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Docket Nos.: 50-440/441

SEP 21 1983

Mr. Murray R. Edelman
Vice President - Nuclear Group
The Cleveland Electric Illuminating Company
P. O. Box 5000
Cleveland, Ohio 44101

Dear Mr. Edelman:

Subject: Acceptability of the Containment Steel Shell Weld Deficiencies and the Containment Annulus Concrete Fill Design Modification for the Perry Nuclear Power Plant (Units 1 and 2)

The NRC staff has completed its review of the containment steel shell weld deficiencies addressed in your letters dated May 31, 1983 and June 22, 1983. It was requested that the staff accept your proposal not to require the repair of the weld flaws in the lower first four circumferential weldments of the steel shell, inaccessible for repair because of subsequent construction work, based on the technical justification provided in your submittals. The staff has also completed its review of the containment annulus concrete fill design modification you proposed for reducing stresses in the containment structure due to safety-relief valve actuation, addressed in your letter dated April 25, 1983.

The staff has reviewed these submittals and finds that the design, analyses, materials and construction aspects of the containment steel shell weld deficiencies, the containment annulus concrete fill design, and the deviations to the ASME Code proposed for both these areas, are acceptable. The analysis performed by Aptech Engineering Services, Inc. on your behalf is considered to be quite conservative and demonstrates that General Design Criterion 51 would be met without repairing the weld flaws. The staff finds that the containment annulus concrete fill design and deviations to the ASME Code requirements proposed would meet the intent of the Code and the applicable provisions of the NRC Standard Review Plan (NUREG-0800, Section 3.8.1) Enclosed are the staff's specific technical evaluation, findings, and conclusions with respect to these areas, which we propose to include in the next SER supplement to be issued in November 1983.

Sincerely,

Original signed by:
B. J. Youngblood

B. J. Youngblood, Chief
Licensing Branch No. 1
Division of Licensing

Enclosure:
As stated

cc w/encl.: See next page

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Enclosure

NRC STAFF EVALUATION

OF

CONTAINMENT STEEL SHELL WELD FLAWS

AND

PROPOSED ANNULUS CONCRETE FILL

DESIGN MODIFICATION

PERRY NUCLEAR POWER PLANT (UNITS 1 AND 2)

In Section 3.8.2 of SER Supplement No. 3 (April 1983), the staff indicated that it was in the process of evaluating: (a) weld deficiencies located in the containment steel shell (in the region of the suppression pool area) found by re-radiography of the welds; and (b) the placement of concrete in the annulus adjacent to the suppression pool area. The purpose of the annulus concrete is to reduce stresses in the containment vessel due to vibration caused by safety-relief valve actuations.

The staff has since completed its review of these items, the results of which are presented below.

Background

The first item, containment steel shell weld flaws, relates to the commitment made by the applicant in Section 3.8.2 of the Perry FSAR which states that the steel containment structure will be designed and built in accordance with the requirements of ASME Code, Section III, Subsesction NE. However, this commitment was not fully met by the applicant because of the fact that several radiographs taken of the welds, now inaccessible due to completion of subsequent construction work, were found not to meet the ASME Code requirements pertaining to implementation of a cost effective program of re-radiographing and or repairing the flawed welds. As an alternative solution, the applicant performed a fracture fatigue analysis of the inaccessible flawed welds, and requested that deviations to the ASME Code requirements concerning radiography or repair be accepted by the staff on the results of their fracture fatigue analysis.

The second item, design adequacy of the containment annulus concrete fill, pertains to the material testing procedures used for the annulus concrete construction. Originally, there was a five (5) foot wide annulus between the steel containment vessel and the shielding building for the entire containment height. However, with the consideration of safety-relief valve (SRV) vibratory loads for the BWR Mark III containment design, it became necessary to fill this annulus with reinforced concrete for a height of 23ft-6in. above the top of the foundation mat (basement) in order to dampen vibratory loads induced within the containment vessel due to SRV actuations. The applicant assumed, in his analysis of the annulus concrete, a composite action of the steel vessel, the annulus concrete and the shielding building to resist the increased loads due to SRV actuations. Furthermore, the staff questioned the appropriateness of the material testing procedures developed for the annulus concrete which also required resolution by the applicant.

Following, is the staff's evaluation of these two items, its conclusions, and the technical basis for the conclusions reached.

Deficiency of the Containment Steel Shell Welds

The location of the questionable inaccessible steel shell weld flaws is in the lowest weld courses of the containment vessel for both Perry Units 1 and 2. (i.e., the first four circumferential welds from the steel shell/basemat interface). These welds were fabricated by Newport News Industrial Corporation (NNIC), and were initially accepted based on a review of their radiographs by NNIC and the Authorized Nuclear Inspector (an inspector retained by the applicant to perform independent inspections for compliance with piping and vessel codes). The welds were made in the 1976-1982 time period, and were radiographed shortly after they were completed. The radiographs were re-reviewed in early 1982 as the basis for continued acceptance of the welds, when the ASME-required magnetic particle inspections were found to have not been performed following some repair welding. This follow-up review raised questions about potential defects or indications (flaws) in some radiographs.

By letters dated May 31,1983 and June 22, 1983, the applicant provided a technical report for supporting and justifying his request for staff acceptance of the flawed welds without repair or re-radiography. The technical report, which was commissioned from Aptech Engineering Services, Inc. (Aptech) by the applicant, presents the results of a fatigue and fracture mechanics analysis based on the flaw sizes, materials, properties and operating conditions of the welds in question, for predicting fracture peformance; i.e., if the flaws present would prevent ductile failure or cause a rapidly propagating fracture. Aptech characterized the flaws by an electronic enhancement technique to define their extent (size), the type of flaw (lack of fusion, crack, slag inclusions, porosity), and their appropriate depth. (Note: approximation of flaw depth by electronic data processing is viewed by the staff as a guide or aid in making judgments as to flaw depth, at the present time. This technique is acceptable as an alternative to repeated radiography provided that the original production radiographs meet minimum specifications as to image quality. Based on the staff's experience with other original production radiographs, the use of computer enhancement has provided assurances as to the actual width and length of weld flaws; however, further demonstrated accuracy of this is needed before it becomes a standard technique (for flaw depth measurement.) The stresses that these flaws would be subjected to over the life of the structure were characterized as to magnitude, direction, and frequency, for both applied and residual stresses.

The ferritic steels used in the containment shell were characterized as to fatigue crack growth by review of other data for the same materials. Upper bound conservative crack growth rates were used when caluclating crack growth, including existing fracture toughness data for the weld metal (Charpy V-notch values of - 20F or - 30F). The lowest value of more than 30 electrode lots, selected to be representative of the electrodes used in fabricating the containment shell, was used as the basis for calculating fracture toughness. Values for base metal toughness, although not relevant to this situation, as all except one of the flaws were found in the welds (i.e. as opposed to the base metal or heat-affected zone), were also assigned a fracture toughness value on a conservative basis. The fatigue crack growth analysis, and the linear elastic fracture mechanics analysis, were performed as specified in ASME Code, Section XI. Conservative assumptions were used in performing these analyses in that the flaws were assumed to be cracks through to the surface of the weld (i.e. surface cracks rather than the internal/cracks), and the applied loads were assumed to act perpendicularly to the flaws.

Based on its review of the Aptech report, the staff finds that the analyses and techniques performed to assess the effects of the flawed welds were quite conservative and demonstrate what General Design Criterion 51, "Fracture Prevention of Containment Pressure Boundary," would be met without repairing the flaws in the inaccessible weld courses of the containment shell. The analyses convincingly show that the flaws will have virtually no growth under the operating loads for which the shell was designed, and that the steel materials used in the containment pressure boundary have adequate toughness such that a large through-thickness flaw would not cause a rapidly propagating fracture. Therefore, the staff accepts the applicant's proposal to leave the flaws in the containment shell welds as is, and not perform any additional repair of those welds. The containment shell will not be strenghened significantly by repairing the welds as they are such a small percentage of the wall thickness. In fact, there would be risks in making weld repairs due to the distortions induced and high restraint of the joint figurations. In addition, the staff believes that repair of the welds will not significantly increase the health and safety of the public, and accordingly, the effort (time and cost) of making repairs is not justified or required.

Annulus Concrete Fill Design Modification

1. Adequacy of Annulus Concrete Analysis Methods and Results

The staff has reviewed the applicant's annulus concrete analysis method, and has also evaluated the analytical results submitted by letter dated April 25, 1983. A finite element method was used to analyze the response of the interface between the containment vessel, shielding building, the foundation mat (basemat), and the annulus concrete. The structural modelling methods, and the computer codes used have been reviewed for use in previous case applications, and therefore, are judged adequate and acceptable. The analysis results and the technical discussions provided by the applicant has allowed the staff to conclude the following:

(a) The annulus concrete and concrete shielding building should act together as monolithic concrete.

(b) The steel containment vessel will adequately be anchored by bond and reinforcement in the annulus concrete at the embedded circumferential stiffeners.

(c) The shear key provided at the basemat of the concrete shielding building should adequately resist the applied transverse shear.

(d) Shear and normal stresses developed at the shielding building/annulus concrete interface assures that debounding of the interface would not generally occur, except at a very localized region near the base of the annulus. Such localized debonding should not affect the integrity of the structures analyzed.

(e) The additional stiffness provided by the annulus concrete is the main reason for a substantial reduction in the acceleration response of the containment vessel, and a frequency shift with respect to the location of peak response.

2. Design of the Annulus Concrete

The annulus concrete design is judged to have met the requirements of Article CC-3000 of the ASME Code, Section III, Division 2, and complies with the provisions of NUREG-0800, Section 3.8.1 with the exception of the allowable tangential shear stress resistance in the annulus concrete. The maximum calculated tangential shear stress in the annulus concrete is 83 psi, which occurs under abnormal/extreme environmental conditions, based on Article CC-3421.5.1 (a), of the ASME Code, Section III. However, for the actual reinforcement provided in the annulus concrete, the allowable tangential shear stress is 107 psi, which is greater than the computed stress of 87 psi, and exceeds the corresponding allowable stress of 60 psi specified in Section 3.8.1-II.5a in

NUREG-0800. Nonetheless, the applicant has provided the following justification for this deviation, and indicated that no inclined reinforcement in the annulus concrete would be used:

(a) The annulus concrete design for tangential shear stress conforms to the requirements of the ASME Code, Section III, Division 2. Recent research results indicate that the shear allowables of the ASME Code are judged to be conservatively low when the actual magnitude of stresses in the orthogonal reinforcement in the annulus concrete are taken into consideration.

(b) The annulus concrete is not truly a part of the typical concrete containment. It is used in Perry just to provide additional stiffness and to dampen vibrations in the steel containment vessel induced by SRV actuations. Therefore, the applicant maintains that the extremely conservative allowable stress of 60 psi specified in NUREG-0800 need not be strictly adhered to in this application.

(c) From test data obtained from the Portland Cement Association, the safety factor computed for the tangential shear stress computed for the annulus concrete is 2.17 (180/83), which the applicant believes to be adequate.

The staff finds that the applicant's proposed annulus concrete design and justification summarized above for deviations to the ASME Code and NUREG-0800 in regard to allowable tangential, shear stress, is acceptable.

3. <u>Materials, Testing and Construction Considerations</u>

(a) Reinforcing Steel - with respect to purchasing, placing and mechanical splicing of reinforced steel bars in the annulus concrete, the applicant indicated that safety-related Perry specifications for concrete and reinforcing steel was used without consideration of the ASME Code, Section III, Division 2 requirements. However, the applicant has indicated that the Authorized Nuclear Inspector was used at the site to review all material certification and construction procedures to verify that the Perry specifications are fully complied with; and that the intent of the aforementioned ASME Code provisions related to reinforcing steel and mechanical splices are generally met, has been assured. The applicant further stated that the cost to remove and replace the reinforcing steel in the annulus to comply fully with the ASME Code provisions will be excessive and will not significantly improve safety.

(b) Concrete Supply and Placement - the applicant stated that, with respect to the supply of concrete, its Specification SP-14 has been revised to meet all applicable ASME Code, Section III, Division 2 requirements. The applicant also provided a comparison of pertinent

ASME Code provisions to those of Specification SP-14. Specification SP-14 meets and exceeds the corresponding ASME Code Section III, Division 2 requirement. The applicant further stated that its site organization will continue to be responsible to operate the concrete batch plant, even though the ASME Code requires that a seperate contractor shall contract the batching plant. The applicant maintains that no improvement in concrete quality can be achieved by following the ASME Code in this regard; in fact some reductions in concrete quality could occur if the contractor were required to control and operate the batch plant for the annulus concrete. The staff has reviewed the applicant's justification for this deviation from the ASME Code requirement with respect to admininstrative control of the concrete batching plant, and concludes that the deviation is acceptable, since the overall Code intent is met by the applicant, and additional improvement in concrete quality would be achieved through his direct control of the batching plant for the rather small amount of concrete to be mixed for this annulus fill.

In view of the discussion and the technical justification delineated by the applicant above, the staff concludes that both the containment steel shell weld deficiencies and the various deviations to the annulus concrete design modifications from the ASME Code requirements and the provisions of NUREG-0800, are acceptable, since the intents of the Code and NUREG-0800 will be met. Further, the staff concludes that the annulus concrete should maintain its structural integrity, and perform its safety functions when subjected to applicable operating load conditions.