UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

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MEMORANDUM FOR: Bernard J. Snyder, Program Director
Three Mile Island Program Office, ONRR

FROM: George Lear, Chief
Structural and Geotechnical Engineering Branch
Division of Engineering

SUBJECT: EVALUATION OF STRUCTURAL DESIGN ADEQUACY OF TMI 2 INTERNALS HANDLING AND INDEXING FIXTURE (TRIPOD)

Docket Number: 50-320
License Number: DPR-73

Reference: Memorandum from B. Snyder to G. Lear, dated August 3, 1983

As requested in the reference, R. E. Lipinski of Structural Engineering Section A of the Structural and Geotechnical Engineering Branch has reviewed the subject matter. He also attended meetings held at the TMI site on August 5, 1983 and at Lynchburg, Virginia on August 31, 1983. Our evaluation of the structural adequacy of the tripod is enclosed.

George Lear

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Enclosure: As stated

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Evaluation of Structural Adequacy Reactor Vessel Head and Internals Handling Fixture (Tripod) at Three Mile Island 2

Structural Engineering Section A
Structural and Geotechnical Engineering Branch

Background

The tripod is a special device which enables the reactor building crane to lift heavy loads such as the reactor vessel head and the reactor internals. The tripod at the Three Mile Island 2 was designed in 1960 and fabricated in 1972. The structural design of the tripod was based on limiting the stresses of structural members below the yield stress of the structural steel, which is 36,000 psi and the weld stresses below the American Institute of Steel construction (AISC) allowables. Several other tripods have been built according to the same criteria and to the same drawings (e.g., Crystal River 3 and Arkansas No. 1). During the inspection of the tripod at the Crystal River plant, it has been found that some of the welds are smaller than those called for in the design drawings. In view of the anticipated use of the TMI-2 tripod during the planned recovery operations, which include lifting the reactor vessel head and internals, it became necessary to verify both the design adequacy and structural integrity of the TMI-2 tripod.

The Structural and Geotechnical Engineering Branch has been requested to provide the necessary technical expertise in evaluating the tripod design adequacy. The following summarizes the scope of our review and the review conclusions.

Scope of Investigation

In view of the lack of QA/QC information and original design calculations, the TMI-2 licensee, proposed a plan for evaluating and verifying the design adequacy of the TMI-2 tripod. The structural aspects of this plan included verification of the sizes of welds, stress analysis and load testing as well as needed tripod repairs and modifications. As a result of a series of communications between the staff and the licensee, it was agreed that the structural analysis will be performed by the licensee to satisfy the current NRC loading criteria as well as the applicable structural design codes and specifications. The analysis will be based on as built conditions. In addition to the analytical investigation, the tripod will be load tested using 1.2 times its rated capacity, which is 340 kips. Furthermore, the licensee agreed to provide information regarding welders workmanship, discuss the disposition of inaccessibility of welds, and address the conservatism used in the tripod design. The staff requested that the licensee correlate the available information for the Crystal River and the Arkansas plant's tripods with that of the TMI-2 tripod in order to provide an additional basis for demonstrating the tripod design adequacy.

Partial Tripod Model Analysis to Determine Adequacy of the Welds and Structural Members

The actual sizes of the fillet welds have been measured by the licensee to determine the minimum effective throat dimensions. These as built weld dimensions are used in computing the weld stresses.

Since the handling fixture is symmetrical both with respect to structural load application and geometry, only one leg and one compression member were modeled. The model included also the clevis plates and the gusset plates. The analysis used the finite element method and the ANSYS computer code. ANYS is a computer code, in public domain, capable of performing static and dynamic analysis of a wide range of problems and includes features to handle elastic and plastic behavior of the material. The model consisted of 641 elements and 706 nodes. The results of the analysis were also used to determine adequacy of tripod members. In order to account for a possible dynamic effect due to jerking of the crane cable, a load factor of 1.5 was used resulting in 85 kips load at the six clevis plates, and 510 kips load at the pick-up point. The computed member stresses were compared with each of the allowables contained in the American Institute of Steel Construction (AISC) "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings," Eighth Edition. The licensee provided the results of the analysis which indicate that for the required safety factor of three the stresses in the critical welds are below the AISC allowables. The maximum computed shear stress of 17.8 ksi is located at the gusset plate to tripod leg junction which is less than the AISC allowable of 18.0 ksi, therefore, is acceptable.

Three Dimensional Frame Analysis of Tripod

In order to ascertain that the partial structural model used in the previous analysis realistically represents the entire structure, accounting for some localized variations in weld orientation, another analysis was performed using a gross three-dimensional frame model. This analysis used also the ANSYS computer code.

The results of the analysis show that the variations of the axial load and bending moment at the three legs of the tripod from those obtained in the partial model analysis are 0.03% and 0.94%, respectively, and are considered negligible. On the basis of this analysis, the staff concludes that the partial tripod model used for evaluation of the welds is acceptable.

Analysis Using the Criteria of the ANSI-N.14.6

The present recommendations for design of lifting devices such as the tripod, endorsed by the staff, are those contained in the ANSI N14.6-1978, "American National Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds of More for Nuclear Materials," which requires that the load bearing members be capable of lifting three times the combined weight of the shipping container without exceeding shear or tensile yield stress of the material. The standard also requires that a factor of five is applied to the lifting device without resulting in exceeding the ultimate strength of the material.

The tripod was analyzed for these conditions and the results indicate that with a load factor of three the yield stress in any member of the tripod is not exceeded. Similarly, when analyzed with a load factor of five, the stresses did not exceed the ultimate strength of the material.

Loading Test of the Tripod

The licensee committed to implement a load test program to demonstrate that the tripod is capable of carrying a 1.2 times the rated capacity. Implementation of such a test program will constitute a positive verification of the structural integrity of the tripod for its rated load and, therefore, will provide a major basis for its acceptance.

Additional Information Reviewed for Judging the Tripod Design Adequacy

The additional information reviewed to judge the adequacy of the tripod included a description of qualifications of the welders, the details on the accessibility of the welds which might offer a better insight on the quality of workmanship, a description of the potential effects of the environmental conditions which prevailed during the TMI-2 accident on the material of the tripod and the conservatism adopted in the original tripod design which might compensate for the lack of the information related to the QA/QC issues. The results of staff evaluation of the above items further supported the findings obtained, based on the analyses discussed previously. The staff also took into consideration the fact that the tripod had been used several times in lifting the reactor head and has not shown any detrimental effect or overstressing of the structural members,an additional basis for establishing the adequacy and acceptability of the TMI-2 tripod.

Conclusion

Based on the above described analyses, discussions and findings, the staff concludes that there is a reasonable assurance that the TMI-2 Category I tripod structure will successfully carry its rated load without impairment of its structural integrity or the ability to perform required safety functions.

References

1. Three Mile Island Unit 2 Reactor Vessel Head and Internals Handling Fixture Serviceability Evaluation." Prepared for GPU Nuclear Corporation by Babcock and Wilcox, July, 1983.

2. TMI-2 Tripod Weld Evaluation, September, 1983. Calculation Package 32-1145001-00.

3. AISC Manual of Steel Construction, 7th Edition, AISC, Inc., New York, New York.

4. AISC Manual of Steel Construction, 8th Edition, AISC Inc., New York, New York.

5. Letter from B. K. Kanga of GPU to B. J. Snyder dated October 4, 1983.

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