RS-002, "PROCESSING APPLICATIONS FOR EARLY SITE PERMITS"

ATTACHMENT 2

2.4.6 PROBABLE MAXIMUM TSUNAMI FLOODING

REVIEW RESPONSIBILITIES

Primary - Mechanical and Civil Engineering Branch (EMEB)

Secondary - None

I. AREAS OF REVIEW

The geohydrological design basis of a nuclear power plant or plants of specified type that might be constructed on the proposed site (discussed in Regulatory Guide 1.59) is developed in this section of the site safety assessment for an early site permit application to determine the extent of plant protection required for tsunami flooding and drawdown (outlined in Regulatory Guide 1.102). The areas of review include the hydrologic characteristics of the maximum locally and distantly generated tsunami and the techniques, methodologies, and parameters, including the geoseismic parameters of the generators, used in the determination of the design basis tsunami.

Hydrologic analysis techniques, including tsunami formation, propagation and shoaling models, and coincident water levels, including astronomical tide, storm surges and waves, are reviewed.

The review will encompass the geologic and seismic characteristics of potential faults that might cause a tsunami, including the earthquake magnitude, focal depth, source dimensions, fault orientation, and vertical displacement. The applicant's values for parameters used to model tsunami, which may represent the upper bounds of the parameters, will be reviewed.

II. ACCEPTANCE CRITERIA

Acceptance criteria for this section of this review standard relate to the following regulations:

1. 10 CFR Parts 52 and 100 as they relate to identifying and evaluating hydrologic features of the site.

2. 10 CFR 100.23, as it relates to investigating the tsunami potential at the site.

Section 52.17(a) of 10 CFR Part 52 and Section 100.20(c) of 10 CFR Part 100 require that the site's physical characteristics (including seismology, meteorology, geology, and hydrology) be taken into account when determining its acceptability for a nuclear power reactor.

The regulations at 10 CFR Parts 52 and 100 are applicable to Section 2.4.6 of this review standard because they address the physical characteristics, including hydrology, considered by the Commission when determining the acceptability of the proposed site. To satisfy the hydrologic requirements of 10 CFR Parts 52 and 100, the applicant's safety assessment must contain a description of the hydrologic characteristics of the coastal region in which the

proposed site is located and an analysis of severe seismically induced waves. The description must be sufficient to assess the acceptability of the site and the potential for a tsunami to influence the design of structures, systems, and components important to safety for a nuclear power plant or plants of specified type that might be constructed on the proposed site.

Section 100.23(c) requires that geologic and seismic factors be considered when determining suitability of the site. Section 100.23(c) requires an investigation to obtain geologic and seismic data necessary for evaluating seismically induced floods and water waves.

Section 100.23(c) is applicable to Section 2.4.6 of this review standard because it requires investigation of distantly and locally generated waves or tsunami that have affected or could affect a proposed site, including available evidence regarding the runup or drawdown associated with historic tsunami in the same coastal region and local features of coastal topography that might modify runup or drawdown. More detailed guidance on the investigation of seismically induced flooding is provided in Regulatory Guide 1.70.

Note: Though not required at the early site permit stage, the applicant for a combined license (COL) will need to demonstrate compliance with General Design Criterion 2 as it relates to structures, systems, and components important to safety being designed to withstand the effects of tsunami.

To meet the requirements of 10 CFR Parts 52 and 100, and 10 CFR 100.23, with respect to tsunami and the analysis thereof, the following specific criteria are used:

1. If it has been determined that tsunami estimates are necessary to identify flood or low water design bases, the analysis will be considered complete if the following areas are addressed and can be independently and comparably evaluated from the applicant's submission:

    a. All potential distant and local tsunami generators, including volcanoes and areas of potential landslides, are investigated and the most critical ones are selected.

    b. Conservative values of seismic characteristics (source dimensions, fault orientation, and vertical displacement) for the tsunami generators selected are used in the analysis.

    c. All models used in the analysis are verified or have been previously approved by the staff. Regulatory Guide 1.125 provides guidance in the use of physical models of wave protection structures.

    d. Bathymetric data are provided (or are readily obtainable).

    e. Detailed descriptions of shoreline protection and safety-related facilities are provided for wave runup and drawdown estimates. Regulatory Guide 1.102 provides guidance on flood protection for nuclear power plants.

    f. Ambient water levels, including tides, sea level anomalies, and wind waves, are estimated using NOAA and Corps of Engineers publications as described below.

    g. If Regulatory Guide 1.59, Position 2, is adopted by the applicant, the design basis for tsunami protection of all safety-related facilities identified in Regulatory

Guide 1.29 must be shown at the COL stage to be adequate in terms of the time required for implementation of any emergency procedures.

2. The applicant's estimates of tsunami runup and drawdown levels are acceptable if the estimates are no more than 5% less conservative than the staff's estimates. If the applicant's estimates are more than 5% less conservative (based on the difference between normal water levels and the maximum runup or drawdown levels) than the staff's, the applicant should fully document and justify its estimates or accept the staff's estimates.

3. This section of the safety assessment will also be acceptable if it states the criteria used to determine that tsunami flooding estimates are not necessary to identify the flood design basis (e.g., the site is not near a large body of water).

III. REVIEW PROCEDURES

Requirements and procedures governing issuance of early site permits for approval of proposed sites for nuclear power facilities are specified in 10 CFR Part 52. Information required for such a permit includes a description of the site's geohydrological characteristics. For this type of permit, the procedures below should be followed.

The references used for this review are general geophysical, seismological, and hydrodynamic publications, such as published data by the National Oceanic and Atmospheric Administration (NOAA), and wave propagation models, such as those developed by NOAA, the Corps of Engineers' Waterways Experiment Station (WES), and Tetra Tech.

Section 2.4.6 of the applicant's safety assessment is reviewed to identify any missing data, information, or analysis necessary for the staff's evaluation of potential tsunami flooding. This section is evaluated when the applicant has responded to all the additional information requested. If the site is not near a large body of water with potential tsunami generators, the staff findings may be prepared a priori.

The EMEB staff will review the potential tsunami sources analyzed by the applicant to ensure that all locations capable of generating a tsunami of significant magnitude at the site have been considered. The EMEB staff will evaluate the geoseismic parameters of the tsunami generators, including fault location and orientation, and amplitude and areal extent of vertical displacement, to ensure that conservative values have been chosen.

An independent staff analysis, using one of the models listed in the references, may be performed. Staff estimates of tsunami levels are compared with the applicant's. The applicant must justify, to the staff's satisfaction, tsunami levels more than 5% less conservative than the staff's.

As an alternative, the staff may perform an independent evaluation of the applicant's model and its utilization. The model's theoretical basis, its inherent conservatism and applicability to the problem, will be evaluated (this can be done on a generic basis). The conservatism of the model's use, including the conservatism of all input parameters, will be evaluated.

Coincident ambient tide and wave conditions will be evaluated to ensure that they are of at least annual severity. Data from publications of NOAA, the Corps of Engineers, and other sources are used to substantiate these conditions chosen.

Criteria and methods of the Corps of Engineers as generally summarized in Reference 15 are used as a standard to evaluate the applicant's estimate of coincident wind-generated wave action and runup.

Criteria and methods of the Corps of Engineers and other standard techniques are used to evaluate the potential for oscillation of waves at natural periodicity.

Criteria and methods of the Corps of Engineers (Ref. 14) are used to evaluate the adequacy of protection from flooding, including the static and dynamic effects of broken, breaking, and nonbreaking coincident waves.

At the COL stage, the maximum wave runup and drawdown will be compared to the design flood level and intake pumphouse design, respectively.

IV. EVALUATION FINDINGS

For early site permit reviews, the findings will consist of a statement summarizing estimates of the maximum and minimum tsunami water levels, and static and dynamic effects of wave action. A statement of acceptability of the tsunami-induced design basis in meeting the requirements of 10 CFR Parts 52 and 100, and 10 CFR 100.23 will be made. If the tsunami conditions do not constitute a design basis, the findings will so indicate.

A sample statement for an early site permit review follows:

> As set forth above, analyses of tsunamic effects from local and distant generators were performed by the applicant. The design tsunami results from a magnitude 8.7 earthquake in the Aleutian Trench. A finite difference numerical model was used to analyze tsunami generation and propagation to the continental shelf. Results of this computation were used in a near-shore model to calculate tsunami runup and drawdown. Including the effects of high and low tides of annual occurrence, the maximum tsunami runup and drawdown are estimated as +7.5 m (+24 ft) MLLW and -4.1 m (-13.4 ft) MLLW, respectively. Wind waves of annual severity were assumed coincident with the tsunami. Plant grade at elevation +55 feet MLLW is well above the tsunami flood level.
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> Historical data for the site are consistent with the flood levels identified in the early site permit application.
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> Therefore, the staff concludes that the applicant has adequately described the potential for a tsunami to impact structures, systems, and components of a nuclear power plant of type specified by the applicant that might be constructed at the site. It therefore meets the requirements of 10 CFR Parts 52 and 100, and 10 CFR 100.23.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this section of this review standard.

This section will be used by the staff when performing safety evaluations of early site permit applications submitted by applicants pursuant to 10 CFR Part 52. Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified

portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

2. 10 CFR Part 100, "Reactor Site Criteria."

3. Li-San Hwang, H. Lee Butler, and David J. Divorky, Tetra Tech, Inc., "Tsunami Model: Generation and Open-Sea Characteristics," Bulletin of the Seismological Society of America, Vol 62, No. 6, December 1972.

4. Li-San Hwang, D. Divorky, and A. Yuen, Tetra Tech, Inc., "Amchitka Tsunami Study," Report NV0-289-7, Nevada Operations Office, U.S. Atomic Energy Commission (1971).

5. Li-San Hwang and D. Divorky, Tetra Tech, Inc., "Rat Island Tsunami Model: Generation and Open-Sea Characteristics," Report NV0-289-10, Nevada Operations Office, U.S. Atomic Energy Commission (1971).

6. H. G. Loomis, "A Package Program for Time-Stepping Long Waves into Coastal Regions with Application to Haleiwa Harbor, Oahu," Hawaii Institute of Geophysics and National Oceanic and Atmospheric Administration (1972).

7. Li-San Hwang and D. Dovorky, "Tsunami Generation," Journal of Geophysical Research, Vol. 75, No. 33 (1970).

8. K. L. Heitner, "Additional Investigations on a Mathematical Model for Calculation of the Run-Up of Tsunamis," California Institute of Technology (1970).

9. R. L. Street, Robert K-C Chan, and J. E. Fromm, "Two Methods for the Computation of the Motion of Long Water Waves - A Review and Applications," NR 062-320, Technical Report 136, Office of Naval Research, distributed as a reprint from the Proc. 8th Symposium on Naval Hydrodynamics, August 1970.

10. B. W. Wilson, "Earthquake Occurrence and Effects in Ocean Areas (U)," Technical Report 69.027, U.S. Naval Civil Engineering Laboratory, Port Hueneme, California, February 1969.

11. C. L. Mader, "Numerical Simulation of Tsunamis," Hawaii Institute of Geophysics and National Oceanic and Atmospheric Administration, February 1973.

12. R. W. Preisendorfer, "Recent Tsunami Theory," Hawaii Institute of Geophysics and National Oceanic and Atmospheric Administration, August 1971.

13. National Oceanic and Atmospheric Administration, Nautical Charts.

14. “Coastal Engineering Manual,” CERC, May 2002 or most recent edition.

15. B. W. Wilson and A. Trum, "The Tsunami of the Alaskan Earthquake, 1964: Engineering Evaluation," Tech. Memo No. 25, Corps of Engineers Coastal Engineering Research Center (1968).

16. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants."

17. Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants."

18. Regulatory Guide 1.102, "Flood Protection Requirements for Nuclear Power Plants."

19. Regulatory Guide 1.29, "Seismic Design Classification."

20. Regulatory Guide 1.125, "Physical Models for Design and Operation of" Hydraulic Structures and Systems for Nuclear Power Plants."

21. R. L. Wiegel, "Oceanographical Engineering," Prentice-Hall, Inc., Englewood Cliffs, NJ (1964).

22. J. R. Houston and A. W. Garcia, "Type 16 Flood Insurance Study: Tsunami Predictions for Pacific Coastal Communities," Technical Report H-74-3, U.S. Army Engineer Waterways Experiment Station (1974).

23. J. R. Houston, R. W. Whalen, A. W. Garcias and H. L. Butler, "Effect of Source Orientation and Location in the Aleutian Trench on Tsunami Amplitude Along the Pacific Coast of the Continental United States," Technical Report H-75-4, U.S. Army Engineer Waterways Experiment Station (1975).

24. R. L. Wiegel, "Earthquake Engineering," Prentice-Hall, Inc., Englewood Cliffs, NJ (1970).

25. M. Brandsma, D. Divoky, and L. Hwang, "Tsunami Atlas for the Coasts of the United States," NUREG/CR-1106, USNRC (1979).

26. L. G. Hulman, W. S. Bivins, and M. H. Fliegel, "Tsunami Protection of Coastal Nuclear Power Plants in the United States," Journal of Marine Geodesy (1978).

27. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."