite the presence of extensive Widmanstaetten graphite. Two ligament cracks immediately adjacent to stud-to-stud cracks extended deeper than 1.5", but only on the stud-hole side of the ligament. SC's failure to distinguish between the liner landing and the stud hole side of the ligament region is important because, contrary to SC B-37, coolant leakage from a ligament crack can only occur if the ligament crack extends beyond the liner landing to a depth of 2.5". Coolant leakage on the stud hole side of the ligament is virtually impossible because the crack would have to propagate more than 6" deep to reach the water jacket. Tr. 25238 (McCarthy); Tr. 24459, 25210-11, 25236 (Wells); Staff Exs. 9 and 10.

RB-4. Contrary to SC's assertion in SC B-26, LILCO did not rely on non-Shoreham operating experience to support its conclusion that ligament cracks are benign. Rather, LILCO relies on the operating experience of the Shoreham EDGs and on FaAA's finite element analysis. See LILCO B-21, -22. Given this and the Board's admonition that non-Shoreham operating experience is not entitled to great weight (Tr. 24682, 26053 (Brenner, J.)), SC's reliance on such experience in SC B-26 and -27 is misplaced.20/ Moreover, contrary to SC B-27, the absence

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19/ Contrary to SC's assertion, stud-to-end cracks are not "ligament-type" cracks. They initiate on the opposite side of the stud hole from ligament cracks and extend outward from the stud hole away from the ligament region. LILCO B-1 n.1.

20/ SC incorrectly asserts that Dr. Wells' testimony is contradicted by the absence of ligament cracks in EDGs used in nuclear service. Dr. Wells' testimony was not limited to EDGs used in nuclear service. He was responding to a question about his prefiled testimony at 46-47, which involved both nuclear and non-

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of ligament cracks in the four nuclear engines cited by SC does not indicate that ligament cracks in the EDG 101 and 102 blocks could propagate below 1.5" because the operating history is different and the factors influencing crack initiation differ from those affecting crack propagation. Tr. 28902-05 (Rau).

RB-5. SC B-28 to -36 misconstrue the use and application of FaAA's strain gauge measurements and finite element analyses. SC erroneously argues that FaAA's finite element analyses are unreliable because they are based on strain gauges that were not placed in locations providing direct evidence of stresses below the block top.21/ In fact, finite element analyses are performed independently of strain gauge measurements and can be utilized without strain gauge measurements, as was the case with FaAA's finite element analysis of the circumferential cracks. See Tr. 25505, 25499-500, 25343-45 (Rau). Further, strain gauges cannot provide direct evidence of stresses below the block top because they only measure surface strains.22/ Tr. 26574 (Bush); Tr. 24517-19 (Wells). Finite element analyses, not strain gauges, are used to compute stresses below the surface of the block top and at locations away from the strain gauge. LILCO B-15; McCarthy et al., ff. Tr. 24372, at 28.

RB-6. SC B-30 incorrectly concludes that Dr. Rau's testimony at Tr. 25499-500 is inconsistent with ligament crack arrest because SC has taken Dr. Rau's testimony regarding stresses on the stud-to-stud side of the stud-hole and

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nuclear engines. See Tr. 24708 (Dynner). Dr. Wells' testimony that ligament cracks are widespread in diesel engines is supported by Staff testimony that repetitive examinations in ship and stationary diesels demonstrate that cracks arrest. See Staff Ex. 14, at 27; 26044-45, 26048 (Bush).

21/ SC B-29 misstates the location of FaAA's strain gauges, which were located between cylinder nos. 5 and 6, not 4 and 5. LILCO Exs. B-22, -23.

22/ SC B-33 n.18 acknowledges that strain gauges only measure surface strains. This contradicts SC's argument in SC B-28 that strain gauges can provide "direct" evidence of stresses below the block top.

erroneously applied it to the ligament side of the stud-hole. The record confirms that the testimony cited by SC concerned stud-to-stud cracks, not ligament cracks. See Tr. 25348, 25499-500 (Rau). Dr. Rau's testimony at Tr. 28820-21 clearly demonstrates that stresses decrease with distance below the block top on both sides of the stud-hole, but that they become compressive on the ligament side.

RB-7. SC B-31 incorrectly asserts that the Staff was skeptical of the validity and reliability of FaAA's strain gauge data and, by implication, of its finite element analysis. The Staff did not challenge the reliability of FaAA's strain gauge data, or suggest that the data made FaAA's finite element analysis unreliable. See Tr. 25833, 25837-39, 25845, 25854, 25880 (Bush). Rather, Dr. Bush's comment was that the strain gauge located in the stud-to-stud region did not, by itself, provide him with fast start stress data in areas remote from that strain gauge, such as the cylinder liner counterbore or the stud hole. Tr. 25837-39 (Bush).

RB-8. SC B-32 and -33 exaggerate Dr. Bush's two limited concerns regarding secondary thermal inputs into FaAA's finite element analysis. SC omits those portions of the record where Dr. Bush indicated that the effect of pulsating thermal gradients would not be pronounced and cold start-up thermal gradients would not contribute markedly to crack propagation. Tr. 25874, 25844 (Bush). Further, SC's purported summary of Dr. Bush's position at Tr. 26247-48 is taken out of context and misrepresents Dr. Bush's overall conclusion. That testimony relates only to Dr. Bush's uncertainties concerning cold start-up thermal gradients. See also Tr. 25804-05 (Bush). Although Dr. Bush could not unequivocally state that ligament cracks arrest on diesels subjected to a large number of fast starts, the complete record shows that Dr. Bush was in general agreement with FaAA's finite element analysis and its conclusions except as to the exact point where the ligament cracks arrest. LILCO B-23.

RB-9. The reliance in SC B-34 to -36 on TDI strain gauge data to refute FaAA's finite element analysis is disingenuous given SC's past refusal to accept any TDI data unless, as was not possible here, it had been independently confirmed. LILCO withdrew its testimony on this data because it could not be verified and FaAA had specific concerns regarding its reliability. Tr. 24850-52 (Wells); Tr. 24826-30 (Wells, Rau). Moreover, SC's reliance on the TDI data is improper since cross-examination on this and other withdrawn testimony was permitted solely to establish why the testimony was withdrawn and to challenge the credibility of the witnesses. Withdrawn testimony cannot be used to establish the truth of the matters asserted in it. Thus, the TDI strain gauge data cannot be used to refute FaAA's finite element analysis, and SC's findings which rely on these data are completely unsupported.

RB-10. SC B-37 to -39 raise no issues regarding coolant leakage not previously rebutted fully by the Staff and LILCO. <u>See</u> LILCO B-25, -26; Staff B-26. SC's assertion that neither the Staff nor LILCO performed a definitive quantitative analysis of potential coolant leakage is irrelevant because no such analysis was required or warranted. Ligament crack propagation to the water jacket will not occur and, in any event, would result in only a dribble of water to the block top even though the coolant water is under a pressure of 25 psi. Tr. 26187 (Henriksen); LILCO B-25. LILCO demonstrated the makeup water capacity is 70 gpm, which is sufficient to replace the entire 200 gallon capacity of the EDG every three minutes. <u>See</u> Tr. 25272 (McCarthy); LILCO B-25. Given this virtually unlimited makeup capacity and the conclusion that the cooling system would never be depleted, it was not necessary for LILCO and the Staff to perform further analysis.

RB-11. SC's discussion of Goodman diagrams in SC B-43 to -45 does not refute FaAA's conclusion that the blocks are capable of performing their intended function. The diagrams indicate only the possibility of crack initiation.

FaAA's cumulative damage analysis assumes crack initiation and propagation to a depth of 1.5", but takes no credit for the operation necessary for this initiation and propagation. LILCO B-30, -34. Further, SC B-43 to -45 ignore LILCO and Staff evidence that stud-to-stud cracks are unlikely to initiate in the superior material of the EDG 101 and 102 blocks given the more than 400 hours of operation at or above 3500 KW without crack initiation. LILCO B-40; Staff B-23, -37. The Goodman diagrams are not to the contrary; they indicate only the possibility, not the likelihood, of crack initiation, and, in any event, they have been demonstrated to be conservative by actual operation. LILCO B-18 to -20.

RB-12. SC concedes in B-49 n.29 that sample location is more important than sample weight in determining whether adequate metallographic sampling was performed on the EDG 101 and 102 blocks. But SC then asserts, without providing any technical basis for its position, that LILCO did not sample enough locations.23/ However, the Staff agrees with LILCO that FaAA's sample locations were adequate to verify that the EDG 101 and 102 blocks have typical microstructures. LILCO B-9; Staff B-17. No credible evidence in the record disputes (1) that cooling rate determines microstructure; (2) that the cooling rate of the heavy-sections within each block was relatively uniform; (3) that destructive sectioning of the original EDG 103 block confirmed the microstructure was uniform and contained extensive amounts of Widmanstaetten graphite; and (4) that identical sample locations in the EDG 101 and 102 blocks revealed typical Class 40 gray cast iron microstructures. LILCO B-7 to -9; Staff B-12, -13.

23/ SC B-50 unfairly infers that FaAA's metallographic testing was characterized by a "lack of thoroughness" because "Dr. Wachob could not affirm that FaAA found no evidence of Widmanstaetten graphite in EDG 102." In fact, Dr. Wachob testified FaAA examined the EDG 102 block extensively, but that the local regions with minor characteristics similar to Widmanstaetten graphite were so isolated it was not possible to determine quantitatively that any Widmanstaetten graphite was present. Tr. 24754 (Wachob); see also Tr. 24755-56 (Rau).

RB-13. Contrary to SC B-54, there is evidence in the record that the load excursion affected the rate of crack growth.24/ Although not able to quantify the loads experienced, Dr. Bush performed a semi-quantitative analysis of crack extension as a function of loads and operating hours and concluded that crack extension during the benchmark period was more than he would have anticipated for the known loading conditions. See Tr. 29038-44, 29047-48, 29076-77 (Bush). Further, Mr. Henriksen analyzed cylinder firing pressures and concluded that they were higher during the load excursion than during normal operation at 3500 KW. Therefore, in the Staff's opinion, the EDG was overloaded even though the fuel rack was set at 3500 KW. See Tr. 25859-60 (Berlinger, Henriksen); compare Tr. 25857-60 (Henriksen) with Tr. 24655-56 (Youngling) (Henriksen and Youngling define "overload" differently). Dr. Wells also believed that the load excursion affected crack growth, but FaAA's cumulative damage analysis took no credit for any rapid crack growth that occurred during the load excursion. As a result, if rapid crack growth did occur, FaAA's analysis conservatively predicts artificially high crack growth rates and therefore provides a conservative bound on crack propagation. LILCO B-34(E), -35; see also LILCO RB-17.

RB-14. The conclusion in SC B-62 that FaAA's cumulative damage analysis is not a reliable indicator of crack behavior is entitled to no weight because SC witnesses were not qualified to review FaAA's analysis.25/ Tr. 25637-42

24/ Also contrary to SC B-54, Dr. Bush, not Dr. Wells, testified that the unusual load excursion was a "major contributor" to crack growth. Tr. 29039-40 (Bush).

25/ SC B-58 contends that FaAA's cumulative damage "analysis itself is unreliable" and SC B-62 similarly contends that the "underlying premise" of FaAA's analysis is invalid. Both claims are disingenuous given Mr. Bridenbaugh's testimony that he did not in any way challenge the methodology used by FaAA for its finite element, fracture mechanics or cumulative damage analyses. To the extent Mr. Bridenbaugh expressed any concern, it was with the way in which the results were utilized. Tr. 29006-07 (Bridenbaugh). Although the Board struck the related portion of Mr. Bridenbaugh's prefiled testimony and his oral testimony stemming from it, Tr. 29008 (Brenner, J.), it is inappropriate for SC to challenge FaAA's methodology and at the same time ignore this testimony.

(Anderson, Bridenbaugh, Christensen, Eley, Hubbard). The assertion in SC B-60 n.34 that Dr. Anderson and Mr. Bridenbaugh were qualified to review and comment on FaAA's analysis flies in the face of the record. Portions of Mr. Bridenbaugh's prefiled testimony following Tr. 28918 and all related oral testimony was striken because the Board ruled that Mr. Bridenbaugh was not qualified and that it would not rely on his testimony with respect to any area in controversy on the block. See Tr. 29008-10 (Brenner, J.). Dr. Anderson's testimony is also entitled to no weight because he is not qualified and he admitted he never reviewed FaAA's cumulative damage calculations. Tr. 25637 (Anderson).

RB-15. SC's specific criticisms of FaAA's cumulative damage analysis in B-60, -61, -67 to -69 also fail to establish that the analysis is unreliable. LILCO responded to each of these concerns in its testimony and findings. See LILCO B-38. Contrary to SC B-61, FaAA did consider the stud-to-end crack at cylinder no. 1. Cumulative damage analysis of the stud-to-end crack demonstrated even more margin (i.e., less crack propagation) for a postulated LOOP/LOCA than that demonstrated for a stud-to-stud crack.26/ FaAA therefore conservatively reported the 50 consecutive LOOP/LOCA margin demonstrated for the stud-to-stud location rather than the larger margin computed for the stud-to-end crack region. Tr. 24811-13 (Rau). Contrary to SC B-60, FaAA testified, and the Staff concurred, that the cumulative damage analysis was conservative because it

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26/ SC confuses propagation of the stud-to-end crack during the benchmark period, which went from a surface indication to 4.4", with crack propagation during a postulated LOOP/LOCA. Cumulative damage analysis demonstrates that during a postulated LOOP/LOCA, the stud-to-end crack would propagate much less than 2% of the stud-to-end crack growth that occurred during the benchmark period. However, a stud-to-stud crack has been shown by the same analysis to propagate about 2% of the stud-to-stud crack growth that occurred in the same benchmark period. Therefore, the benchmark testing has demonstrated greater margin for the stud-to-end crack than for the stud-to-stud crack. SC's argument that the stud-to-end crack propagated more during the benchmark period is irrelevant because FaAA's cumulative damage analysis considered both stud-to-end and stud-to-stud cracks and determined that the stud-to-end region had more margin to withstand a postulated LOOP/LOCA than the stud-to-stud region. Tr. 24812-13 (Rau).

took no credit for load sequencing and crack initiation, and these factors further increase the demonstrated margin. LILCO B-34; Staff B-33; Tr. 26228, 26313, 29077-78, 29094-95 (Bush). The Staff and LILCO also agreed that FaAA's cumulative damage analysis conservatively bounded the maximum rate of crack propagation, and FaAA testified it was unnecessary to perform a more detailed fracture mechanics analysis given the margin demonstrated by the conservative cumulative damage analysis. LILCO B-39. Finally, SC's argument that Widmanstaetten graphite may have resulted in imprecise crack depth measurements in some stud holes ignores Dr. Johnson's unrebutted testimony that the only eddy current measurement used in FaAA's cumulative damage analysis was rechecked and confirmed to be between 1.4" and 1.6" deep at the beginning of the benchmark period. Tr. 28823 (Johnson); LILCO B-38. Thus, the record directly refutes SC's assertion that imprecise crack measurements rendered FaAA's cumulative damage analysis unreliable.

RB-16. SC B-51, -64, -65 and -66 incorrectly assert that FaAA's cumulative damage analysis is unreliable because the EDGs reach a "critical point" in their load history that causes cracks to initiate and propagate at an accelerating rate. This theory is not supported by any expert testimony, including the testimony of SC's own witnesses; rather, it is based solely on SC speculation and misuse of LILCO load tables and crack maps.27/ Absent expert testimony establishing a scientific foundation for SC's new theory of crack acceleration, SC's findings are entitled to no weight and cannot be accepted.28/

27/ SC B-66 n.40 does not support SC's theory that crack initiation and crack growth accelerate when the EDGs reach a critical point in their load history. Dr. Bush's testimony is that some cracks can propagate faster as they get larger. This testimony does not support the argument that the blocks have a critical point in their load history which causes new cracks to initiate and existing cracks to propagate faster, regardless of their depth.

28/ Operation of the EDGs since the original EDG 103 block was replaced contradicts SC's theory that the blocks reach a so-called "critical point" in their

(footnote continued)

Further, even if crack acceleration were hypothetically assumed to have occurred for any reason during the benchmark period, FaAA's cumulative damage analysis is still valid because it is based on the actual crack propagation that occurred during the benchmark period. Thus, if the unusual load excursion (which SC totally ignores) played a role in increasing the rate of crack initiation and propagation during the benchmark period, FaAA's cumulative damage analysis conservatively predicts artificially high fatigue crack growth rates. Tr. 29075-78 (Bush). Similarly, if a critical point in the block load history is assumed to cause accelerating crack growth during the benchmark period, the EDGs would withstand a postulated LOOP/LOCA with even greater margin.29/

RB-17. Staff B-31 correctly notes that during the benchmark period, the original EDG 103 block experienced 150% of the loading that would have been required of it during a postulated LOOP/LOCA. However, the Staff incorrectly states that this was due to the unusual load excursion. McCarthy et al., ff. Tr. 24372, at 52-53. Further, the Staff omits that the EDG 101 and 102 blocks

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(footnote continued)

load history because the EDG 101 and 102 blocks have now accumulated more hours at or above 3500 KW without initiation of stud-to-stud cracks than the original EDG 103 block had accumulated when it allegedly reached the "critical point" in its load history. See LILCO B-5; LILCO Exs. B-13, -14; see also Tr. 28887-88 (Rau). Further, SC's extrapolations from crack maps are illogical. For example, SC's use of average crack depths of all cracks in SC B-66 ignores that ligament cracks arrest at the liner landing. Adding the total depth of all ligament and stud-to-stud cracks and dividing by the number of cracks, as SC has done, produces a meaningless number. Similarly, it ignores both the differences in material properties in the blocks and the fact that EDGs 101 and 102 have no stud-to-stud cracks despite more operation at or above 3500 KW than the original EDG 103 block. LILCO B-5.

29/ Specifically, because the cumulative damage analysis has demonstrated that 50 consecutive LOOP/LOCAs would be required to produce 1.5" of stud-to-stud crack growth (i.e., from 1.5" to 3"), a single LOOP/LOCA would cause only about 2% of the 1.5" crack growth. If hypothetically the rate of crack growth had been accelerating, the crack would grow slower at the beginning and faster at the end of the benchmark period. Thus, FaAA's cumulative damage analysis conservatively bounds the rate of crack growth that would occur during a LOOP/LOCA because the first LOOP/LOCA of the 50 LOOP/LOCA margin would produce less crack growth than later LOOP/LOCAs. LILCO B-30, -35; Staff B-36.

would experience only 2% of the cumulative damage that the original EDG block experienced, thus demonstrating a margin of 50 consecutive LOOP/LOCAs. LILCO B-30.

RB-18. Contrary to SC B-55, the evidence shows that the 3" deep stud-to-stud crack did not impair engine operation. No witness disputed LILCO's testimony on this point. McCarthy et al., ff. Tr. 24372, at 18. Further, SC B-55, -70 to -74 present no new arguments to refute the conclusion reached by LILCO and the Staff that stud-to-stud cracking substantially deeper than 3" would not cause EDG failure.30/ LILCO B-34(D); Staff B-33. Contrary to SC's assertions, it was not necessary to perform a detailed quantitative analysis of crack growth beyond a depth of 3" because FaAA did not seek to rely on the EDGs' ability to operate with cracks deeper than 3". Further, LILCO's and the Staff's testimony was supported by qualitative analyses based on their experts' knowledge of the block geometry and its interaction with the heads, studs, bosses and jacket water system. See Tr. 25234-37 (Wells); Tr. 25237-38 (McCarthy); Tr. 26189 (Henriksen); Tr. 26189 (Bush); Tr. 26190 (Berlinger). Further, LILCO's decision to replace the block, and Dr. Bush's testimony that he would not return the block to service if it developed a stud-to-stud crack, do not contradict the conclusion that cracks deeper than 3" would not impair EDG operation. Although analysis and operating experience demonstrate that additional margin exists, LILCO's decision and Dr. Bush's testimony conservatively do not rely on this margin. See LILCO B-34(D); Staff B-33.

RB-19. SC B-76 and -77 erroneously assert that LILCO's nondestructive examinations of the EDG 101 and 102 blocks are not reliable because these

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30/ Contrary to SC B-73, SC did not assert in either its prefiled or oral testimony that it was concerned about leakage from a stud-to-stud crack. Nevertheless, SC's newfound concern is not supported by the record. Drs. Wells and McCarthy testified that leakage from stud-to-stud cracks would not occur, and Mr. Henriksen testified that leakage would present no problem, even if it occurred. Tr. 25236 (Wells); Tr. 25238 (McCarthy); Tr. 26189 (Henriksen).

examinations failed to discover circumferential cracks in original EDG 103. SC's conclusion, based solely on LILCO's liquid penetrant inspections, ignores results of ultrasonic inspections which LILCO relied on in its testimony and findings. LILCO B-44, -45. Liquid penetrant inspections, coupled with ultrasonic inspections, are highly reliable because ultrasonic inspections are not affected by deposits collecting in the liner landing corner. Reliability of the ultrasonic inspection procedure was demonstrated when it detected the presence of circumferential cracks in the original EDG 103 block. Tr. 28816 (Schuster); LILCO B-44 and -45. Further, contrary to SC's assertion in SC B-77, Mr. Schuster's testimony that no circumferential cracks are present in the EDG 101 and 102 blocks does not contradict LILCO's prefiled testimony, which conservatively assumes the presence of 360° circumferential cracks. SC ignores testimony at Tr. 28874, in which Dr. Rau states that he, not Mr. Schuster, conservatively assumed the presence of circumferential cracks in the analyses described in the prefiled testimony. Dr. Rau did so independently of LILCO's inspection results, and the analyses demonstrated that circumferential cracks, if they should initiate, would arrest and not impair EDG operation. Tr. 28874 (Rau).

RB-20. Contrary to the inference drawn in SC B-83 and -84, Dr. Bush did not disagree with FaAA experts that no branching cracks were revealed in LILCO Ex. B-64. Rather, Dr. Bush was unable to comment because he did not see the sample in which Dr. Anderson claimed he saw an organized pattern of branching cracks. Tr. 26689 (Bush); Staff B-52. Further, SC B-84 significantly misrepresents the testimony of Drs. Bush and Rau since both testified that either NDE examinations or metallographic polishing could accurately determine whether branching cracks were present. Tr. 26682 (Bush); Tr. 25139, 26668 (Rau). LILCO performed three NDE examinations which disclosed no branching cracks in the sample examined by Dr. Anderson. Thus, Dr. Anderson's visual observations without either metallographic polishing or NDE examination were unreliable and incorrect. See LILCO B-52; Staff B-52.

RB-21. Contrary to SC B-85, details of FaAA's finite element analyses were not "sketchy" or based on "hypothesis." In fact, Drs. Rau and Wells provided significant details regarding their two- and three-dimensional finite element analyses. Tr. 25341-45, 25099 (Rau); Tr. 25091-95 (Rau, Wells). Further, as noted in LILCO RB-5, finite element analyses are performed independently of strain gauge measurements and are not based on hypothesis because they do not require the use of strain gauges.

RB-22. SC B-89 abandons SC's theory, summarized in SC B-86, that circumferential cracks could cause movement of the cylinder liner relative to the block which could result in escape of combustion gasses into the water jacket system. However, SC now asserts for the first time and without any support from the record that fire could escape into the engine room, causing panic and confusion. No witness so testified. Absent such testimony, SC's finding lacks any foundation and cannot be adopted. SC's assertion in B-91 that "even a layman" can visualize a failure is similarly deficient and entitled to no weight because it is unsupported speculation refuted by FaAA's finite element analysis and the operating experience of the original EDG 103 block. See LILCO B-56 and -57; Staff B-54 and -55.

RB-23. Contrary to SC B-96 to -98, LILCO did introduce evidence that operation at the qualified load placed lower stresses on the EDGs, thus reducing the possibility of crack initiation and retarding the rate of crack propagation, if cracks should initiate. LILCO B-32, -33 and -43. Further, LILCO has met its burden of proof with regard to ligament and circumferential cracks at 3300 KW since LILCO's evidence demonstrates these cracks arrest at loads of 3900/3500 KW, and are less likely to initiate or propagate at lower loads. See LILCO B-21, -22, -32, -48 to -50.

RC-1. In SC C-1 and n.1, SC's conclusion that the analytical evidence fails to demonstrate the adequacy of the replacement crankshafts at loads at or

above 3300 KW is a mischaracterization of the record.31/ Professor Sarsten's calculations showing the DEMA limits were exceeded at overspeed and underspeed at 3500 KW used 24 orders instead of major orders as DEMA requires. His DEMA calculation at 3300 KW showed noncompliance only at overspeed and was based on interpolation. LILCO C-7 n.2. Dr. Pischinger performed a calculation at 3300 KW utilizing 24 orders. Simple arithmetic demonstrates that Dr. Pischinger's 24 order calculation showed DEMA was exceeded only at overspeed and then by just 34 psi. See Tr. 22804, 22809 (Pischinger). This is less than one-half of 1%. Dr. Pischinger stated, however, that the calculation was not performed to check DEMA compliance and that it should not be compared with DEMA because it was not based upon major orders, which would result in 10-15% less stress. Tr. 22805, 22809 (Pischinger); see Tr. 22831-32 (Chen). Contrary to SC's assertion in n.1, Dr. Pischinger's Kritzer Stahl calculations do demonstrate the adequacy of the crankshafts. See LILCO C-6; C-82 to -91 (11/84); RC-30 to -35 (12/84).32/ The fact that none of the parties introduced evidence concerning compliance with various classification societies is irrelevant. See LILCO C-8 to -15 (11/84). Furthermore, ABS has certified the crankshaft at 3500 KW and its CIMAC (IACS) calculation showed a safety factor of 1.15 at 3500 KW. LILCO C-11 (11/84); LILCO Ex. C-13. Thus, since the stresses between 3300 KW and 3500 KW are linear and are lower at 3300 KW, the crankshafts do comply with ABS's rules and CIMAC from 3300 KW to 3500 KW. See LILCO Ex. C-16, figure B-4.

31/ Given that SC C-1 states that SC does not challenge the crankshafts at loads up to 3300 KW, SC is disingenuous in stating in footnote 1 that DEMA is not met at 3300 KW. This is particularly surprising in view of SC's consultants' determination that the crankshafts comply with DEMA, ABS and Lloyds at 3300 KW. See LILCO C-1. Staff Findings C-8 and -9 similarly ignore the fact that SC acknowledged that DEMA is met at 3300 KW.

32/ LILCO's proposed findings and reply findings previously filed in November and December, 1984, are referred to as LILCO C and LILCO RC, respectively, with the filing date in parentheses. All references herein to SC's proposed findings on crankshafts are to those filed in April, 1985.

RC-2. Contrary to SC C-3, the KW meter was not "off by 70 KW," during the 525 hour run. The record shows the accuracy was ± 60-70 KW. Dawe et al., ff. Tr. 27153, at 28-29, 39; Tr. 27265, 27268 (Dawe). Thus, a reading is not necessarily off by 70 KW. The meter can be expected to have been high as often as low so that the indicated load is a reliable mean.33/ Tr. 27309-10 (Dawe); Tr. 28427 (Pischinger); see also LILCO L-39, -40. Additionally, 220 hours of the 745-hour confirmatory test accumulated prior to the 525 hour endurance run were at loads of 3500 KW or substantially above and the loads during a majority of these hours were recorded with an accuracy of ± 0.6%. Since a kilowatt hour of operation above 3300 KW contributes more to cumulative damage than a kilowatt hour of operation below 3300 KW, the contribution of these 220 hours may further compensate for any possible effect of meter error during the 525 hour run. See Pischinger et al., ff. Tr. 28416, at 11-12; Tr. 27311-14, 27423 (Youngling); Tr. 28419-20, 28448-49 (Pischinger).

RC-3. SC distorts the record by stating in SC C-3 n.4 that the Staff recommended that LILCO conduct the endurance test at 3500 KW. Dr. Berlinger actually stated that the Staff recommended that the engine be tested at 3500 KW if LILCO wanted to license the engine at 3500 KW, and tested at 3300 KW if that is where LILCO wanted to license the EDGs. Tr. 28005 (Berlinger). Finally, SC's comments as to LILCO's rationale or motivation for testing or not testing at levels other than 3300 KW is not relevant to any issue in this litigation.34/

33/ In SC C-4, SC mistakenly attributes this variation within the error range to pulsation caused by the grid. In fact, it is inherent in the meter. LILCO L-40; Tr. 27307-11 (Dawe, Youngling).

34/ The assertion in SC C-3 n.4 that LILCO refused to conduct the last 525 hours of testing at 3500 KW is not cited to the record and cannot be supported by the record. SC's claim that LILCO attempted to avoid any testing at all is a misrepresentation of the cited testimony. Mr. Youngling actually stated that LILCO attempted to persuade the Staff that testing at 2600 KW was appropriate. Tr. 27347-48 (Youngling).

RC-4. SC C-5 and -6 and the footnotes thereto ignore the testimony of Dr. Pischinger which describes the number of hours at various loads above 3500 KW. Tr. 28419-20 (Pischinger). These findings also ignore Dr. Pischinger's testimony that hours above 3300 KW have a more significant effect on cumulative damage than hours below 3300 KW, Pischinger et al., ff. Tr. 28416, at 11-12; Tr. 28448-49 (Pischinger); ignore the testimony that a meter can be expected to read high as often as low, Tr. 27309-10 (Dawe); Tr. 28427 (Pischinger), see also LILCO RC-3; ignore the fact that a majority of the 220 hours of operation at or above 3500 KW was recorded on the more accurate test loop, Tr. 27423 (Youngling); and conclude without logical basis that the calculations performed by Drs. Pischinger and Bush to establish the endurance limit of the crankshaft at 3505 KW and 3430-3480 KW, respectively, are not reliable. See LILCO C-8, -9.

RC-5. SC C-7 and -8 and the footnotes thereto attack Dr. Bush's conclusion that the onset of the fatigue endurance limit for the replacement crankshafts is at least 3430 KW.35/ Contrary to SC's argument, the fact that the metals grouped in Dr. Bush's Table I show the beginning of endurance limits ranging from 0.2 to 3 X 10E6 cycles does not cast doubt upon Dr. Bush's conclusion. Even if the extreme case of 3 X 10E6 cycles were taken as the beginning of the endurance limit, the crankshaft has successfully completed in excess of 220 hours (2.97 X 10E6 cycles) at or substantially above 3500 KW. Tr. 28419-20 (Pischinger); Staff C-12, -14. Furthermore, SC's criticisms of Dr. Bush's data are unfounded since the whole purpose of the table was simply to show that all ferritic steel such as ABS Grade 4, regardless of surface and heat treatment, tends to begin the onset of its endurance limit within a fairly narrow band (0.2 to 3 X 10E6 cycles).36/ Bush et al., ff. Tr. 28503, at 17; Tr. 28534-35,

35/ SC's attack upon LILCO's C-9 mischaracterizes the record. See SC C-7 n.8. LILCO merely cited Dr. Bush's answer to a hypothetical question in which he was asked to assume a ± 0.6% meter accuracy. See LILCO C-9. The accuracy of ± 0.6% is established by LILCO testimony. LILCO L-41.

36/ Again it should be noted that Dr. Bush never stated that surface or heat treatment did not affect the beginning of the fatigue limits as Suffolk County

(footnote continued)

28641-42, 28649-50, 28695 (Bush); see also Staff C-13. SC's assertion that Dr. Bush's Table I was not the result of a sufficiently extensive survey of scientific literature is meaningless in view of Dr. Bush's statement that using more examples would not affect his conclusions as to the endurance limit of ferritic steels. Tr. 28749 (Bush). Finally, SC's claim in SC C-8 n.14 that the onset of the fatigue endurance limit could be as much as 4 or 5 X 10E6 cycles or 10E7 cycles is rank speculation and not supported by any citation.

RC-6. SC C-9 miscites and distorts the record in an attempt to dismiss the cumulative damage calculations of Drs. Bush and Pischinger. The first sentence of n.16 is unsupported by the transcript reference for Dr. Bush. Moreover, Dr. Pischinger never testified that particular sequencing of loads has a "significant effect" on the crankshaft fatigue limit. He simply stated there can be an effect or influence. Tr. 28421-22 (Pischinger). In n.17, SC asserts incorrectly that Dr. Bush did not sufficiently vary the load sequencing in performing his cumulative damage analysis. While Dr. Bush did indicate in his prefiled testimony that the fatigue limits would vary markedly depending on the load sequencing using the Manson approach, Bush et al., ff. Tr. 28503, at 16, he subsequently testified that he concluded after analyzing seven different load sequences, including a most and a least severe case, that load sequencing in this instance was of no significant effect. This is consistent with his view that the stress differential between 3300 KW and 3500 KW is not significant. Tr. 28609-13, 28659-60, 28662 (Bush); see also Staff C-12. Thus, since there was no differentiating effect between using these various load sequences, the endurance limit of the crankshafts must be around 3500 KW or possibly higher. Tr. 28660, 28717 (Bush).

(footnote continued)

asserts. Indeed, he testified that the beginning of the fatigue limit would be "relatively unaffected" which is consistent with the results shown on Table I. Tr. 28649 (Bush).

RC-7. SC C-9 n.18 fails to reflect that Dr. Pischinger intentionally did not consider cycles below 3300 KW (500+ hours) in his cumulative damage analysis (which Miner-Palmgren would allow) in order to provide additional conservatism to his figure. Tr. 28420-21, 28426, 28452-53 (Pischinger). SC disingenuously argues in n.18 that Dr. Pischinger's suggestion that the actual load sequence may have been beneficial can be given no weight in view of Dr. Bush's statement that the application of these loads should not have a pronounced effect on the endurance limits. This statement follows SC's previous argument in n.17 that Dr. Bush's conclusion is wrong. SC cannot have it both ways. In any event, Dr. Pischinger never utilized any such possible benefit in his calculations.

RC-8. SC C-11 distorts the record by asserting that Dr. Berlinger stated the endurance run does not provide an adequate basis for drawing conclusions about the ability of the crankshafts to handle loads above 3430 KW to 3460 KW. Dr. Berlinger merely stated that testing an engine for 10E7 cycles at 3000 KW does not mean the engine has, by definition, an overload rating of 3300 KW. SC ignores Dr. Berlinger's testimony concerning the significance of testing at Shoreham at loads well above 3300 KW. Tr. 27988-89 (Berlinger); LILCO RL-1.

RC-9. Contrary to SC C-15, there is no evidence that the crankshafts will be subjected to loads as high as 3900 KW for any period of time. The record does reflect that an unlikely operator error could result in a load as high as 3741.8 KW following a LOOP event. LILCO L-56. The record also reflects that such an error would be promptly recognized and remedied. LILCO L-59. Finally, in the unlikely event a diesel generator failed, the on-site power system satisfies the single failure criterion. LILCO L-60.

LILCO, May 2, 1985

CERTIFICATE OF SERVICE

DOCKETED USNRC

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

'85 MAY -7 A10:23

OFFICE OF SECRETARY DOCKETING & SERVICE BRANCH

I hereby certify that copies of LONG ISLAND LIGHTING COMPANY'S REPLY FINDINGS OF FACT CONCERNING EMERGENCY DIESEL GENERATOR CONTENTIONS were served this date upon the following by first-class mail, postage prepaid, or by hand, as indicated by as asterisk:

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