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UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION

DOCKETED  
USNRC

ATOMIC SAFETY AND LICENSING BOARD

'84 AGO 13 ATT:

In the matter of  
METROPOLITAN EDISON COMPANY, ET AL.  
(Three Mile Island Nuclear  
Station, Unit No. 1)

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Docket No. 50-289  
(Steam Generator Repair)  
August 10, 1984

PRODUCTION  
PROD. & UTIL. TAG. 50-289 OLA

PROPOSED FINDING OF FACT AND CONCLUSIONS  
OF LAW OF THREE MILE ISLAND ALERT, INC. (TMIA)  
ON THE ISSUE OF STEAM GENERATOR REPAIR ON UNIT NO. 1

I. INTRODUCTION

A. Background

In November, 1981 it was discovered that of the approximately 31,000 tubes of both once-through steam generators (OTSG), almost all of the tubes at Unit 1 had been damaged and were capable of leaking. The vast majority of the cracks occurred within the 24 inch thick Upper Tubesheet (UTS). The once-through straight tubes are 56 feet and 1 inch in length of which 2 feet at each end is inside of the tubesheets with the remaining  $\frac{1}{2}$  inches on each end protruding into the primary head above and below each UTS respectively.

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Between the drilled tubesheet hole and the outer tubesheet there is a 8 mil. radial gap. The repair involved the use of an explosive inserted into the tubes which when exploded is intended to push the tube against the tubesheet and close the 8 mil. radial gap. All of the tubes of both OTSG except for those already plugged were subjected to these detonations.

#### B. Procedural History

Pursuant to the Notice of Hearing on Issuance of Amendment to Facility Operating License issued on August 8, 1983, Three Mile Island Alert, Inc., (TMIA) on September 21, 1983 filed their proposed contentions. A special pre-hearing conference was held on October 17, 1983 which resulted in a substantial reduction in the number and scope of the contentions to be addressed. The public hearings took place on July 16, 17 and 18, 1984 at the Penn State Capitol Campus.

#### C. Procedural History of TMIA's Document Request 22.

On December 30, 1983 TMIA filed its Just Set of Interrogations and Request For Production of Documents to the Licensee. Document Request 22 asked that the Licensee:

Provide all documents or portions thereof which have been withheld from all parties, or from the intervenors, on the basis of the "proprietary" or "trade or commercial secret" information claimed to have been within the documents.  
Include all Topical Reports and Technical Data Reports.

After a failure of the Licensee to respond adequately, on January 25, 1984 with respect to Document Request 22 TMIA filed a Motion For Order

Compelling Discovery. On January 27, 1984 Licensee filed Objections to TMIA's Motion for Order Compelling Discovery on Document Request 22 and on February 6, 1984, the Licensee filed its own Motion For Protective Order and Answer to TMIA's Motion. TMIA did not respond to Licensee's Motion For Protective Order and on March 2, 1984 the Atomic Safety and Licensing Board granted the Licensee's proposed Protective Order after making a few revisions.

On April 3, 1984 TMIA filed a Motion for Reconsideration on the issue and additionally requested the Board to evaluate the validity of the proprietary claim. The motion was denied on May 1, 1984.

## II. FINDING OF FACTS:

### A. Introduction

- 1 This decision involves the amendment of the Technical Specifications to the operating license for Unit 1 at Three Mile Island. Public hearings took place on July 16, 17 and 18, 1984. Parties present were the NRC Staff, The Commonwealth of Pennsylvania, GPU and TMIA.

### B. Contention 1a. Sub-Issues 1a. 1b. 1c.

- ..a. Reliability of Leak Rate Measurements
- 1.b. Method of Determining Frequency of ECF Tests
- 1.c. Method of Determining Power Ascension Limitations

- 2 Sub-issues 1a, 1b, and 1c concern the adequacy of proposed license conditions, resolution of these issues depends upon the accuracy of

Licensee and Staff's predictions that the steam generator tubes will 'leak before break' and thus whether these license conditions are adequate to insure that Licensee will detect cracks in time to prevent rupture. We have examined the Licensee's testing program and have found it inadequate, therefore we find that the proposed license conditions will not be sufficient to assure the safety of the public.

C. Contention 1a. Sub-issue 1d: The Adequacy of Simulation of Operating Conditions by Long-Term Corrosion Tests

- 3 An essential factor which underlies Licensee and Staff's reasoning that the proposed license will be sufficient to detect leakage or rupture, is the assertion that Licensee's so-called 'long-term corrosion test' is adequate and that the test will be reliably predictive of future tube failure. ff. Tr. 231 at 4.
- 4 The test utilized actual TMI-1 tube samples, which were selected from various regions of each OTSG, including a tube with a known defect. 1d at 5. There was no evidence with regard to the number of tube sections included in this test sequence. The test was designed to worst case chemistry conditions. Id Tube sections were thermally cycled and oxygen was introduced in an effort to simulate operating conditions as closely as possible. Id.
- 5 Other testing performed by the Licensee utilized archival tubes, these are tubes which have not been installed in the steam generator, they are stored in a warehouse, Tr. 574, (Slear), and of course, do not reflect the history of the tubes which have been in the TMI-1 steam generators for ten years.

6 At first glance, the long-term corrosion test appears to be well conceived, the use of actual TMI-1 tube samples adequately factors in the complete history of the TMI-1 steam generators. However, the test is seriously deficient. Licensee has failed to account for the mechanical stresses present in the steam generators, nor has Licensee introduced transient loads into the testing sequence. Clearly for a test to be adequately predictive, it must simulate all conditions which may be experienced during operation, including flow induced vibration and transient stresses. Licensee has stated that it never intended for this test to provide assurance that tube rupture due to mechanical failure will not occur. ff. Tr. 231 at 3. Licensee has provided no alternate means for gaining this assurance.

7 The type and magnitude of the corrosion damage and the subsequent repair method of the TMI-1 steam generators, are unprecedented in the nuclear industry. The Licensee bears a heavy burden of proof in demonstrating that its repair method is adequate, thereby providing assurance that the public health and safety will be protected. Licensee has not met that burden.

8 The Licensee had available a mechanism with which to simulate all operating conditions but chose not to use it. In response to Board questioning, witnesses stated that it would have been possible to simulate transient loads during the corrosion tests, but that it would have required an adjustment to the testing fixture. Tr. 541 (Giacobbe). They went on to say:

"...we didn't consider that it was necessary and therefore, we didn't persue it,.....Frankly, it didn't cross our minds to consider loading these tubes to design basis type loads."

Tr. 542, (Slear).

9 This incredible statement demonstrates a callous disregard for public safety, but it contradicts more importantly other statements made by the witnesses which make it clear that the actual TMI-1 tubes are not capable of withstanding the 3,140 pound design basis transient load. When asked if it would have been possible to subject the actual TMI tube samples used in the long-term corrosion test to abnormal transient stresses, the witness replied:

"We attempted to do that by putting in C-rings. ...We felt that we would go to the maximum load that one C-ring could tolerate, which was the yield strength."

Tr. 370, (Giacobbe)

10 The maximum load that the tube could tolerate falls far short of the 3,140 pound design basis load. When the Board asked again why the actual TMI-1 tube samples used in the long-term corrosion test were not subjected to large transient stresses, the witness responded:

"So we had samples or pieces of tubes stressed to the level you would expect the material to be stressed at during situations where you have a transient. But the tube itself, due to the limitations of the mock-up was only loaded to approximately 1,100 pounds."

Tr. 541, (Slear).

11 These two statements show the maximum load that the actual TMI-1 tubes can tolerate to be 1,100 pounds, and not the 3,140 pounds which Licensee has asserted. Furthermore, the statement that the Licensee just did not consider exposing the tube samples to transient loads is not truthful, rather it is designed to cover up the fact that the TMI-1 steam generator tubes cannot withstand design basis loads.

12 Therefore, because the Licensee has failed to include mechanical stresses as part of the long-term corrosion test sequence, and because the evidence

indicates that the actual TMI tubes will not withstand loads greater than 1,100 pounds, we find that the long-term corrosion test is not adequately predictive of conditions in the TMI-1 steam generators.

D. Contention 1.a. Issue 3. The reason for not including hardness tests on repaired tubes in the post repair testing program.

- 13 The hardness test is designed to determine the degree to which the TMI-1 tubing material has become embrittled. Licensee states that increased hardness can result in high residual stress, which in turn can increase susceptibility to intergranular stress assisted cracking. ff. Tr. 423 at 3.
- 14 The witness testified that Licensee wanted to measure the degree of hardness produced by the original rolled expansion and the degree of hardness resulting from the kinetic expansion and compare these measurements to a section of tube which had not been expanded by any means. Tr. 441 (Lee). Such a comparison could only be meaningful if all three measurements were taken from tubes of the same population. The actual TMI-1 tubes present the most logical population choice for the following reasons:
1. These tubes reflect the total history of the TMI-1 steam generators.
  2. These are the only tubes which feature the original rolled expansion.
  3. These tubes present the only accurate prediction of the response of the TMI-1 steam generators, with regard to high residual tensile stress.

- 15 Licensee witnesses testified that hardness tests were performed on actual TMI-1 tubes in the section encompassing the original rolled joint. Tr. 543 (Giacobbe). The tests to determine the hardening effects of kinetic expansion and the test of unexpanded tubing, however, utilized archival tubes. Tr. 442, (Lee). As we stated above, no meaningful conclusion can be drawn from a comparison of the results of tests conducted on different populations of tubing.
- 16 Furthermore, Licensee's Reference Document 19 - "TMI-1 OTSG Kinetic Expansion Repair - Structural Justification" at 42, reveals that when x-ray defraction was employed in detecting residual stresses in the transition zone on archival tubes, it was found that the stresses varied substantially, the document went on to state that 'The KSI value exceeds the .45 percent Y-S criterion by 48 percent.' Tr. 494 (Bradford). The archival tubes which were examined for hardness by this method, had of course never been in service in the steam generators, and have not been exposed to the sensitizing stress relief process as have the actual TMI-1 generator tubes. In fact, since Licensee has chosen not to test for the hardening effects of the kinetic expansion on the severely sensitized TMI tubes, we can have no confidence that this process has not increased the hardness, thereby decreasing the yield strength of the TMI-1 steam generator tubes.
- 17 In addition to high residual stresses resulting from hardening, common sense dictates that as a material becomes embrittled it loses ductility and yield strength. Tr. 442 (Giacobbe). Licensee witnesses testified that yield strength



is one of the key parameters in determining the reliability of the expanded joint, ff. Tr. 379 at 5, therefore a determination of the hardening effects of the kinetic expansion is essential to insure the integrity of the joint. And record reveals other instances of loss of yield strength, which would indicate that subjecting a tube to repeated kinetic expansions increases the hardening effect.

- 18 The Licensee claimed 'proprietary privilege' attached to this information, and we disallowed cross examination on this issue, we also expunged material from the record, Tr. 442 (Wolfe) therefore, it was not possible to develop the record fully on this important issue. Nevertheless, from the evidence available, we find that Licensee should have performed tests for hardness after the kinetic expansion process.

E. Contention 1a. Issue 4

Recalling Licensee's statement in #6-8 that the use of kinetic expansions to seal heat exchanger tubes with tubesheets has a broad base of successful experience, information is requested about whether tube integrity during subsequent operation depends on whether the process is a repair, or a manufacturing process using new materials.

- 19 In addition to relying on their qualification program, Licensee directed the Board's attention to industry experience with kinetic expansion as a method of repair. Dr. David H. Pai, Senior Vice-President of the Engineering and Services division of Foster Wheeler Energy Applications, Inc.,

(F.W.) appeared before us to testify on this issue. F.W. was responsible for implementation of the actual repair. F.W. also conducted the qualification program which they helped to develop. Dr. Pai had overall responsibility for both of these programs. ff. Tr. 379 at 1.

20 During his direct testimony, Pai revealed that there was no correlation between F.W.'s prior experience with kinetic expansion as a method of repair, and the repair of the TMI-1 steam generators. In fact the prior experience listed in his written testimony involved heat exchangers other than steam generators. Tr. 409 (Pai). He said that F.W. had never conducted tests to determine if the repair was successful after the repaired plant was returned to service. Pai further stated that these other applications of repair method did not require stringent quality assurance, nor were they subject to the same stringent leak rate limits as TMI. Tr. 404, 401 (Pai). Pai also stated:

"...the TMI repair requirements of certain leak rates and the requirements of pull out strength, those are the kinds of requirements that generally are not imposed in a commercial program."

Tr. 396 (Pai)

The reason of course, is all of the other applications referred to by the witness are either located in the secondary side of nuclear power plants, or are heat exchangers in fossil fuel plants. Tr. 403 (Pai). If these systems suffer a ruptured tube, or leak excessively for any reason, there will be no danger to the public. Additionally there is no need to constantly monitor leakage from these systems as there is at TMI-1, Tr. 401-402 (Pai), consequently, Dr. Pai's testimony was of no value in determining

the adequacy of the proposed license conditions for TMI-1.

21 Dr. Pai was deliberately evasive when he testified. Although Licensee had been aware for over a month prior to the hearings, that the Board's interest in industry experience, was to develop an understanding based on that experience, of the reliability of the newly formed tube to tubesheet joint. In our June, 1, 1984 Order, we stated that we had uncertainties with regard to the adequacy of 'leak rate measurements' among other things. Nevertheless, when Dr. Pai appeared at the hearing in behalf of the Licensee, he was asked to identify which of the plants listed in his written testimony were nuclear plants, he responded:

"I don't believe I can give you all the right identities, but we can supplement that. But off the top of my head, 1979 PSE&G for sure and some of the TVA plants are nuclear plants. But in order to be accurate we would have to supply you with which ones were nuclear and which were fossil."

Tr. 407 (Pai)

22 He was also asked which of the repairs to plants listed in Table 1 of his testimony involved repair of existing tubes to existing tubesheets, he replied:

"....The 1979 PSE&G, and I believe the 1981 Detroit Edison. Again I don't have the total background here, but we could supply that."

Id.

23 The witness told Judge Lamb that those repairs were comparable to the repairs at TMI. He was asked if there was continuing leak rate monitoring for those plants and he responded:

"I do not know the exact procedure they followed in terms of requirements during operation."

Tr. 409 (Pai)

24 It is not credible that Dr. Pai would not have discovered the answers to these questions when he was preparing his written testimony. He was in charge of the repair effort at TMI-1, and was aware of the importance of the leak rate requirements for the TMI-1 steam generators. Tr. 401-2 (Pai). He was also equally aware that no other heat transfer system repaired by F.W. using the kinetic expansion method had stringent leak rate requirements similar to those at TMI-1. Tr. 406 (Pai). Neither Dr. Pai, nor Licensee made any effort to supply the promised supplements. The Board is deeply troubled by the disingenuous testimony of Dr. Pai.

25 In addition to Pai's testimony, other Licensee witnesses testified to the lack of industry experience. Staff witnesses related industry experience with this method in Japan, Tr. 630 (McCracken) and in other foreign countries. Tr. 614 (McCracken). However, foreign plants are not subject to inspection by the NRC as are American plants. Tr. 615 (McCracken). Therefore, this industry experience does not correlate to the repairs of TMI-1, and the only method to evaluate the predictions of Licensee and Staff is to examine closely the qualification of the repairs, and thus determine whether the license conditions are adequate.

Archival tubes vs. actual TMI-1 Tubes

Although this was not an admitted contention, it became an issue during the hearing.

26 The record contains no evidence from which the Board can conclude that the qualification program is either reliable or sufficient. Licensee placed no evidence in the record on this issue, and while Licensee was unable to prepare written testimony without reference to the qualification program, Tr. 387 (Churchill), we nevertheless severely restricted questioning on

this important issue. See e.g. Tr. 394, 395. To the extent that questioning on this issue was permitted, either in a limited context related to the proposed license conditions, or in connection with other issues, it became apparent that the Licensee's qualification program is grossly deficient, as we discuss below.

27 Although Licensee's witnesses initially referred to the archival tube samples used in the qualification program as 'identical' to the tubes which experienced corrosion cracking in the TMI-1 steam generators, Tr. 465 (Giacobbe), they later conceded that the archival tubes were representative rather than identical to actual TMI-1 tubes. Tr. 531 (Slear). However, even this depiction of the correlation between the two sets of tubes is exaggerated. Licensee tested only three actual TMI-1 steam generator tubes to determine geometry and yield strength, Tr. 572 (Giacobbe), although these are the key parameters which affect the integrity of the expanded joint. ff. Tr. 379, at 5. Tr. 539 (Slear). Based on the results of these tests, Licensee concluded that the mechanical properties of 31,000 tubes are unaffected by ten years of operation and maintenance and by the corrosion damage. Tr. 572 (Giacobbe). It was impossible for the Board to test this assertion, since as we noted above, Licensee provided no evidence to support their testimony.

28 Mr. Slear's attempt to assure us that it is industry practice to analyze only 2 or 3 tubes, Tr. 532, does not take into account the amount and

unique nature of the damage to the TMI-1 steam generator. Tr. 532 (Slear).

With the exception of the limited data obtained from the three tubes, Licensee made no effort to factor the unique history of the TMI-1 steam generator tubes into the qualification test.

29 Witnesses testified that Licensee performed three crucial tests on the archival tubes which were not performed on actual TMI-1 tubes, these tests were: the hardness test, the pull-out test, and tests for leak tightness. Tr. 537 (Slear). Licensee admits that these tests could have been conducted on tube samples which were removed from the TMI-1 steam generators. This was not done because it would have created problems of dual responsibility between B&W and Foster Wheeler, Licensee's contractors. Tr. 538 (Slear). This feeble excuse is unacceptable, Licensee had available to them means with which to conduct a meaningful series of tests, the results of those tests would have provided an accurate prediction of expected conditions in the steam generators. Given the safety significance of these tests, Licensee's failure to conduct them on actual TMI-1 tubes is inexcusable.

30 In addition to the program deficiencies noted above, we heard evidence which indicates that the qualification program, although limited in scope and relevance to actual conditions in the steam generators, raised questions regarding the expanded joint's ability to maintain a good seal under certain transient loads.

31 Portions of Licensee's Reference Document 20 were read into the record. Tr. 556-7. The document is titled "OTSG Kinetic Expansion Qualification

Evaluation of Pull-Out and Leakage Data". Pages 7 and 9 of this document contained a series of calculations, followed by comments from the author of the document which suggest a reduction in pull-out load under certain conditions. The notation at the bottom of page 9 states: 'the difference in means is statistically significant.' Tr. 557 (Slear) (emphasis in original).

32 Witness Slear, whose qualifications identify him as the OTSG Repair Project Manager; ff. Tr. 224 (Slear) testified that he did not understand the document and was unable to explain it. Tr. 558 (Slear). He did say that part of this test was designed to examine tube response to increased temperatures, Tr. 567 (Slear), and noted that the test block in question was heated at 330°. Tr. 568 (Slear). It simply is not credible that the Repair Project Manager would not be familiar with all aspects of this important test, Mr. Slear is not being candid when he states otherwise. In fact he went on to discuss the tests at some length, carefully avoiding any mention of the failures identified during the testing. Tr. 567-8 (Slear). We terminated cross examination before this evidence could be developed, however, but the evidence before us, raises grave questions as to the newly formed joint's ability to maintain its integrity under certain conditions. And, despite the overall favourable conclusion, it is incumbent upon us to carefully scrutinize any weakness identified during testing, for the system is only as reliable as its weakest component.

33 The archival tubing was not representative of the tubes in the steam generators, and therefore tests utilizing the archival tubes are not predictive of conditions in the TMI-1 Steam generators.

B. Contention 1b. Issue 5: The Probability of Simultaneous Tube Ruptures Involving both TMI-1 Steam Generators

34 To evaluate this probability we must examine the facts established:

1. There is no industry experience with kinetic expansion which correlates with the repairs of the TMI steam generators.
2. The long-term corrosion program is not predictive of actual conditions in the TMI-1 OTSG.
3. The archival tubing used in the qualification program is not representative of the conditions of the actual TMI-1 tubing.
4. Actual tubes shown to have a maximum tolerance of 1,100 lbs. rather than the 3,140 lb. design basis transient load.
5. Licensee did not conduct post repair hardness tests on the actual TMI-1 tubes to determine if those tubes had reduced ductility and yield strength.
6. The yield strength of the tube is a key factor in determining the integrity of the repaired joint.

35 In addition to these facts it was established that 600 tubes slipped down and lost preload as a result of the corrosion damage, these tubes were then fixed in this new position by the kinetic expansion.



36 The loss of preload on these tubes has resulted in an increase of 290 pounds of compressive load. Tr. 478 (Croneberger). Licensee has not established the exact location of the 600 tubes within the tube bundle, Tr. 479 (Slear) and therefore is unable to determine if the tubes which lost preload also contain pre-critical defects, that is defects below the greater than 40% through wall plugging criteria. Tr. 484 (Slear). The tube will be weakened in the area of the defects. Tr. 347-8 (Croneberger). The 800 lbs. compressive load required to initiate bowing, Tr. 482 (Slear), will be exceeded under certain conditions for the 600 tubes. Since Licensee has not established the exact location of the tubes without preload, a strong possibility exists that 2 or more tubes are grouped together within the tube bundles of both steam generators, and if bowing occurs these tubes will rub and wear during operation which will result in rupture of one or more tubes in each steam generator.

37 Based on the facts reiterated above we find that Licensee has not provided adequate assurance that the kinetic expansion repair has significantly reduced the probability of simultaneous tube rupture in both TMI-1 steam generators.

III. CONCLUSIONS OF LAW

38 Based upon the preponderance of the reliable, probative and substantial evidence of record in this proceeding, and the foregoing findings of fact related to the amended license request by Licensee should be denied.

Respectfully submitted,

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August 10, 1984

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### III. CONCLUSION OF LAW

UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

DOCKETED  
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'84 AGO 13 A11:44

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METROPOLITAN EDISON COMPANY, ET AL.  
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Docket No. 50-289

(Steam Generator Repair)

August 10, 1984

OFFICE OF PUBLIC AFFAIRS  
DOCKETING SERVICE  
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CERTIFICATE OF SERVICE

I hereby certify that copies of "Proposed Findings of Fact and Conclusions of Law of Three Mile Island Alert, Inc., (TMIA) On the Steam Generator Repair On Unit, No. 1" were served, by deposit in the U.S. Mail, first class, postage prepaid, or hand-delivered to parties noted by \*, to all those persons on the attached Service List, this 10th day of August, 1984.

*Louise Bradford*

Louise Bradford

Dated: August 10, 1984

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