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

JUL 26 1984

Docket No.: 50-412

MEMORANDUM FOR: Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

FROM: James P. Knight, Assistant Director
for Components and Structures Engineering
Division of Engineering

SUBJECT: SAFETY EVALUATION REPORT - STRUCTURAL ENGINEERING
BEAVER VALLEY POWER STATION UNIT 2

Plant Name: Beaver Valley Power Station, Unit 2
Docket Number: 50-412
Licensing Stage: OL Review
Responsible Branch and Project Manager: LB-3, M. Ley

The FSAR submitted by the applicant has been reviewed and evaluated by the Structural and Geotechnical Engineering Branch. A brief summary of status and scope of review findings is contained in Enclosure 1. The structural engineering sections of the safety evaluation report are provided in Enclosure 2. This evaluation is based on information provided by the applicant through Amendment No. 6 dated April, 1984 and the applicant's responses to the design audit conducted during January 30 through February 3, 1984. The enclosures were prepared by K. C. Leu of the Structural Engineering Section A of the Structural and Geotechnical Engineering Branch.

James P. Knight, Assistant Director
for Components and Structures Engineering
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Enclosure:
As stated

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ENCLOSURE 1

SUMMARY OF STATUS AND SCOPE OF REVIEW
BEAVER VALLEY POWER STATION UNIT 2

3.3.1 Wind Loadings

Review is complete, no open items exist.

3.3.2 Tornado Loadings

Review is complete, no open items exist.

3.4.2 Water Level (Flood) Design Procedures

Review is complete, no open items exist.

3.5.3 Barrier Design Procedures

Review is complete, no open items exist.

3.7.1 Seismic Input

Completion of the review is subject to the resolution of the following item:

Applicant's submittal of his assessment that the site-specific response spectra as approved by the Geosciences Branch will be comparable to that shown on FSAR Fig. 3.7B-1. Also the applicant will address the deviations of the vertical spectra from those given in Regulatory Guide 1.60.

3.7.2 Seismic System Analysis and Seismic Subsystem Analysis

Completion of the reveiw is subject to the resolution of the following items:

(a) Impact assessment of three-component seismic input versus the current two-component combination on key structures, important piping systems, and equipments.

(b) Compliance of SSI analyses according to SRP 3.7.2.II.4. As a result of the SSI analyses, develop pertinent floor response spectra for piping and equipment design and address the design adequacy of the four-inch clearance between seismic Category I structures.

3.7.4 Seismic Instrumentation Program

Review is complete, no open items exist.

3.8.1 Concrete containment

Completion of the review is subject to

(a) applicant's submittal of identification and justification of all deviations of his containment design from the applicable provisions of ASME Section III, Division 2 Code.

(b) staff review and acceptance of the above item (a).

3.8.2 Steel Containment

Not applicable.

3.8.3 Concrete and Structural Steel Internal Structures

Completion of the review is subject to the resolution of the following items:

(a) applicant's submittal of his assessment and justification of all FSAR deviations from the applicable requirements of the ACI 349 Code as augmented by Regulatory Guide 1.142.

(b) applicant's submittal of responses to applicable items identified in Section 3.8.6.

(c) applicant's submittal of confirmatory information to the dynamic analyses and design of internal structures using cracked section properties.

(d) staff review and acceptance of the above items (a), (b), and (c).

3.8.4 Other Category I Structures

Completion of the review is subject to the applicant's submittal of responses to the confirmatory and open items and staff review and acceptance of the same.

3.8.5 Foundations

Completion of the review is subject to:

(a) applicant's demonstration of the fact that the re-assessed safety factors against sliding and overturning for the containment, auxiliary building, and intake structure are adequate.

(b) staff review and acceptance of the above item (a).

ENCLOSURE 2

DUQUESNE LIGHT COMPANY

BEAVER VALLEY POWER STATION UNIT 2

DOCKET NO. 50-412

STRUCTURAL ENGINEERING

STRUCTURAL AND GEOTECHNICAL ENGINEERING BRANCH

SAFETY EVALUATION REPORT

3.3 Wind and Tornado Loadings

3.3.1 Wind Design Criteria

All Category I structures exposed to wind forces were designed to withstand the effects of the design wind. The design wind specified has a velocity of 80 mph based on a recurrence interval of 100 years.

The procedures that were used to transform the wind velocity into pressure loadings on structures and the associated vertical distribution of wind pressures and gust factors are in accordance with ASCE paper No. 3269. This document is acceptable to the staff.

The staff concludes that the plant design is acceptable and meets the requirements of General Design Criterion (GDC) 2. This conclusion is based on the following:

The applicant has met the requirements of GDC 2 with respect to the capability of the structures to withstand design wind loading so that the design reflects

1. appropriate consideration for the most severe wind recorded for the site with an appropriate margin;

2. appropriate combinations of the effects of normal and accident conditions with the effects of natural phenomena; and

3. the importance of the safety function to be performed.

The applicant has met these requirements by using ASCE paper No. 3269, which the staff has reviewed and found acceptable, to transform the wind velocity into an effective pressure on structures and for selecting pressure coefficients corresponding to the structural geometry and physical configuration.

The applicant has designed the plant structures with sufficient margin to prevent structural damage during the most severe wind loadings that have been determined appropriate for the site so that the requirements of item 1 above are met. In addition, the design of seismic Category I structures, as required by item 2 above, has included, in an acceptable manner, load combinations which occur as a result of the most severe wind load and the loads resulting from normal and accident conditions.

The procedures used to determine the loadings on structures induced by the design wind specified for the plant are acceptable because these procedures have been used in the design of conventional structures and have proven to provide a conservative basis that, together with other engineering design considerations, ensures that the structures will withstand such environmental forces. The use of these procedures provides reasonable assurance that in the event of design-basis winds, the structural integrity of the plant structures that have to be designed for the design wind will not be impaired and, in consequence, safety-related systems and components located within these structures are adequately protected and will perform their intended safety functions if needed. Thus, the requirement of item 3 above is satisfied.

3.3.2 Tornado Design Criteria

All Category I structures exposed to tornado forces and needed for the safe shutdown of the plant were designed to resist a tornado of 290 mph tangential wind velocity at a radius of 150 ft and a 70 mph translational wind velocity. With regard to the pressure drop rate, the applicant considered a 3 psi pressure drop taking place over a 3 second interval in the structural design as

opposed to the requirements of Regulatory Guide 1.76, which stipulates a rate of pressure drop of 2 psi per second for Region I. The applicant has performed pertinent analysis and calculations to demonstrate that the results from both are comparable considering the Beaver Valley 2 plant. The staff has requested and received the justifying document and find it acceptable. This item is considered resolved. Tornado missiles also are considered in the design as discussed in Section 3.5 of this report.

The procedures that were used to transform the tornado wind velocity into pressure loadings are similar to those used for the design wind loadings as discussed in Section 3.3.1 of this report. The tornado missile effects were determined using procedures to be discussed in Section 3.5 of this report. The total effect of the design tornado on Category I structures is determined by appropriate combinations of the individual effects of the tornado wind pressure, pressure drop, and tornado associated missiles. Structures are arranged on the plant site and protected in such a manner that collapse of structures not designed for the tornado will not affect other safety-related structures.

The staff concludes that the plant design is acceptable and meets the requirements of GDC 2. This conclusion is based on the following:

The applicant has met the requirements of GDC 2 with respect to the structural capability to withstand design tornado wind loading and tornado missiles so that the design reflects

1. appropriate consideration for the most severe tornado recorded for the site with an appropriate margin;

2. appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena; and

3. the importance of the safety function to be performed.

The applicant has met these requirements by using ASCE paper No. 3269 to transform the wind velocity generated by the tornado into an effective pressure on structures and for selecting pressure coefficients corresponding to the structural geometry and physical configuration.

The applicant has designed the plant structures with sufficient margin to prevent structural damage during the most severe tornado loadings that have been determined appropriate for the site so that the requirements of item 1 above are met. In addition, the design of seismic Category I structures, as required by item 2 above, has included in an acceptable manner, load combinations that occur as a result of the most severe tornado wind load and the loads resulting from normal and accident conditions.

The procedures used to determine the loadings on structures induced by the design basis tornado specified for the plant are acceptable because these procedures have been used in the design of conventional structures and been proven to provide a conservative basis that, together with other engineering design considerations, ensures that the structures will withstand such environmental forces.

The use of these procedures provides reasonable assurance that in the event of design basis tornado, the structural integrity of the plant structures that have to be designed for the tornadoes will not be impaired and, in consequence, safety-related systems and components located within these structures are adequately protected and will perform their intended safety functions if needed. Thus the requirement of item 3 above is satisfied.

3.4.2 Water Level (Flood) Design Procedures

The design flood level resulting from the most unfavorable condition or combination of conditions that produce the maximum water level at the site is discussed in Section 2.4. The hydrostatic effect of the flood was considered in the design of all Category I structures exposed to the water head.

The procedures utilized to determine the loadings on seismic Category I structures induced by the design flood or highest groundwater level specified for

the plant are acceptable because these procedures provide a conservative basis for engineering design to ensure that the structures will withstand such environmental forces.

The staff concludes that the applicant has met the requirements of GDC 2 with respect to the structural capability to withstand the effects of the flood or highest groundwater level so that the design reflects

1. appropriate consideration for the most severe flood recorded for the site with an appropriate margin;

2. appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena; and

3. the importance of the safety function to be performed.

The applicant has designed the plant structures with sufficient margin to prevent structural damage during the most severe flood or groundwater and the associated dynamic effects that have been determined appropriate for the site so that the requirements of item 1 above are met. In addition, the design of seismic Category I structures, as required by item 2 above, has included in an acceptable manner load combinations that occur as a result of the most severe flood or groundwater-related loads and the loads resulting from normal and accident conditions.

The procedures utilized to determine the loadings on seismic Category I structures induced by the design flood or highest groundwater level specified for the plant are acceptable because these procedures have been used in the design of conventional structures and been proven to provide a conservative basis, which together with other engineering design considerations, ensures that the structures will withstand such environmental forces.

The use of these procedures provides reasonable assurance that in the event of floods or high groundwater, the structural integrity of the plant seismic Category I structures will not be impaired and, in consequence, seismic Category I

systems and components located within these structures will be adequately protected and may be expected to perform necessary safety functions, as required, thus satisfying requirement of item 3 above.

3.5.3 Barrier Design Procedures

The plant Category I structures, systems, and components (SSC) are shielded from, or designed for, various postulated missiles. Missiles considered in the design of structures include tornado generated missiles and various containment internal missiles, such as those associated with a loss-of-coolant accident.

Information has been provided indicating procedures that were used in the design of the structures, shields, and barriers to resist the effect of missiles. The applicant stated that the overall structural response of the concrete barriers to missile impact was evaluated using methods presented in Appendix C of SWECO 7703 (SWEC 1977). The staff has reviewed the pertinent sections of the report and determined that the criteria used in calculating the overall structural response of the concrete barriers meet the intent of SRP Section 3.5.3. This item is considered resolved.

The staff concludes that the barrier design is acceptable and meets the requirements of GDC 2 and 4 with respect to the capabilities of the structures, shields, and barriers to provide sufficient protection to equipment that must withstand the effects of natural phenomena (tornado missiles) and environmental effects, including the effects of missiles, pipe whipping, and discharging fluids. This conclusion is based on the following.

The procedures utilized to determine the effects and loadings on seismic Category I structures and missile shields and barriers induced by design basis missiles selected for the plant are acceptable because these procedures provide a conservative basis for engineering design to ensure that the structures or barriers are adequately resistant to and will withstand the effects of such forces.

The use of these procedures provides reasonable assurance that in the event of design-basis missiles striking seismic Category I structures or other missile shields and barriers, the structural integrity of the structures,

shields, and barriers will not be impaired or degraded to an extent that will result in a loss of required protection. Seismic Category I systems and components protected by these structures are, therefore, adequately protected against the effects of missiles and will perform their intended safety function, if needed. Conformance with these procedures is an acceptable basis for satisfying in part the requirements of GDC 2 and 4.

3.7.1 Seismic Input

In the design of Beaver Valley 2 Seismic Category I structures, systems, and components, the spectra for the safe shutdown earthquake (SSE) corresponding to a maximum ground surface acceleration of 0.12g, and the spectra for the ½ safe shutdown earthquake (½SSE) corresponding to a maximum ground acceleration of 0.06g are used. These spectra differ from the spectra defined in Regulatory Guide 1.60. The vertical design response spectra used in design are taken to be two-thirds of the horizontal design response spectra for the entire frequency range. The applicant is requested to demonstrate that the site-specific response spectra as approved by the Geosciences Branch will be comparable to those used in actual plant seismic design and shown in the FSAR. The applicant should also address and justify the deviations of the vertical spectra from those given in Regulatory Guide 1.60. Until these items are satisfactorily resolved through applicant's submittal of additional information and staff review, they will be considered as open items.

The damping ratios (expressed as a percentage of critical) used in the analysis of various seismic Category I structures, systems, and components are in compliance with those listed in Regulatory Guide 1.61. However, the applicant is requested to confirm that the stress and strain levels of key structural elements are in compliance with those of the position C.3 of Regulatory Guide 1.61. The applicant has demonstrated by reanalyzing the auxiliary building that the seismic respnses of structures are insensitive to variations of damping values for the structural elements. This confirmatory information is acceptable to the staff.

Pending resolution of the above described items, the staff concludes that the seismic design parameters used in the plant structure design are acceptable

and meet the requirements of GDC 2 and Appendix A to 10 CFR Part 100. This conclusion is based on the following:

The applicant has met the relevant requirements of GDC 2 and Appendix A to 10 CFR Part 100 by appropriate consideration for the most severe earthquake record for the site with an appropriate margin and considerations for two levels of earthquakes, the SSE and ½SSE. The applicant has met these requirements by the use of the methods and procedures indicated below.

The site specific seismic design response spectra (½SSE and SSE) applied in the design of seismic Category I structures, systems, and components have been reviewed and approved by the Geosciences Branch. The specific percentage of critical damping values used in the seismic analysis of Category I structures, systems, and components are in conformance with Regulatory Guide 1.61. The artificial synthetic time history used for the seismic design of Category I plant structures, systems, and components is adjusted in amplitude and frequency content to obtain response spectra that envelop the design response spectra specified for the site. Conformance with the recommendations of the Geosciences Branch on the site specific spectra and Regulatory Guide 1.61 assures that the seismic inputs to Category I structures, systems, and components are adequately defined so as to form a conservative basis for the design of Category I structures, systems, and components to withstand seismic loadings.

3.7.2 Seismic System Analysis

3.7.3 Seismic Subsystem Analysis

The scope of review of the seismic system and subsystem analysis for the plant included the seismic analysis methods for all Category I structures, systems, and components. It included review of procedures for modeling, development of floor response spectra, inclusion of torsional effects, evaluation of Category I structure overturning, and determination of composite damping. The review has included design criteria and procedures for evaluation of interaction of non-Category I structures with Category I structures and effects of parameter variations on floor response spectra. The review has also included criteria and seismic analysis procedures for Category I buried piping outside the containment.

The plant site is a relatively uniform gravel terrace approximately 110 feet deep resting on a bedrock. The containment structure and the fuel building were analyzed to account for the soil-structure interaction effects using the finite element method. They were also analyzed for the same effects using the lumped-mass-spring approach. The same lumped-mass-soil spring method was used for all other seismic Category I structures. However, in the final analysis, the lumped-mass-soil spring method was used for all buildings other than the containment structure.

For all seismic Category I buildings except the containment structure, floor response spectra were developed using the modal analysis time history method. Floor response spectra for the containment were developed using the modal analysis method with PLAXLY, a computer program used in the finite element analysis of the containment.

The system and subsystem analyses were performed by the applicant on an elastic basis. Modal response spectrum and time history methods form the basis for the analyses of all major Category I structures, systems, and components. When the modal response spectrum method was used, all modes except the closely spaced modes are combined by the SRSS method. The double sum method in compliance with Regulatory Guide 1.92 is used to combined the closely spaced modes.

During the structural audit, the following action items were identified which require the applicant to provide:

(1) An impact assessment of three-component seismic input versus the current two-component combination on the structural design adequacy for the key locations in the containment (the crane support, apex, reactor support, operating floor, and base mat), the auxiliary building, and the fuel building (the roof, operating floor, and base mat).

(2) The floor response spectra accounting for three-component earthquake input for key piping systems (primary loop cooling system, main feedwater

line piping system, component cooling water piping system) and key equipment locations, namely:

(a) Containment - reactor vessel support, one steam generator, pressurizer, one hot-leg piping system, and primary coolant pump.

(b) Auxiliary building - component cooling water pump, boric acid transfer pump.

(c) Control building - main control board

(d) Fuel building - fuel pool cooling pump

(e) Intake structure - service water pump

(3) Perform soil-structure interaction analyses for the two key structures (containment and intake structure) to show that Section 3.7.2.II.4 of SRP is complied with. Also, develop pertinent floor response spectra for the two structures as a result of the SSI analyses and discuss the design adequacy of the four-inch clearance provided between all seismic Category I structures.

The results obtained from this item should be used as input to items (1) and (2), as applicable.

Completion of the review of this section is pending on the resolution of the above described items.

The following conclusions are subject to resolution of the unresolved items and review and approval of the confirmatory items yet to be received from the applicant.

The staff concludes that the plant design is acceptable and meets the requirements of GDC 2 and Appendix A to 10 CFR Part 100. This conclusion is based on the following:

The applicant has met the requirements of GDC 2 and Appendix A to 10 CFR Part 100 with respect to the capability of the structures to withstand the effects of the earthquakes so that their design reflects

1. appropriate consideration for the most severe earthquake recorded for the site with an appropriate margin (GDC 2); consideration of two levels of earthquakes (Appendix A, 10 CFR Part 100);

2. appropriate combination of the effects of normal and accident conditions with the effect of the natural phenomena; and

3. the importance of the safety functions to be performed (GDC 2); the use of a suitable dynamic analysis or a suitable qualification test to demonstrate the SSC can withstand the seismic and other concurrent loads, except where it can be demonstrated that the use of an equivalent static load method provides adequate consideration (Appendix A, 10 CFR Part 100).

The applicant has met the requirements of item 1 listed above by use of the acceptable seismic design parameters, as per SRP Section 3.7.1. The combination of earthquake-related loads with those resulting from normal and accident conditions in the design of Category I structures as specified in SRP Sections 3.8.1 through 3.8.5 will be in conformance with item 2 listed above.

The staff concludes that the use of the seismic structural analysis procedures and criteria delineated above by the applicant provides acceptable bases for the seismic design, which are in conformance with the requirements of item 3 listed above.

3.7.4 Seismic Instrumentation Program

The type, number, location, and utilization of strong motion accelerographs to record seismic events and to provide data on the frequency, amplitude, and phase relationship of the seismic response of the containment structure comply with Regulatory Guide 1.12. Supporting instrumentation is being installed on Category I structures, systems, and components in order to provide data for the verification of the seismic responses determined analytically for such Category I items.

The staff concludes that the seismic instrumentation system provided for the plant is acceptable and meets the requirements of GDC 2, 10 CFR Part 100, Appendix A and 10 CFR Part 50, §50.55a. This conclusion is based on the following:

The applicant has met the requirements of 10 CFR Part 100, Appendix A by providing the instrumentation that is capable of measuring the effects of an earthquake which meets the requirements of GDC 2. The applicant has met the requirements of 10 CFR 50.55a by providing the inservice inspection program that will verify operability by performing channel checks, calibrations, and functional test at acceptable intervals. In addition, the installation of the specified seismic instrumentation in the reactor containment structure and other Category I structures, systems, and components constitutes an acceptable program to record data on seismic ground motion as well as data on the frequency and amplitude relationship of the seismic response of major structures and systems. A prompt readout of pertinent data at the control room can be expected to yield sufficient information to guide the operator on a timely basis for the purpose of evaluating the seismic response in the event of an earthquake. Data obtained from such installed seismic instrumentation will be sufficient to determine that the seismic analysis assumptions and the analytical model used for the design of the plant are adequate and that allowable stresses are not exceeded under conditions where continuity of operation is intended. Provisions of such seismic instrumentation complies with Regulatory Guide 1.12.

3.8.1 Concrete Containment

The containment structure is a heavily reinforced concrete steel-lined vessel with a 10-foot thick flat base mat, cylindrical walls, and a hemispherical dome. The inside diameter of the containment cylinder is 126 feet, and the cylinder wall is 4 feet-6 inches thick. The containment is not structurally integral with any of the structures surrounding it. A shake space is provided between the containment and the adjacent structures.

The reinforced concrete containment is designed for a pressure load of 45 psi resulting from the design base accident, and is designed and constructed to the requirements of the American Concrete Institute Building Code ACI 318-71.

The containment steel liner is designed following the requirements of ASME Code Section III, Division 1. With respect to the tangential stress consideration for the containment design, the applicant met the applicable provisions of SRP Section 3.8.1. However, the current SRP requires that the concrete reactor vessels and containments including the liners should be designed in accordance with the ASME Code Section III, Division 2. The applicant has been requested to resolve these concerns by demonstrating that the intent of the ASME Code Section III, Division 2 is met pertaining to load combination, analysis procedures, design allowables, materials, quality control and special construction techniques for the concrete containment including specific criteria used in the design for liners. These items remain open.

The staff has reviewed the applicant's submittal regarding the ultimate capacity analysis of the containment and find it acceptable. This item is resolved.

Pending resolution of the above open items we conclude that:

1. The applicant has met the requirements of Section 50.55a and GDC 1 with respect to ensuring that the concrete containment is designed, fabricated, erected, constructed, tested, and inspected to quality standards commensurate with its safety function to be performed by meeting the guidelines of Regulatory Guides and industry standards indicated below.

2. The applicant has met the requirements of GDC 2 by designing the concrete containment to withstand the most severe earthquake that has been established for the site with sufficient margin and the combinations of the effects of normal and accident conditions with the effects of environmental loadings such as earthquakes and other natural phenomena.

3. The applicant has met the requirements of GDC 4 by ensuring that the design of the concrete containment is capable of withstanding the dynamic effects associated with missiles, pipe whipping, and discharging fluids.

4. The applicant has met the requirements of GDC 16 by designing the concrete containment so that it is an essentially leaktight barrier to prevent the uncontrolled release of radioactive effluents to the environment.

5. The applicant has met the requirements of GDC 50 by designing the concrete containment to accommodate, with sufficient margin, the design leakage rate and calculated pressure and temperature conditions resulting from accident conditions, and by ensuring that the design conditions are not exceeded during the full course of the accident condition. In meeting these design requirements, the applicant has used the recommendations of regulatory guides and industry standards indicated below.

The criteria used in the analysis, design, and construction of the concrete containment structure to account for anticipated loadings and postulated conditions that may be imposed upon the structure during its service lifetime are in conformance with established criteria, and with codes, standards, guides, and specifications acceptable to the staff. These include meeting the intent of Regulatory Guides 1.31 and 1.55 and ASME Boiler and Pressure Vessel Code, Section III, Division 1 and Division 2.

The use of these criteria as defined by applicable codes, standards, guides, and specifications; the loads and loading combinations; the design and analysis procedures; the structural acceptance criteria; the materials, quality control programs, and special construction techniques; and the testing and inservice surveillance requirements, provide, reasonable assurance that, in the event of winds, tornadoes, earthquakes, and various postulated accidents occurring within and outside the containment, the structure will withstand the specified design conditions without impairment of structural integrity or safety function of limiting the release of radioactive material.

3.8.2 Steel Containment

Not Applicable.

3.8.3 Concrete and Structural Steel Internal Structures

The containment internal structures consist of heavily reinforced concrete walls and slabs. The reinforced concrete primary shield wall forms the reactor cavity at the center of the containment. Located concentrically to the primary shield wall is the reinforced concrete crane wall which is supported

by reinforced concrete columns extending from the foundation mat. Between the primary shield wall and the crane wall are reinforced concrete walls and slabs which separate the internals into cubicles. The slabs at the floor of three cubicles provide structural platforms for the steam generator and reactor coolant pump.

The major code used in the design of concrete internal structures was American Concrete Institute Standard 318-71, "Building Code Requirements for Reinforced Concrete." For steel internal structures, the American Institute of Steel Construction Specification, "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings," was used.

SRP Section 3.8.3 specifies that the code to be used in the design of concrete internal structures is American Concrete Institute Standard 349 as augmented by Regulatory Guide 1.142. The applicant has provided information regarding an assessment and justifications for all deviations of his internal structural design and analysis from the applicable staff positions as given in SRP Section 3.8.3. The staff has reviewed the information and determined that the applicant should list out the controlling load combinations for different parts of the internal structures and show they are compatible to those of ACI-349 and Regulatory Guide 1.142, or assess and justify the deviations. This item is confirmatory.

Additionally, 2 action items (2 and 13) discussed under Section 3.8.6 are pending the results of the applicant's confirmation program in verifying the design of the internal structures (including steam generator cubicle) for final pressure loads. The results should also include the findings with regard to DLF and neglecting of cracking effect.

Item No. 28 regarding the temperature load application in the analysis of the steam generator cubicle, needs further clarification and is considered confirmatory. Item No. 27 related to the design of the polar crane needs further assessment on seismic analysis, remains as open item.

Pending the resolution of the above open items, we conclude that the design of containment internal structures is acceptable and meets the relevant requirements of 10 CFR §50.55a and GDC 1, 2, 4, 5, and 50. This conclusion is based on the following:

1. The applicant has met the requirements of Section 50.55a and GDC 1 with respect to assuring that the containment internal structures are designed, fabricated, erected, constructed, tested, and inspected to quality standards commensurate with its safety function to be performed by meeting the guidelines of regulatory guides and industry standards indicated below.

2. The applicant has met the requirements of GDC 2 by designing the containment internal structure to withstand the most severe earthquake that has been established for the site with sufficient margin and the combinations of the effects of normal and accident conditions with the effects of environmental loadings such as earthquakes and other natural phenomena.

3. The applicant has met the requirements of GDC 4 by ensuring that the design of the internal structures is capable of withstanding the dynamic effects associated with missiles, pipe whipping, and discharging fluids.

4. The applicant has met the requirements of GDC 5 by demonstrating that structures, systems, and components are not shared between units or that if shared they have demonstrated that sharing will not impair their ability to perform their intended safety function.

5. The applicant has met the requirements of GDC 50 by designing the containment internal structures to accommodate, with sufficient margin, the design leakage rate, and calculated pressure and temperature conditions resulting from accident conditions and by assuring that the design conditions are not exceeded during the full course of the accident condition. In meeting these design requirements, the applicant has used the recommendations of regulatory guides and industry standards indicated below.

The criteria used in the design, analysis, and construction of the containment internal structures to account for anticipated loadings and postulated conditions that may be imposed during their service lifetime are in conformance with established criteria, and with codes, standards, and specifications acceptable to the staff. These include meeting the intent of Regulatory Guides 1.10, 1.15, 1.55, 1.94; ACI-349; ASME Code, Section III, Division 2; ASME Code, Section III, Division 1, Subsections NE and NF; and AISC, "Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings."

The use of these criteria as defined by applicable codes, standards, and specifications, the loads and loading combinations; the design and analysis procedures; the structural acceptance criteria; the materials, quality control programs, and special construction techniques; and the testing and inservice surveillance requirements provide reasonable assurance that, in the event of earthquakes and various postulated accidents occurring within the containment, the interior structures will withstand the specified design conditions without impairment of structural integrity or the performance of required safety functions.

3.8.4 Other Category I Structures

Category I structures other than containment and its interior structures are all of structural steel and concrete. The structural components consist of slabs, walls, beams, and columns. The major code used in the design of concrete Catgory I structrues is the ACI 318-71. For steel Category I structures, the AISC, "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings," is used. The applicant has provided an assessment and justification of all deviations from the applicable requirements of ACI 349 Code as augmented by Regulatory Guide 1.142. The staff has reviewed the applicant's submittal and found it acceptable.

The staff has reviewed the responses provided by the applicant and determined that 6 of the 9 action items in this section of the SER are resolved. However, item (19) needs confirmatory information that the applicant is requested to submit a typical analysis of seismic wave effect on conduits at bends and

tees. Items (20) and (22), requiring the applicant to provide further evaluation on the seismic design and analysis, remain as open items.

The concrete and steel Category I structures were designed to resist various combinations of dead loads; live loads; environmental loads including winds, tornados, ½ SSE and SSE; and loads generated by postulated ruptures of high energy pipes such as reaction and jet impingement forces, compartment pressures, and impact effects of whipping pipes.

The various Category I structures are designed and proportioned to remain within limits established by the staff under the various load combinations. These limits are, in general, based on the ACI 318-71 Code and on the AISC specification for concrete and steel structures, respectively, modified as appropriate for load combinations that are considered extreme.

The materials of construction, their fabrication, construction, and installation, are in accordance with the ACI 318-71 Code and AISC Specification for concrete and steel structures, respectively.

The applicant confirmed that there are no safety-related masonry walls for the Beaver Valley 2 facility.

Pending the resolution of the above open items, we conclude that the design of safety-related structures other than containment is acceptable and meets the relevant requirements of 10 CFR 50.55a and GDC 1, 2, 4, and 5. This conclusion is based on the following:

1. The applicant has met the requirements of Section 50.55a and GDC 1 with respect to assuring that the safety-related structures other than containment are designed, fabricated, erected, constructed, tested, and inspected to quality standards commensurate with its safety function to be performed by meeting the guidelines of regulatory guides and industry standards indicated below.

2. The applicant has met the requirements of GDC 2 by designing the safety-related structures other than containment to withstand the most severe

earthquake that has been established for the site with sufficient margin and the combinations of the effects of normal and accident conditions with the effects of environmental loadings such as earthquakes and other natural phenomena.

3. The applicant has met the requirements of GDC 4 by ensuring that the design of the safety-related structures is capable of withstanding the dynamic effects associated with missiles, pipe whipping, and discharging fluids.

4. The applicant has met the requirements of GDC 5 by demonstrating that SSC are not shared between units or that if shared they have demonstrated that sharing will not impair their ability to perform their intended safety function.

5. The applicant has met the requirements of Appendix B because his quality assurance program provides adequate measures for implementing guidelines relating to structural design audits.

The criteria used in the analysis, design, and construction of all the plant Category I structures to account for anticipated loadings and postulated conditions that may be imposed during their service lifetime are in conformance with established criteria, and with codes, standards, and specifications acceptable to the staff. These include meeting the intent of Regulatory Guides 1.10, 1.15, 1.94; ACI 349; and AISC, "Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings."

The use of these criteria as defined by applicable codes, standards, and specifications, the load and loading combinations; the design and analysis procedures; the structural acceptance criteria; the materials, quality control programs, and special construction techniques; and the testing and inservice surveillance requirements provide reasonable assurance that, in the event of winds, tornadoes, earthquakes and various postulated accidents occurring within and outside, the structures will withstand the specified design conditions without impairment of structural integrity or the performance of required safety functions.

3.8.5 Foundations

Foundations of Category I structures are described in FSAR Section 3.8.5. Primarily, these foundations are reinforced concrete and of the mat type. The major code used in the design of the concrete mat foundations is ACI 318-71 Code. These concrete foundations have been designed to resist various combinations of dead loads; live loads; environmental loads including winds, tornadoes, ½ SSE and SSE; and loads generated by postulated ruptures of high energy pipes.

The design and analysis procedures that were used for these Category I foundations are the same as those approved on previously licensed applications and, in general, are in accordance with procedures delineated in the ACI 318-71 Code. The various Category I foundations were designed and proportioned to remain within limits established by the staff under the various load combinations. These limits are, in general, based on the ACI 318-71 Code and on the AISC specification for concrete and steel structures, respectively, modified as appropriate for load combinations that are considered extreme. The applicant has provided an assessment and justifications of all deviations of his design from the applicable requirements of ACI 349 Code as augmented by Regulatory Guide 1.142. The staff has reviewed the applicant's submittal and find it acceptable.

The applicant has been requested to re-assess the safety factors against sliding and overturning for the containment structure, auxiliary building, and intake structure. Three-component earthquake input from the revised seismic analysis results, if applicable, should be used in the reassessment. This item remains to be resolved.

The materials of constructions, their fabrication, construction, and installation are in accordance with the ACI 318-71 Code and AISC Specification for concrete and steel structures, respectively.

The criteria that were used in the analysis, design, and construction of all the plant Category I foundations to account for anticipated loadings and postulated conditions that may be imposed upon each foundation during its

service lifetime are in conformance with established criteria, and with codes, standards, and specifications acceptable to the NRC staff.

Pending the resolution of the above open items, we conclude that the design of the seismic Category I foundations is acceptable and meets the relevant requirements of 10 CFR 50.55a and GDC 1, 2, 4, and 5. This conclusion is based on the following:

1. The applicant has met the requirements of Section 50.55a and GDC 1 with respect to assuring that the seismic Category I foundations are designed, fabricated, erected, constructed, tested, and inspected to quality standards commensurate with its safety function to be performed by meeting the guidelines of regulatory guides and industry standards indicated below.

2. The applicant has met the requirements of GDC 2 by designing the seismic Category I foundation to withstand the most severe earthquake that has been established for the site with sufficient margin and the combinations of the effects of normal and accident conditions with the effects of environmental loadings such as earthquakes and other natural phenomena.

3. The applicant has met the requirements of GDC 4 by assuring that the design of the seismic Category I foundations is capable of withstanding the dynamic effects associated with missiles, pipe whipping, and discharging fluids.

4. The applicant has met the requirements of GDC 5 by demonstrating that structures, systems, and components are not shared between units or that if shared they have demonstrated that sharing will not impair their ability to perform their intended safety function.

The criteria used in the design, analysis, and construction of the plant seismic Category I foundations to account for anticipated loadings and postulated conditions that may be imposed upon each foundation during its service lifetime are in conformance with established criteria, and with codes, standards, and specifications acceptable to the Regulatory staff. These include meeting the

positions of Regulatory Guide 1.142 and industry standards ACI-349, AISC, "Specifications for the Design, fabrication, and Erection of Structural Steel for Buildings."

The use of these criteria as defined by applicable codes, standards, and specifications, the loads and loading combinations; the design and analysis procedures; the structural acceptance criteria; the materials, quality control, and special construction techniques; the testing and inservice surveillance requirements provide reasonable assurance that, in the event of winds, tornadoes, earthquakes and various postulated events, seismic Category I foundations will withstand the specified design conditions without impairment of structural integrity of the performance of required safety functions.

3.8.6 Structural Audit

From January 30 through February 3, 1984, the staff met with the applicant and his consultants to conduct the structural audit. The audit covered each major safety-related structure at the Beaver Valley 2 nuclear power plant.

The staff conducted the audit in order to accomplish the following objectives:

1. To investigate in detail how the applicant has implemented the structural and seismic design criteria that he committed to use, prior to obtaining construction permits for the facility.

2. To verify that the key structural and seismic design and the related calculations have been conducted in an acceptable way.

3. To identify and assess the safety significance of those areas where the plant structures were designed and analyzed using methods other than those recommended by the NRC Standard Review Plan (NUREG-0800).

As a result of the audit, the staff identified twenty-eight action items. Review and evaluation of the information resulting from these action items also provided a basis for the conclusions reached and reported by the staff in this report.

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Section 3.3 - Wind and Tornado Loadings

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3.3-1 "American National Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures," American National Standards Institute, A58-1 - 1972.

Section 3.5 - Missile Protection

3.5-1 A. Amirikian, "Design of Protective Structures," Bureau of Yards and Docks, Publication No. NAVDOCKS P-51, Department of the NAVY, Washington, DC, August 1950.

3.5-2 Williamson, R. A., and Alvy, R. R., "Impact Effect of Fragments Striking Structural Elements," Holmes and Narver, Revised Edition, 1973.

Section 3.7 - Seismic Design

3.7-1 USAEC Regulatory Guide 1.60, "Design Response Spectra for Nuclear Power Plants."

3.7-2 USAEC Regulatory Guide 1.61, "Damping Valves for Seismic Analysis of Nuclear Power Plants."

3.7-3 USAEC Regulatory Guide 1.12, "Instrumentation for Earthquakes."

Section 3.8 - Design of Category I Structures

3.8-1 American Institute of Steel Construction, "Specification for Design, Fabrication and Erection of Structural Steel for Buildings," 101 Park Avenue, New York, NY 10017, Sixth Edition, 1969.

3.8-2 American Concrete Institute, "Building Code Requirements for Reinforced Concrete (ACI 318-1971)," P.O. Box 19150, Redford Station, Detroit, MI 48219.

3.8-3 American Society of Mechanical Engineers, "ASME Boiler and Pressure Vessel Code," Section III and Addenda, United Engineering Center, 345 East 47th Street, New York, NY 10017.

3.8-4 American Concrete Institute, "Code Requirements for Nuclear Safety Related Structures, ACI 349," P.O. Box 19150, Redford Station, Detroit, MI 48219.