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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO CORRECTION OF SEISMIC AND STRUCTURAL DEFICIENCIES

CAROLINA POWER & LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2

I. BACKGROUND

On April 7, 1992, Carolina Power & Light Company (the licensee or CP&L) declared an emergency diesel generator inoperable at the Brunswick Steam Electric Plant, Units 1 and 2 (BSEP), because of identified anchorage deficiencies of masonry walls in the Diesel Building (DB). In a letter dated April 9, 1992 (Ref. 1), the NRC staff requested CP&L to provide information concerning the anchorage deficiencies identified in masonry block walls at BSEP. The licensee's responses were provided in a letter dated April 15, 1992 (Ref. 2). Since that time, the licensee found that the seismic deficiencies were more widespread than originally anticipated. On April 21, 1992, the licensee shut down both units due to the extent of the seismic deficiencies identified. In a letter dated April 27, 1992 (Ref. 3), the NRC staff requested further information concerning the anchor bolt deficiencies and CP&L's proposed corrective action. In addition to seismic issues related to the walls, the letter also asked questions related to the short-term structural integrity program. This is the program by which CP&L qualifies civil engineering items that are identified to be outside of their seismic design basis for continue safe operation until restoration to the design basis can be effected. The licensee's responses were presented during a May 12, 1992, meeting (Ref. 4) with the NRC staff. In letters dated May 29, 1992 (Ref. 5), and July 16, 1992 (Ref. 6), CP&L documented the commitments on corrective actions made during the May 12, 1992, meeting and provided written responses to issues raised in the April 27, 1992, letter from the NRC staff. These letters were supplemented by letters dated July 1, 1992, and August 13, 1992, as a result of NRC staff requests for additional information.

In addition to the seismic qualification issues of the walls, CP&L's investigation extended to the miscellaneous steel (MS) structures that provide support for pipes, electrical raceways, HVAC ducts and other components that are not supported from building structures. In a meeting with the NRC staff on June 25, 1992 (Ref. 7), CP&L discussed the Miscellaneous Steel Verification Program (MSVP) that CP&L initiated for the BSEP. The short-term objective of the MSVP is to provide CP&L with assurance that the structural condition of MS in BSEP is adequate for safe plant operation. CP&L has committed to meet the short-term objective of the MSVP for each of the BSEP units prior to the restart of that unit. The long-term objective of the MSVP is to document and restore the design basis of the MS in BSEP. In letters dated July 27, 1992 (Ref. 8), and August 7, 1992 (Ref. 9), CP&L submitted the details of the MSVP and responses to NRC staff questions concerning the MSVP.

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II. EVALUATION

This Safety Evaluation addresses the scope, criteria and methodology of CP&L's program and corrective action concerning the seismic qualification issues at BSEP. Specifically, this evaluation reviews the adequacy of CP&L's program for safe operation in three areas of concern (1) walls and wall anchorages, (2) miscellaneous steel and (3) short-term structural integrity (STSI) qualified items and CP&L's Design Guide DG-II.20, "Design Guide for Civil/Structural Operability Reviews," under which the STSI items are qualified.

1.0 WALLS AND WALL ANCHORAGES

1.1 Introduction

In April 1992, the licensee first found that approximately seven percent of the through-bolts that tied the steel-plated masonry walls together and approximately 60 percent of the concrete expansion anchor bolts that were intended to anchor the plated masonry walls to the concrete beams and columns in the diesel generator building had the bolt head only tack-welded to the steel plate or steel angles. There were ten steel plated masonry walls, each about 21 feet wide and 23 feet high. Each wall was constructed of 8-inch deep concrete masonry blocks. The block wall was sandwiched between two 1/4-inch thick steel plates and tied together by through bolts at about 18-inch spacing. Structural steel angles, 3 in. x 3 in. x 3/8 in., were welded to the steel plates around the perimeter of the wall. Concrete expansion anchors were used to anchor the walls to concrete columns and beams through the structural steel angles. A few weeks later, the licensee found that approximately 85 percent of the concrete expansion anchor bolts that were used to hold five reinforced concrete walls in place in the diesel generator building also had the bolt heads tack welded to structural steel angles.

In a meeting with the NRC staff on May 12, 1992, the licensee informed the staff that the licensee's review had determined that six masonry walls in the Control Building also needed to be upgraded to become safety-related walls for control room habitability requirements. Those walls were previously classified as non-safety related walls during the IE Bulletin 80-11 reviews.

In a letter from the licensee to the NRC dated May 29, 1992 (Ref. 5), the licensee stated that prior to the restart of both units it would complete the following five-item program for walls and wall anchorages:

1. Repair of five reinforced concrete non-load bearing wall panels in the diesel generator building to restore them to their design configuration. The licensee will also install new anchor bolts at the perimeter of walls to upgrade wall anchorages to their design configuration in the diesel generator building.

2. Perform a design review and field inspection, when necessary, of the non-safety related masonry walls at the plant to verify that the walls are appropriately classified.

3. Remove accessib[illegible] n-functional through-bolts in the plated masonry walls and insta[illegible] er plates over the holes.

4. Perform an integrity inspection (i.e., for cracks, general condition) of unreinforced masonry walls that are classified as safety-related walls.

5. Repair walls being upgraded to safety-related class in the control building which have been determined to be required as a pressure boundary for control room habitability.

The staff has also reviewed copies of calculations of the analysis and design of wall anchorage, "BNP Masonry Wall Re-Evaluation," and of the results of the walkdown of masonry block walls.

1.2 Evaluation of Walls and Wall Anchorages

1.2.1 Composite Action of the Steel Plated Masonry Block Wall:

The licensee states that since the through-bolts are closely spaced at about 18 inches, the absence of seven percent of the bolts would only have a negligible effect on the composite action of the steel plates and concrete masonry walls. The staff agrees that because of the close intervals of the through-bolts, the absence of seven percent of the bolts would not significantly affect the seismic qualification of the walls.

1.2.2 Adequacy of Wall Anchorages:

The licensee has used the STARDYNE computer code to analyze wall frequencies and forces in anchor bolts. The staff has reviewed the input assumptions with regard to wall geometries and boundary conditions and found that they were reasonable. The staff has also used simplified hand calculations to verify that the licensee's computer output was reasonable. With respect to the design of anchor bolts, the licensee assumed that the seismic force, which is computed by using the entire weight of the wall multiplied by the corresponding wall acceleration value, is resisted only by the allowable shear capacity of the anchor bolts located at the top and bottom of the wall, neglecting the contribution of anchor bolts along the vertical sides of the wall (page seven of Rev. A of calculation ID: ODGB-0010). The staff believes that this design assumption is very conservative. The licensee has used a factor of safety of four for Hilti Kwik bolt I and Maxi bolts and of five for Red head bolts. The staff considers these factors of safety adequate and acceptable.

1.2.3 Inspection Of Masonry Walls And Wall Anchorages:

Although all masonry walls were qualified during the IE Bulletin 80-11 review and were accepted by the NRC staff, the licensee conducted another overall review of the IE Bulletin 80-11 program. The review will address wall functions, including missile barrier, tornado barrier, ventilation barrier and other functions, as stated in the licensee's submittal dated July 16, 1992 (Ref. 6). Except for the masonry walls in the Turbine and Radwaste Buildings that were known to be non-safety related, the licensee performed walkdowns of all other buildings to verify wall classifications. As a result of these walkdowns, the licensee reported that all the masonry walls in the service water intake and auxiliary off-gas buildings are non-safety related, that walls 8A and 8B in the unit 1 reactor building were unreinforced, had some cracks and were slightly overstressed, that walls 8A and 8B in the unit 2 reactor building were unreinforced and had cracks, that wall 11B in the unit 2 reactor building had not been constructed per design drawing, and that several walls needed to be upgraded and other walls in the Control Building needed to be reanalyzed. Although, the physical modifications of walls and reanalysis of walls have not been completed, the staff believes that the

licensee has undertaken a comprehensive and acceptable program. With respect to the wall anchorages, the licensee has performed a 100 percent inspection of the anchor bolts for the walls that were categorized as original construction and reviewed the quality assurance records to ensure that the field installations matched the drawings for the walls modified subsequent to the IE Bulletin 80-11 review. Because the licensee has established that the wall anchorage problem was limited to the walls categorized as original construction, the licensee's inspection program on wall anchorage is considered acceptable by the staff.

1.3 Conclusion on Walls and Wall Anchorages

Based on CP&L's committed program to restore the seismic qualification of all safety-related walls in BSEP and based on the above evaluation, the staff finds the scope, criteria and analysis methods of CP&L's program to be acceptable. The staff concludes that full implementation of the licensee's program should provide reasonable assurance that the walls are properly classified and the safety-related walls are configured according to design basis.

2.0 MISCELLANEOUS STEEL

2.1 Introduction

A bent structural steel beam (W12X27) was identified by a CP&L system engineer during the walkdown of the standby gas treatment system in the Unit 2 Reactor Building (RB) in October 1985. The licensee had documented this in an Engineering Evaluation Report, EER 85-0364, which justified interim operability of the beam. In October 1988, during an IEB 79-14 walkdown, the bent steel beam was again identified, but no actions were taken by the licensee to ensure long-term operability. In August 1989, the NRC issued a notice of violation on the issue of pipe supports and apparent deficiencies in design and construction of supplemental steel. The licensee's responses were focussed on demonstration of short-term operability on a case-by-case basis.

Following the plant shutdown on April 21, 1992, the licensee began a systematic examination of the physical condition of the plant, including the structural components of the plant. This effort includes the establishment of the MSVP to demonstrate the integrity of miscellaneous steel in seismic Category I structures of both units of the plant.

2.2 Evaluation of Miscellaneous Steel

The MSVP is a program by which CP&L is performing a systemmatic and comprehensive review of the as-built configuration of the MS in BSEP. The MS within the scope of the licensee's MSVP consists of the five platforms in each drywell (DW), and all MS between the three floors in the RB of each unit. This portion of MS constitutes about 90 percent of the entire MS scope. The remaining 10 percent of the MS is installed in the Diesel Building, the Service Water Building and the Control Building. Initially, this 10 percent portion of MS was not in the MSVP. However, in the meeting on August 27, 1992, between the staff and the licensee, the licensee committed to include this subset of MS in Phase II of the MSVP. The MSVP consists of two phases. Phase I includes the engineering walkdown of 100 percent of the MS between the floors in the RB, and Phase II includes three parts. Part 1 of Phase II consists of a combined engineering evaluation and measurements

of as-built configurations of the DW platform steel and an engineering evaluation of the MS in the RB. CP&L committed to complete Phase I and Part 1 of Phase II and complete any corrective actions or modifications required as a result of the walkdown and engineering evaluations prior to the restart of the plant. Parts 2 and 3 of Phase II of the MSVP consist of mainly the reconstitution of the design basis documents, and they will be completed prior to completion of the next outage of each unit. The results of the walkdown and evaluations are reviewed by a licensee-sponsored independent Technical Advisory Committee consisting of civil and structural engineering professionals well versed in the subject areas.

The staff reviewed the overall scope of the program, the walkdown procedures, the evaluation criteria, analysis methodology and the comprehensiveness of the program. The staff also reviewed sample walkdown results, the basis for evaluation of the walkdown results, the criteria for requiring an MS component modification, the adequacy of DW MS structural models used and the applicability of computer codes utilized in the evaluation. Additionally, the staff conducted selected MS walkdowns and inspected some of the modifications performed by the licensee.

The staff reviewed the basic evaluation and acceptance criteria being used for the MS evaluation. Initially, the licensee proposed to use the Licensee's Design Guide DG II-20 as the interim operability criteria for qualifying the MS prior to restart ot BSEP. However, recognizing that the proposed interim criteria are not significantly different from the commitments in the Updated Final Safety Analysis Report (UFSAR) for BSEP (Ref. 10), the licensee decided to qualify all the MS using the UFSAR criteria. The shear stress allowable for the structural and bolt materials in the UFSAR is 0.6 Fy (Fy being the yield stress of the material) for extreme environmental and accident loading conditions. However, the maximum allowable shear stress provided in the AISC specification (Ref. 11) is 0.55 Fy. As a result of the staff's concern related to this lower allowable shear stress, the licensee has committed to identify and to evaluate the MS connections and parts whose shear stresses exceed 0.55 Fy. Loads on the MS due to the postulated Design Basis Earthquake (DBE) are also calculated in accordance with UFSAR with due consideration for vertical seismic amplifications to account for the flexibility of the structures being analyzed. Other criteria for evaluation of the MS are also in accordance with the UFSAR and are, therefore, acceptable to the staff.

2.3 Conclusion on Miscellaneous Steel

The licensee has initiated and is implementing an in-depth program for correcting the deficiencies and irregularities of the MS at BSEP. The staff has reviewed the scope of the MSVP, the walkdown procedures, the training of walkdown personnel, MS evaluation criteria, MS modeling and analysis methods, computer codes used in the evaluation and sample walkdown results. The staff also conducted selected walkdowns and inspected some modified MS. Additionally, through discussions with licensee technical staff and consultants, the staff assessed the adequacy of experience and competence of licensee personnel for implementing the program. Based on the above review and evaluation, the staff concludes that implementation of Phase I and Part 1 of Phase II of the MSVP, and modifications to correct identified deficiencies in accordance with the established criteria, should provide adequate assurance that the structural integrity of the MS is acceptable for safe operation of the plant.

3.0 SHORT-TERM STRUCTURAL INTEGRITY CRITERIA

3.1 Introduction

The STSI criteria are used by the licensee to evaluate conditions within a piping system or components to ensure that they will continue to operate safely although the system or components are found to be outside of their current licensing basis as described in the UFSAR. These criteria are intended to be used to permit interim operation until appropriate modifications to the system or components can be implemented to restore the system or component to its current design basis. CP&L uses the Design Guide II.20, "Design Guide for Civil/Structural Operability Reviews," to establish technical criteria when performing structural aspects of structural, component and piping reviews as related to post-seismic operability determination.

3.2 Evaluation of STSI Qualified Item

In the letter dated July 16, 1992, CP&L identified the type, number and safety significance of the backlog items qualified under the STSI. CP&L identified 48 backlog items in the STSI list. Of these 48 items, four items have already been or will be modified prior to plant restart to meet the licensing basis. CP&L expects 44 items to remain in the STSI list at the time of plant restart. These items consist of pipe supports (41), service water pumps, fuel oil small bore line and main steam radiation monitor. For the structural integrity of the fuel oil small bore line and the main steam radiation monitor, CP&L has contracted for an independent review by an engineering firm and found the short-term qualification to be acceptable. The acceptability of the pipe systems and the service water pumps qualified under the licensee's STSI program is evaluated below.

3.2.1 Piping Systems

For the determination of structural integrity of piping systems, the licensee uses the following design documents: NED Design Guide II.20; CP&L Study Report M-20, "Criteria for Evaluating and Performing Computerized Piping Analyses of Existing Systems with Minor Modifications"; CP&L Study Report M-21, "Evaluation and Design Criteria for Existing Pipe Supports Associated with NRC Bulletins IE 79-02, 79-14 for Modification to or Design of Pipe Supports"; and Mechanical Design Guide MDG-2 for pipe stress analysis. According to the structural integrity criteria, pipe stresses for BSEP are calculated in accordance with the current UFSAR methodologies and piping codes, with the exception that when Code Case N-411 damping values are used, an alternate procedure to perform the model analysis will be followed.

As indicated in CP&L Study Report M-20, the loading combination for structural integrity evaluations includes pressure and sustained loads, as well as loadings due to the DBE and transients caused by safety valve discharge, valve closure or other flow-induced vibrations. The combined stresses are limited to 2.4 times the stress limit (Sh). This primary stress limit is more conservative than the current ASME Code Level D requirements. Conformance to the above stress limit provides assurance that the structural integrity and functionality of the piping system are preserved. The structural integrity criteria for piping stress is, therefore, acceptable for interim use. For pipe support structural integrity evaluations, the criteria include the gravity and dynamic loadings previously specified, pipe thermal loads and loads from seismic anchor movements, as well as

pressure and thermal anchor movements, as described in the Study Report M-21. These pipe support integrity criteria, in general, are more conservative than the Level D limits specified for component supports in the ASME Code, Section III, Appendix F, 1986 Edition. In addition, a safety factor of 2 for anchor bolts and an allowable load of 1.5 times the normal load rating for seismic snubbers are also consistent with the interim operability criteria previously accepted by the staff for a number of other licensees.

With regard to the use of Code Case N-411 alternate damping values in the seismic piping analysis, in an August 28, 1985, letter to the licensee, the staff conditionally approved such damping values for piping modifications and future piping stress analyses. The alternate damping values are required to be used in their entirety in a response spectrum method of analysis. In addition, analysis methodologies consistent with those being accepted by the staff for plants which would currently be undergoing licensing review are to be employed. However, a comparison of the BSEP design spectra with the current seismic design spectra of Regulatory Guide (RG) 1.60, in accordance with the guidance of RG 1.84, was not made at the time conditional approval was given. The potential impact of the difference in the design spectra on the validity of the alternate damping values is difficult to assess without performing an extended review. The licensee did indicate in the letter dated July 16, 1992 (Ref. 6), however, that the use of the higher damping values will be considered only on a specific case-by-case basis as a "quick look" and will be supplemented by more rigorous analysis, including time history, using the original FSAR damping values. With this restriction and the conservatism of the previously mentioned stress restriction on allowable loads against the current ASME Code requirements, the staff concludes that the interim use of the Code Case N-411 damping values is acceptable.

3.2.2 Service Water Pumps

The service water pumps at BSEP have had a history of both engineering and design problems since 1979. These problems included an error in the pump's natural frequency determination and the use of inappropriate response spectra curves in seismic response calculations.

Resolution of the seismic response spectra issue was combined with those of other emerging service water system design issues related to system hydraulics and single failure. As a result, the current revised design of the service water pumps, which are to replace the existing ones, simultaneously addresses seismic upgrades, elimination of the lubrication water system, specification of minimum flow requirements for the pumps, and other design upgrades to minimize pump maintenance. According to the licensee, the latter upgrades are to address system corrosion, enhancement of capability to withstand single-failures, and improvement of hydraulic margin. The current schedule of the licensee is to begin the replacement of the service water pumps starting in 1993. The installation of all ten pumps, as well as all the design upgrades, is scheduled to be completed by November 30, 1994.

The licensee has determined that during the interim period, the service water pumps in the plant are capable of withstanding a DBE and, thus, meet the short-term criteria until their replacement. This conclusion is based on the following:

(1) Stresses on all pump components are within short-term tensile allowable of 0.9 Fy, under DBE loading and the UFSAR damping values.

(2) Those components with less than 10 percent margin to the allowable stress value are made of stainless steel, thus ensuring a ductile failure.

(3) All carbon steel components have at least a 20 percent margin to the allowable stress value.

(4) Pump deflections are found to be within manufacturer's recommended values under the DBE loading, thus ensuring pump operability. In addition, the licensee is currently conducting an additional field inspection and design audit to verify the adequacy of the above DBE calculations. This will be completed prior to restart of either BSEP unit.

Based on the above information, the staff concludes that the service water pumps in the plant satisfy the interim operability criteria and that the proposed replacement schedules are acceptable. In addition, the staff has performed a confirmatory review of the licensee's maintenance program for the service water pumps and found it to be acceptable.

3.3 Conclusion on the STSI Qualified Items and Design Guide II.20

The short-term structural integrity criteria presented by the licensee for BSEP for the STSI qualification are generally more conservative than the current ASME Code, Section III, Level D limits, and are, therefore, acceptable. Such criteria provide a simple approach for evaluating the interim acceptability of a discrepant condition when stresses and loadings exceed UFSAR limits. It should be noted, however, that although Code Case N-411 damping values have been conditionally approved by NRC for BSEP in the past, the licensee's current justification for using Code Case N-411 damping is not in strict compliance with the provisions of RG 1.84. However, the staff concludes that the interim piping criteria as presented and employed by the licensee on a case-by-case basis are acceptable. It is also noted that if a piping system is found to exceed UFSAR limits, but meets the structural integrity limits, repairs or modifications should be made by the next refueling outage, if practical, to return the system to within UFSAR limits. The licensee's proposed schedule for piping modification is consistent with this practice and is, therefore, acceptable.

For the service water pumps, the licensee has established an acceptable interim criterion based on both the structural integrity as well as functional operability considerations. The licensee's current schedule is to begin replacement of the service water pumps with the revised design starting in 1993. The installation and upgrades will be completed by November 30, 1994. This schedule is acceptable to the staff.

The staff has reviewed the majority (42/44) of the list of items that will remain on the STSI list after plant restart according to the licensee's letter dated July 16, 1992 (Ref. 6). The remaining two items were reviewed by an independent engineering firm contracted by the licensee and found to be acceptable for interim operation. Since all these items were short-term qualified by the licensee in accordance to Design Guide II.20, and since the staff has reviewed the application of the design guide to qualify the majority of the STSI items and finds the application to be acceptable, the staff concludes that the criteria and

methodology of Design Guide II.20 are acceptable to establish structural aspects of each structure, component or piping for post-seismic operability determination. However, CP&L should perform an integrated safety review under the provisions of 10 CFR 50.59 to assure that the accumlated safety impact of the items qualified under the STSI criteria does not constitute an unreviewed safety question.

III. CONCLUSION

With regard to CP&L's program on corrective action on the walls and wall anchorages, the staff finds that the licensee's program should properly classify the safety related walls and restore them to design criteria. The staff finds the scope, criteria and methodology of CP&L's MSVP to be adequate for identifying deficiencies of miscellaneous steel in BSEP that would require modifications. The complete implementation of these modifications should provide adequate assurance that the structural integrity of the miscellaneous steel is acceptable for safe operation of the plant. The staff also concludes that the backlog items qualified individually through the short-term structural integrity criteria to be acceptable for interim plant operation until modifications for restoration to design criteria. In addition, the staff finds that the application of the licensee's Design Guide II.20 to be acceptable to determine post-seismic operability concerning the structural integrity of the system or component until modification can be effected to restore the item to its current design basis. However, the cumulative safety impact of the items qualified through the licensee's STSI criteria should be evaluated by the licensee under the provisions of 10 CFR 50.59.

IV. REFERENCES

1. Letter from S. A. Varga (NRC) to R. A. Watson (CP&L), dated April 9, 1992, "Masonry Block Walls At Brunswick Steam Electric Plant, Units 1 and 2".

2. Letter from R. B. Starkey, Jr. (CP&L) to Document Control Desk (NRC), dated April 15, 1992, "Masonry Block Walls."

3. Letter from S. A. Varga (NRC) to R. A. Watson (CP&L), dated April 27, 1992, "Masonry Block Walls At Brunswick Steam Electric Plant, Units 1 and 2."

4. Summary of Meeting with CP&L on Masonry Wall Seismic Issues on May 12, 1992, dated June 3, 1992.

5. Letter from R. A. Watson (CP&L) to Document Control Desk (NRC), dated May 29, 1992, "Corrective Action Plan."

6. Letter from R. B. Starkey, Jr. (CP&L) to Document Control Desk (NRC), dated July 16, 1992, "Masonry Block Walls."

7. Summary of Meeting with CP&L on Brunswick Units 1 and 2 on June 25, 1992, dated July 1, 1992.

8. Letter from D. C. McCarthy (CP&L) to Document Control Desk (NRC), dated July 27, 1992, "Miscellaneous Steel Verification Program."

9. Letter from D. C. McCarthy (CP&L) to Document Control Desk (NRC), dated August 7, 1992, "Miscellaneous Steel Verification Program."

10. Updated Final Safety Analysis Report, Amendment No. 10, Brunswick Steam Electric Plant, Units 1 and 2.

11. "Specification for Design, Fabrication and Erection of Steel Buildings," American Institute of Steel Construction, 8th Edition, 1978.

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