METROPOLITAN EDISON COMPANY

JERSEY CENTRAL POWER & LIGHT COMPANY

AND

PENNSYLVANIA ELECTRIC COMPANY

THREE MILE ISLAND NUCLEAR STATION, UNIT 1

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Operating License No. DPR-50
Docket No. 50-289
Technical Specification Change Request No. 153

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This Technical Specification Change Request is submitted in support of Licensee's request to change Appendix A to Operating License No. DPR-50 for Three Mile Island Nuclear Station, Unit 1. As a part of this request, proposed replacement pages for Appendix A are also included.

GPU NUCLEAR CORPORATION

BY R J Toole for
Director, TMI-1

Sworn and Subscribed to before me this 4th day of February, 1986.

Sharon P. Brown
Notary Public

SHARON P. BROWN, NOTARY PUBLIC
MIDDLETOWN BORO, DAUPHIN COUNTY
MY COMMISSION EXPIRES JUNE 12, 1989
Member, Pennsylvania Association of Notaries

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

IN THE MATTER OF

DOCKET NO. 50-289
LICENSE NO. DPR-50

GPU NUCLEAR CORPORATION

This is to certify that a copy of Technical Specification Change Request No. 153 to Appendix A of the Operating License for Three Mile Island Nuclear Station Unit 1, has, on the date given below, been filed with executives of Londonderry Township, Dauphin County, Pennsylvania; Dauphin County, Pennsylvania; and the Pennsylvania Department of Environmental Resources, Bureau of Radiation Protection, by deposit in the United States mail, addressed as follows:

Mr. Jay H. Kopp, Chairman
Board of Supervisors of
Londonderry Township
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Mr. Norman P. Hetrick, Chairman
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GPU NUCLEAR CORPORATION

BY RJ Toole for
Director, TMI-1

DATE: February 4, 1986

## I. TECHNICAL SPECIFICATION CHANGE REQUEST (TSCR) NO. 153

GPUN requests that the attached revised pages (Attachment 1) replace pages 4-80 and 4-82, and add page 4-80a in the TMI-1 Technical Specifications.

## II. REASON FOR CHANGE

GPUN in the past has repaired OTSG tubes based on a general 40% throughwall repair limit. This repair limit defines as acceptable a tube with an imperfection extending up to 40% of the tube wall thickness. The imperfection may be up to 360° in circumferential extent. GPUN recently has developed an analytical basis to demonstrate that an equivalent margin to safety can be provided by a tube with an imperfection of greater than 40% of the tube wall thickness and a given continuous length (specifically, 50% of the tube wall thickness with a continuous length of 0.55 inches on the interior wall of the tube). Eddy current technology has evolved such that it is possible to characterize continuous imperfections in terms of volumetric degradation, more specifically circumferential or axial extent, as well as throughwall penetration.

Implicit in the application of the general 40% throughwall repair limit have been an allowance of 10% on the throughwall extent for inaccuracies associated with the eddy current detection capability, and an allowance of 10% for corrosion. GPUN has demonstrated eddy current capability to characterize imperfections with inaccuracy of less than 10% of nominal throughwall. Also, GPUN has demonstrated to the satisfaction of the NRC staff, as well as the Atomic Safety and Licensing Board, that corrosion is not an ongoing phenomenon in the primary side of the TMI-1 Once Through Steam Generators.

Also, application of the proposed criteria would result in a reduction in occupational radiation doses. During the most recent TMI-1 eddy current outage beginning in November 1984, GPUN removed from service 328 tubes by plugging, 118 of which would have been dispositioned to remain in service in accordance with the repair limit proposed herein. The occupational exposure rate inside the OTSG's during the 1984 plugging activity was approximately 700mR/hr. which resulted in an average exposure of approximately 120mR per tube. GPUN cannot make a projection at this time as to the number of tubes which will require removal from service, if any, during the next eddy current outage; however, based on recent history of plant operation, an exposure rate of 2-10R/hr within the steam generators is anticipated. Thus, a significant reduction in occupational exposure could be expected with application of the proposed repair limit.

## III. SAFETY EVALUATION JUSTIFYING CHANGE

The existing steam generator tube repair limit defines as acceptable a tube with a imperfection extending up to 40% of the tube wall thickness and up to 360° in circumferential extent and unlimited axial extent. This is based on analyses and state of the art eddy current technology typical of the mid 1970's. With today's eddy current technology, imperfections can be better characterized in terms of volumetric degradation, more specifically circumferential, as well as throughwall penetration. Recent analyses have demonstrated the acceptability of tubes based on the extent of both depth and length of the imperfection. These analyses show that many imperfections exceeding 40% throughwall are acceptable because they would not be of a size or configuration, either at the time of ECT detection or during the interval between inspections, to adversely affect the degree of required tube integrity. Hence, the proposed criteria are based on the total cross section of unimpaired tube remaining in the tube freespan, rather than a consideration of throughwall depth alone.

The following paragraphs discuss the analytical basis for the proposed repair limit based on extent of volumetric degradation, the characterization of defects previously discovered in the TMI-1 OTSG tubes, the capabilities of the eddy current program in place at TMI-1, and compliance with NRC General Design Criteria 14, "Reactor Coolant Pressure Boundary," 15, "Reactor Coolant System Design," and 31, "Fracture Prevention of Reactor Coolant Pressure Boundary." Also provided, as Appendix A, is TDR-758, "Assessment of 50% TW Repair Limit with Respect to Reg. Guide 1.121 Guidelines" which presents a detailed demonstration that the proposed criteria are in accordance with the guidelines presented in Regulatory Guide 1.121.

GPUN has demonstrated that a imperfection extending greater than 0.55 inches in continuous length with a throughwall penetration of 50% can withstand loads associated with normal operation and faulted conditions (i.e., main steam line break), with margins to safety as suggested in Reg. Guide 1.121, assuming a 10% allowance on nominal throughwall for eddy current inaccuracy. The error associated with the eddy current process at TMI-1 has been shown to be within this allowance.

The proposed criteria apply to primary side (internal diameter, ID) imperfections only. Areas of reduced eddy current sensitivity on the primary side (namely, the upper and lower tubesheet secondary faces and tube support plate entry and exist locations) are excluded; the repair limit for indications in these areas remains 40% of the nominal tube wall thickness.

The proposed criteria address imperfections both predominantly circumferential in orientation and predominantly axial in orientation. The analytical basis was derived for both axial and circumferential imperfections; however, no axial imperfections have been found in the ID tube freespan, either during previous eddy current examinations or metallographic examinations. The TMI-1 Eddy Current Inspection Progam can discriminate between axial and circumferential imperfections.

## ANALYTICAL BASIS

The bases for plugging criteria based on extent of volumetric degradation were developed from several existing analyses of the serviceability of flawed tubes under normal, transient or accident conditions. These analyses included ASME Section III (Ref. 1) and Section XI (Ref. 2) fatigue evaluations, and a solid mechanics single accident load (Main Steam Line Break Accident, MSLB) analysis conducted as part of GPU Nuclear's response to the 1981 tube cracking experience, as presented in TR-008 (Reference 3). These analyses have been previously reviewed and endorsed by the NRC staff.

GPUN's approach to determining a minimum required tube wall thickness was twofold: (a) to establish by fatigue analysis that tubes inservice would not develop cracks under normal operating conditions, even in areas of suspected degradation and (b) to demonstrate that existing cracks, should they go undetected, would not propagate throughwall under normal operating or postulated accident loading conditions. GPUN's evaluation combines the methodology of both ASME Sections III and XI in order to assess the reduction in fatigue resistance caused by identified or hypothetical ECT indications. ASME Section III provides guidance for designing nuclear pressure components against failure; ASME Section XI provides guidance for evaluating the impact of suspected flaws in pressure retaining components in service.

1. ASME Section III Fatigue Analysis

   The Section III fatigue failure analysis uses crack initiation as the criterion for loss of fatigue resistance of the material; therefore design using this approach assumes only a degraded material condition and not outright structural failure. The approach used to enter the ASME III design fatigue curve was originally discussed in TDR-421 (Ref. 4) and is summarized in TR-008 (Ref. 3), which formed a basis for NRC conclusions in NUREG-1019 (Ref. 5).

2. Non-Propagation of a Hypothetical Crack

   In ASME Section XI, the methods of linear elastic fracture mechanics (LEFM) are recommended. In this approach the presumed crack is analytically interacted with the local stress field in order to predict enlargement and propagation as service loads (both mechanical and thermal) are cycled in the anticipated manner. As discussed previously in TDR-388 (Ref. 6) and TR-008, a particular fracture mechanics solution was used by GPUN in order to properly model the response of a thin tube to the presence of an ID circumferential crack under applied axial load, internal pressure, and bending stress due to flow induced vibration.

The aim of this analysis was to demonstrate the adequacy of the threshold of ECT detection sensitivity; however, the results of that analysis also satisfy the Section XI flaw acceptance criteria when combined with the results of the main steam line break analysis.

The rupture strength of a flawed tube to the maximum axial load, applied one time only, was evaluated under the faulted condition of a main steam line break (MSLB). The tube response was analyzed by methods of solid mechanics, capturing the increased flexibility of the tube at the elevation of the flaw and utilizing the flow stress as the limited material condition.

Based on these discussions in TR-008, the NRC staff reached the following relevant conclusions on page 12 of NUREG-1019 (Ref. 5):

1. Cracks which are large enough, i.e, critical size, to propagate due to flow-induced vibration are readily detectable by ECT;

2. Cracks which are below the threshold of ECT detectability will not propagate under combined cyclic, flow-induced and thermal loadings;

3. The maximum crack size which will remain stable during a MSLB has been determined;

4. Throughwall defects which may propagate during operation can be detected well below the threshold size that could fail during a MSLB.

3. Conclusion

The analytical results of the ASME Section III fatigue evaluation, the Section XI LEFM results, and the MSLB solid mechanics evaluation were developed in terms of allowable tube wall degradation. The proposed revision to the plugging criteria (i.e, a repair limit based on degradation less than 50% throughwall penetration with a length of no greater than 0.55 inches, or 40% throughwall penetration for lengths greater than 0.55 inches) bounds the Section III fatigue evaluation, the Section XI LEFM results, and the MSLB solid mechanics analysis. In addition, the margin separating the ASME Section III fatigue analysis results and the proposed plugging criteria of 50% throughwall with a length no greater than 0.55 inches is twenty percentage points (20% on nominal throughwall). The margins separating the ASME Section XI analysis and the solid mechanics single accident load analysis are even greater (See TR-008 Figure IX-2).

## CHARACTERIZATION OF TMI-1 OTSG DEFECTS

In order to identify the cause of eddy current indications detected during the TMI-1 OTSG tube examination beginning in November, 1984, GPUN performed an in-depth review of the eddy current results and plant chemistry history since the OTSG's were first filled after the kinetic expansion repairs. The results of this analysis were initially presented to the NRC in TDR-638 "Evaluation of Eddy Current Indications Detected During the 1984 Tech. Spec. Inspection" Rev. 0 (Reference 7), and subsequently in TDR-638 Rev. 1 (Appendix B). TDR-638 discusses the two possible causes evaluated for the 1984 eddy current indications: corrosion, either continuing or newly initiated, and enhanced eddy current detectability of existing intergranular attack (IGA) or intergranular stress assisted cracking (IGSAC), and concludes that the most likely reason for having eddy current indications at this time was enhanced detectability of preexisting areas of IGA/IGSAC.

TDR-652 "Evaluation of the 1984 Required Technical Specification Examination of the TMI-1 OTSG" (Appendix C) provides an in-depth evaluation of the results of the 1984 eddy current examination, and concludes that the 1984 examination identified indications that were already present in the tubes in 1982 but because of their weak signal amplitude were masked by background noise. TDR-652 also concludes that the mechanical, thermal and hydraulic loads imposed on the OTSG since the 1982 examination may have enhanced the eddy current detection of small indications by increasing the signal amplitude but without evidence of increase to percent throughwall. The review of the 1984, 1983 and 1982 examination results revealed that the percent through wall determination showed no trend of continued throughwall growth, and provided no evidence of an active mechanism occurring during the period of observation.

Recently, additional investigations were performed in an attempt to further characterize the intergranular attack (IGA) that existed in the OTSG's as a result of thiosulfate intrusion into the RCS in 1981 as well as to help clarify the sensitivity and accuracy of eddy current examination for IGA/IGSAC, as summarized in TDR 686, "Characterization of IGA in TMI-1 OTSG Samples," Rev. 1 (Appendix D). Existing reports were reviewed and reported IGA areas were characterized. Tubes that had been previously removed and stored were eddy current and fiberoptic inspected. Two tube sections were also cut and examined by metallography. TDR-686 concludes that the metallographically determined sizes of IGA patches were below the established level of eddy current sensitivity for IGSAC.

## CAPABILITY OF TMI-1 EDDY CURRENT TECHNIQUE

During eddy current examination of the TMI-1 OTSG's the percent throughwall penetration of a discontinuity is determined by measuring the signal's phase angle and using a conversion curve to determine the percent throughwall. The traditional curves used for this purpose are designed for outside diameter discontinuities. For inside diameter discontinuities the percent throughwall determinations are obtained by extrapolation from the outside diameter curve. This traditional extrapolation tends to overcall small volume inner diameter discontinuities. The presence of inner diameter initiated, intergranular stress assisted cracks in the TMI-1 OTSG's has required GPUN to develop a more accurate means of assigning the percent throughwall values.

In TDR-642, "Qualification of Conversion Curve for Inner Diameter Discontinuities", (Appendix E), GPU Nuclear Corporation developed a conversion curve which more accurately represents small volume, inner diameter initiated discontinuities, by enhancing the traditional inner diameter conversion curve with supplemental data from EDM notches with various known depths. The accuracy of the enhanced curve was verified through metallurgical correlations using actual IGSAC.

The ECT accuracy may be demonstrated using six data points (eddy current calls) from these metallurgical samples. The mean of these six data points represents an overcall of 13.4%. A statistical evaluation resulted in a standard deviation of + 16.7%. Thus, within one standard deviation, an undercall of up to 3.3% was observed which is well within the allowance for eddy current error. As discussed under ANALYTICAL BASIS, above, the minimum margin separating the fatigue analysis results from the new plugging criteria of 50% throughwall penetration with a length no greater than 0.55 inches is twenty percentage points (20% on nominal throughwall thickness).

## COMPLIANCE WITH GENERAL DESIGN CRITERIA 14, 15 and 31

Use of the proposed repair limit would not reduce or alter the extent of TMI-1 compliance with General Design Criteria 14, 15, and 31.

1. General Design Criterion 14 - Reactor Coolant Pressure Boundary

   GDC 14 specifies that the reactor coolant pressure boundary shall be designed, fabricated, erected and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

   The proposed change does not involve any change to the reactor coolant pressure boundary design, fabrication and erection.

   The OTSG tubes have an extremely low probability of abnormal leakage or of rapidly propagating failure as demonstrated, by the margin (greater than 30% of nominal throughwall) between the proposed plugging criterion and the LEFM Section XI analytical results. In addition, the TMI-1 Operating License includes the exceedingly restrictive condition that if primary to secondary system leakage exceeds the baseline leakage rate by more than 0.1 gpm, the facility is to be shutdown and the leaking tube(s) removed from service.

Also, the probability of gross rupture is extremely low, as demonstrated by the margin (greater than 40% of nominal throughwall) to the results for loadings associated with the Main Steam Line Break analysis. Independent analysis in TDR-758 (Appendix A) has demonstrated adequacy of the proposed plugging criteria for loads associated with faulted conditions, with a margin to safety of 1.428, as prescribed by Reg. Guide 1.121.

2. General Design Criterion 15-Reactor Coolant System Design

GDC 15 specifies that the reactor coolant system and associated auxiliary, control and protection systems shall be designed with sufficient margin to assure that the design conditions of the reactor coolant pressure boundary are not exceeded during any condition of normal operation, including anticipated operational occurrences.

As discussed under ANALYTICAL BASIS, above, GPUN has verified that sufficient margin exists with the proposed plugging criteria such that design conditions of the OTSG tubes are not exceeded during any condition of normal operation, including anticipated operational occurrences.

3. General Design Criterion 31-Fracture Prevention of Reactor Coolant Pressure Boundary

GDC 31 specifies that the reactor coolant pressure boundary shall be designed with sufficient margin to assure that when stressed under operating, maintenance, testing and postulated accident conditions (1) the boundary behaves in a nonbrittle manner and (2) the probability of rapidly propagating fracture is minimized. The design shall reflect consideration of service temperatures and other conditions of the boundary material under operating, maintenance, testing and postulated accident conditions and the uncertainties in determining (1) material properties, (2) the effects of irradiation on material properties, (3) residual, steady state and transient stresses, and (4) size of flaws.

The use of the proposed criteria would not alter the boundary material and hence would not affect the nonbrittle behavior of the boundary material.

As discussed under GDC 14, above, sufficient margin is provided to minimize the probability of rapidly propagating fracture.

The analysis presented herein includes consideration of service conditions associated with operating and postulated accident conditions. Loads associated with maintenance and testing conditions are small by comparison, and are enveloped by the loads assumed in the analyses.

The analytical results include a margin of twenty percentage points or greater on throughwall for the proposed plugging criteria of 50% throughwall with a length no greater than 0.55 inches to account for uncertainties in determining flaw size.

4. Conclusion

Use of the proposed criteria would not reduce the extent of compliance with General Design Criteria 14, 15 and 31.

REFERENCES


1. ASME Boiler and Pressure Vessel Code Section III 1977 Edition and Addenda through Summer 1978.

2. ASME Boiler and Pressure Vessel Code Section XI 1977 Edition and Addenda through Summer 1978.

3. TR-008, "Assessment of TMI-1 Plant Safety for Return to Service After Steam Generator Repair," Rev. 3, August 1983.

4. TDR-421, "Steam Generator Adequacy of Tube Plugging and Stabilizing Repair Criteria." Rev. 0, March 1983.

5. NUREG-1019, "Safety Evaluation Report Related to Steam Generator Tube Repair and Return to Operation - Three Mile Island Nuclear Station Unit No. 1."

6. TDR-388, "Mechanical Integrity Analysis of TMI-1 OTSG Unplugged Tubes," Rev. 3, May 1983

7. TDR-638, "Evaluation of Eddy Current Indications Detected During the 1984 Tech. Spec. Inspection," Rev. 0, January 1985.


IV. NO SIGNIFICANT HAZARDS CONSIDERATIONS

Application of the revised OTSG tube repair limits would not involve significant hazards considerations for reasons as follows:

1. Use of the proposed criteria would not involve a significant increase in the probability of occurrence or consequences of an accident previously evaluated.

   The proposed criteria provide assurance of OTSG tube wall integrity under normal operating conditions. In accordance with the recommendations of Reg. Guide 1.121, a margin of safety against ductile failure equal to 3.0x normal loads has been verified. Thus, use of the proposed criteria does not involve a significant increase in the probability of occurrence of a steam generator tube rupture event.

The proposed criteria also provide assurance that the OTSG tube wall integrity will be maintained under faulted conditions, specifically under loads associated with the main steam line break accident. In accordance with the recommendations of Reg. Guide 1.121, a margin of safety against ductile failure equal to 1.428x upset loads has been verified. Thus, use of the proposed criteria does not involve a significant increase in the consequences of an accident previously evaluated.

2. Use of the proposed criteria would not create the possibility of a new or different kind of accident from any accident previously evaluated.

   Use of the proposed criteria has no bearing on any accident other than the steam generator tube rupture or main steam line break, discussed above.

3. Use of the proposed criteria would not involve a significant reduction in a margin of safety.

   The margin of safety for the proposed revised criteria is no less than the licensing basis for the existing repair limit. The limiting margin of safety previously approved by NRC is not affected or reduced. The margin separating the proposed revised criteria from the analytical results for normal operating and faulted conditions is in accordance with the guidelines of Regulatory Guide 1.121.

Thus, the use of the proposed criteria involves no significant hazards considerations.

## V. IMPLEMENTATION

It is requested that the amendment authorizing this change become effective immediately after receipt.

## VI. AMENDMENT FEE (10CFR 170.21)

Pursuant to the provisions of 10CFR 170.21, a check for $150.00 is being forwarded by separate correspondence as payment of the fee associated with this TSCR.