U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN
OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 3.11 ENVIRONMENTAL DESIGN OF MECHANICAL AND ELECTRICAL EQUIPMENT

REVIEW RESPONSIBILITIES

Primary - Electrical, Instrumentation and Control Systems Branch (EICSB)

Secondary - Auxiliary and Power Conversion Systems Branch (APCSB)
Containment Systems Branch (CSB)
Reactor Systems Branch (RSB)
Quality Assurance Branch (QAB)

I. AREAS OF REVIEW

The information presented in Section 3.11 of the applicant's safety analysis report (SAR) should be sufficient to support the conclusion that all items of safety-related mechanical and electrical equipment are capable of performing their design safety functions under all normal and accident environmental conditions. The "normal and accident environmental conditions" are deemed to include all environmental conditions which may result from any normal or abnormal mode of plant operation, design basis events, post-design basis events, and containment tests. The information presented should include identification of the safety-related equipment, and for each item of equipment, the environmental design bases, definition of normal and postulated environments, and documentation of the qualification tests and analyses performed to demonstrate the required environmental capability. In the preliminary safety analysis report (PSAR), this documentation may consist of a description of the tests and analyses that have been or will be performed. In the final safety analysis report (FSAR), the results of the qualification tests and analyses for each type of equipment should be provided. Seismic qualification is addressed in Standard Review Plan 3.10.

Section 3.11 of the SAR is reviewed to determine whether the required environmental capability of all safety-related equipment, i.e., the capability to perform design safety functions under normal and accident environments, will be or has been adequately demonstrated.

The EICSB makes a completeness check of the information provided by the secondary review branches as detailed below.

When requested, the secondary review branches (APCSB, CSB, RSB, QAB) will provide information to the EICSB with regard to mechanical and electrical equipment of safety-related systems within their respective primary review responsibilities, but exclusive of any electrical equipment located in the control room or other designated electrical equipment rooms or areas (this equipment is an EICSB responsibility). The SAR sections reviewed by the branches in performance of their secondary review functions are as follows: APCSB reviews Section 3.4.1 and applicable sections of Chapters 9 and 10; CSB reviews Section 6.2; RSB reviews Sections 3.2.1, 3.2.2, 4.4, 6.3, and applicable sections of Chapter 15; and QAB reviews Chapter 17. Guidance with regard to the definition of "safety-related systems" for the purposes of this plan is contained in Standard Review Plan 7.1, and the assignments of primary review responsibility for these systems are contained in the applicable review plans.

The APCSB, CSB, and RSB confirm that the SAR identifies all safety-related equipment.

The APCSB and CSB confirm the location of each item if equipment, both inside and outside the containment. Inside the containment, the location must specify whether inside or outside of the missile shield, for pressurized water reactor (PWR) plants, or whether inside or outside of the drywell, for boiling water reactor (BWR) plants with Mark III containment designs.

The APCSB, CSB, and RSB confirm the validity of the descriptions of both the normal and accident environments provided in the SAR. They will also confirm the acceptability of the values provided in the SAR for the length of time that equipment is required to operate in accident environments.

With regard to the environments resulting from loss of environmental control systems (ventilation, heating, air conditioning), the APCSB will confirm the description of these environments as provided in the SAR for those areas which contain safety-related equipment, including electrical control and instrumentation equipment.

The QAB reviews the environmental design and qualification program described in Section 3.11 of the SAR to ascertain that it is being implemented in accordance with the requirements of the quality assurance program described in Chapter 17 of the SAR.

Specific information may be requested from the MEB as needed.

II. ACCEPTANCE CRITERIA

The general requirements for environmental design and qualification of all equipment important to safety are embodied in General Design Criteria 1, 4, and 23 of Appendix A to 10 CFR Part 50, and in Section XI of Appendix B to 10 CFR Part 50. In addition, the requirement for environmental qualification is included in IEEE Std 279 (Ref. 3) and in IEEE Std 308 (Ref. 4). However, none of the above documents provide specific criteria for assessing the acceptability of an environmental design and qualification program.

Simply stated, the general requirements for environmental design and qualification are as follows. (1) The equipment shall be designed to have the capability of performing design safety functions under all normal and accident environments. (2) The equipment environmental capability shall be demonstrated by appropriate testing and analyses. (3) A quality assurance program shall be established and implemented to provide assurance that these requirements are met. The environmental design of safety-related mechanical and electrical equipment is acceptable when it can be ascertained that all three requirements are met.

Section V of this review plan lists the documents which provide both acceptance criteria and evaluation guidance used in the review. The most important of these documents is IEEE Std 323-1974, "General Guide for Qualifying Class I Electric Equipment for Nuclear Power Generating Stations" (Ref. 6). This document, although specifically written for Class I electric equipment, contains a clear presentation of the principles and criteria that are generic to the environmental qualification process itself; therefore, IEEE Std 323-1974 is considered applicable to the environmental qualification of other types of equipment. This document contains detailed criteria applicable to whatever method of qualification is used, i.e., type testing, analyses, operating experience, on-going qualification, or combined qualification. The environmental design and qualification of safety-related equipment is acceptable when it is ascertained that the criteria of IEEE Std 323-1974 have been met.

IEEE Std 334-1971, "Guide for Type Tests of Continuous-Duty Class I motors Installed Inside the Containment of Nuclear Power Generating Stations" (augmented by Regulatory Guide 1.40); IEEE Std 382-1972, "Guide for Type Test of Class I Electric Valve Operators for Nuclear Power Generating Stations" (augmented by Regulatory Guide 1.73); and IEEE Std 383-1974, "Standard for Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations," are specific with regard to type test qualification of the equipment identified in their titles. The detailed criteria contained in these documents should be used in conjunction with the more comprehensive criteria of IEEE Std 323-1974 for evaluating the respective equipment environmental qualifications.

IEEE Std 317-1972, "Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations" (augmented by Regulatory Guide 1.63), contains general guidance for qualification of penetration assemblies. Therefore, this document should be used in conjunction with IEEE Std 323-1974 for evaluating the environmental qualification of this equipment.

The criteria in IEEE Std 336-1971, "Installation, Inspection and Testing Requirements for Instrumentation and Electric Equipment During the Construction of the Nuclear Power Generating Stations" (augmented by Regulatory Guide 1.30), are used by QAB to evaluate the quality assurance program described by the applicant. The quality assurance program is acceptable if it can be ascertained that the criteria of this standard and guide are met.

III. REVIEW PROCEDURES

This section of the review plan describes the essential elements of the review process including the use of the criteria and evaluation guides.

The review objective is to determine from the information presented in the SAR whether there is reasonable assurance that all items of safety-related electrical and mechanical equipment are capable of performing design safety functions under all normal and accident environmental conditions.

To achieve the objective, the review is divided into two distinct phases; the information audit phase and the evaluation phase. The audit phase is concerned with the completeness of the information presented. The evaluation phase is concerned with whether the required environmental capability will be or has been adequately demonstrated for each item of equipment. The two phases of the review process are performed as follows:

1. Information Audit Phase

The review should determine that the following information is included:

a. Equipment Identification

All safety-related mechanical and electrical equipment must be identified. The equipment tabulations provided should be checked for completeness against the descriptions of safety-related systems contained in SAR Chapters 4, 5, 6, 7, 8, 9, 10, and 11. Definitions of the three categories of safety-related systems are contained in Standard Review Plan 7.1.

The EICSB is responsible for verifying the completeness of the identification of all the electrical power, control, and instrumentation equipment. In addition, the EICSB confirms the equipment identification inputs of the secondary review branches.

The secondary review branches are responsible for verifying the completeness of the identification of all mechanical equipment, and all electro-mechanical equipment located outside of the control room or other designated electrical equipment areas which pertain to the safety systems within their primary review responsibilities.

b. Equipment Location

The location of each item of safety-related equipment must be identified, both inside and outside the containment. Inside the containment, the location must specify whether inside or outside of the missile shield (for PWR's) or whether inside or outside of the drywell (for BWR Mark III's). Location of equipment is required in order to establish accurate definitions of both the normal and accident environments.

The EICSB and the secondary review branches are responsible for verifying the location of the items of equipment identified by these branches in accordance

with Section III.1.a above. The equipment locations are verified by review of the descriptions of the safety-related systems and the plant layout drawings in applicable sections of the SAR.

c. Normal and Accident Environmental Conditions

Both the normal and accident environmental conditions must be explicitly defined for each item of equipment. These definitions must include the following parameters: temperature, pressure, relative humidity, radiation, chemicals, and vibration (non-seismic).

For the normal environment, specific values should be provided. For the accident environment, these parameters should be presented as functions of time and the cause of the postulated environment (loss-of-coolant accident, steam line break, or other) should be identified.

The EICSB will verify that the normal and accident environments have been defined as indicated above for each item of equipment.

d. Time Required to Operate

The length of time that each item of equipment is required to operate in the accident environment must be provided. EICSB will verify the inclusion of this information. The secondary review branches will confirm the adequacy of the specified time interval for the equipment in their respective areas of primary review responsibility.

e. Environmental Qualification

The SAR should contain a complete description of the design bases and environmental qualification tests and analyses that have been (FSAR) or will be (PSAR) performed on each item of safety-related equipment. This should include qualification for the accident environments, qualification for extreme normal operating environments, and qualification to assure that loss of environmental control systems that are not classified as safety-related will not adversely affect the operability of safety-related equipment, particularly electrical equipment located in the control room and other control equipment rooms. The EICSB will confirm that this information is provided. The evaluation of the adequacy of the information is addressed in the following section of this review plan.

2. Evaluation Phase

The evaluation phase of the review involves the exercise of engineering judgement to determine from the information presented, particularly that regarding environmental qualification, whether an adequate demonstration of the required environmental capabilities of safety-related equipment will be or has been made. This phase of the review is performed after it has been established (by means of the information audit phase of the review previously described) that the information content requirements for Section 3.11 of the SAR have been satisfied. Although specifically written for use in evaluating the environmental qualification of Class

I electric equipment, IEEE Std 323-1974 contains principles and criteria that are comprehensive and generic to the qualification process itself; therefore, it is considered applicable to the environmental qualification of other types of equipment.

This phase of the review is performed as follows:

a. EICSB verifies that for each item of safety-related equipment, the environmental qualification program performed (FSAR) or proposed (PSAR) meets the detailed requirements of IEEE Std 323-1974, with particular emphasis on the following:

   (1) The accuracy and validity of the definitions of the normal and accident environments are verified by checking against the appropriate environmental control system design requirements for normal environments, and against the accident analyses with regard to accident environments resulting from loss-of-coolant accidents (LOCA) or steam or feedwater line breaks.

   (2) Type testing, or partial type testing in conjunction with one or more of the other methods, as defined in IEEE Std 323-1974, must be used for qualifying equipment for postulated accident environments. The qualification method used (type test, operating experience, analysis, combined qualification, or on-going qualification) should be identified. The corresponding requirements of IEEE Std 323-1974 then apply.

   (3) The type test must be designed to demonstrate that the equipment performance meets or exceeds the requirements of the equipment specifications for the plant, i.e., some margin must be demonstrated as indicated in IEEE Std 323-1974. Margin is demonstrated by increasing the levels of testing, the number of test cycles, and the test duration.

   (4) The test sequence, i.e., the order of application of the simulated environmental conditions (aging, radiation, vibration, etc.) during testing, must constitute the most severe sequence for the item being tested.

   (5) The equipment being type tested should be operated under design operating conditions and adequately monitored during testing to determine performance characteristics.

   (6) The equipment qualified by type testing must be prototypical of the actual equipment to be used in the plant. If this is not the case, a detailed analysis must be provided to justify the qualification.

   The criteria of IEEE Stds 317, 334, 382, and 383, and Regulatory Guides 1.40, 1.63, and 1.73 should be used, as applicable, in conjunction with IEEE Std 323 in evaluating the environmental qualification program.

b. The APCSB, CSB, and RSB evaluate the validity of the descriptions of both the normal and accident environments in those areas of the plant for which they have primary review responsibility. The normal environments are evaluated by means of a review of the design of the environmental control systems (ventilation, heating, cooling, air-conditioning); the accident environments by checking against the environmental conditions described in the accident analyses. The

accident environments resulting from LOCA and from steam and feedwater line breaks are the responsibility of the RSB. The secondary review branches will advise EICSB of any inadequacy in the descriptions of the normal and accident environments.

c. The APCSB evaluates the validity of the description of the environment resulting from the loss of environmental control systems (ventilation, heating, cooling, air-conditioning) in those areas of the plant which contain safety-related equipment, including the control room and other electrical equipment rooms. This evaluation is performed by review of the design of the respective environmental contol systems and calculation of the environment resulting from failure of the systems. The APCSB will advise EICSB of any inadequacy in the descriptions of the environments resulting from the loss of environmental control systems.

d. The APCSB, CSB, and RSB evaluate the acceptability of values provided in the SAR for the length of time that safety-related equipment is required to operate in the accident environment. This evaluation is performed by checking against the particular system or equipment operating requirements as postulated in the accident analysis. The secondary review branches will advise EICSB if any of the equipment accident environment operating times listed in the SAR are unacceptable.

e. QAB reviews the environmental qualification program to verify that the test control, documentation, inspection, and material control requirements are in accordance with IEEE Std 336-1971 (as augmented by Regulatory Guide 1.30) and with the requirements of the quality assurance program described in Chapter 17 of the SAR. The objective of this review is to ascertain that the programs described provide adequate assurance that only environmentally qualified equipment will be installed in the plant and that this equipment will be properly installed.

IV. EVALUATION FINDINGS

The review should verify that sufficient information is contained in the SAR to support conclusions of the following type, to be included in the staff's safety evaluation report:

"The applicant has identified all the safety-related mechanical and electrical equipment, defined the normal and postulated accident environments that this equipment may be subjected to, and described the environmental qualification program that has been (for FSAR) or will be (for PSAR) performed to demonstrate its required environmental capability. It is concluded from this information that there is assurance that all items of safety-related equipment will be capable of performing needed safety functions under normal and accident environmental conditions."

V. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 1, "Quality Standards and Records;" Criterion 4, "Environmental and Missile Design Bases;" and Criterion 23, "Protection System Failure Modes."

2. 10 CFR Part 50, Appendix B, Section XI, "Test Control."

3. IEEE Std 279-1971 (ANSI N42.7-1972), "Criteria for Protection Systems for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.

4. IEEE Std 308-1971, "Criteria for Class IE Electric Systems for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.

5. *IEEE Std 317-1972, "Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.

6. **IEEE Std 323-1974, "General Guide for Qualifying Class I Electric Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.

7. *IEEE Std 334-1971, "Guide for Type Tests of Continuous Duty Class I Motors Installed Inside the Containment of Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.

8. *IEEE Std 336-1971, "Installation, Inspection, and Testing Requirements for Instrumentation and Electric Equipment During the Construction of Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.

9. *IEEE Std 382-1972, "Guide for Type Test of Class I Electric Valve Operators for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.

10. *IEEE Std 383-1974, "Standard for Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.

11. *Regulatory Guide 1.30, "Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment" (this guide supplements IEEE Std 336-1971).

12. *Regulatory Guide 1.40, "Qualification Tests of Continuous Duty Motors Installed Inside the Containment of Water-Cooled Nuclear Power Plants" (this guide supplements IEEE Std 334-1971).

13. *Regulatory Guide 1.63, "Electric Penetration Assemblies in Containment Structures for Water-Cooled Nuclear Power Plants" (this guide supplements IEEE Std 317-1972).

14. *Regulatory Guide 1.73, "Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants" (this guide supplements IEEE Std 382-1972).

*Acceptance criteria or evaluation guidance.
**Basic acceptance criteria.

APPENDIX

STANDARD REVIEW PLAN 3.11

CHEMICAL AND RADIOLOGICAL ENVIRONMENT
IN CONTAINMENT DURING POSTULATED ACCIDENTS

REVIEW RESPONSIBILITIES

Primary - Accident Analysis Branch (AAB)

Secondary - None

I. AREAS OF REVIEW

Detailed methods of defining the radiological environment during postulated accidents are now under development by an IEEE standards committee for inclusion in IEEE-323. (Appendix A to IEEE-323 currently gives illustrative examples of environmental conditions but is not part of the standard.) When this standard has been completed, reviewed, and accepted by the staff, it will form the basis for evaluation. Review of source terms by the AAB will then be required only if unusual situations arise. Until the IEEE standard is available, the staff review of the chemical and radiological environment in the containment during postulated accidents will be in accordance with this appendix. This review is implemented primarily by comparing the applicant's proposed chemical and radiological source terms with those previously computed for similar plants. The purpose of this review is to assure that safety equipment inside containment will function in design basis accident environments.

II. ACCEPTANCE CRITERIA

1. The applicant's estimate of the chemical environment is acceptable if it reflects the chemical composition of all fluids and additives present in the primary system or added to the containment environment in the course of the accident for various modes of equipment operation.

2. The applicant's estimate of the radiation environment is acceptable if it reflects source terms comparable to those postulated in Regulatory Guides 1.3, 1.4, and 1.7 (Refs. 1, 2, 3) and results in equipment exposure levels similar to those presented in other applications and checked by independent staff calculations. The radiological source term for qualification tests in a radiation environment for pressurized water reactor (PWR) and boiling water reactor (BWR) equipment, such as pumps and seals, which normally is exposed to a water environment, should be based on the same source terms as given in Reference 3, i.e., 50% of the halogens and 1% of the solid fission products present in the core are intimately mixed with the coolant water. For PWR and BWR equipment, such as instrumentation

From the source term information, the reviewer may calculate the radiation dose rates and integrated doses in the containment, ESF filters, and in equipment rooms housing ESF components. For exposed organic material in ESF systems, a source term for both beta and gamma radiation is used. The methods, techniques, and appropriate data to be used in the calculations can be found in radiation shielding references such as those listed in References 6 through 8. The results are compared with those of the applicant. The evaluation findings of the chemical and radiation environmental source terms are given to EICSB and MEB when there is a disagreement with the applicant's submittal.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes aspects of the areas covered by this review plan as may be appropriate for each particular case. The judgment on areas to be given attention and emphasis in the review is based on an inspection of the material presented to see whether it is similar to that recently reviewed on other plants and whether items of special safety significance are involved.

The reviewer confirms that the estimates of chemical and radiation environments given by the applicant are comparable with those of similar plants recently reviewed and approved or are comparable to those that may be determined by an independent calculation on a typical plant. If an independent calculation is determined to be necessary, the procedure outlined below may be followed.

1. Chemical Environment

The chemical environment inside the containment can be established by considering the total quantity of injection liquid and the total quantity of additives (e.g., NaOH, Na_2SO_3, N_2H_2). From this information the reviewer may calculate the weight and volume percent of the additive. The pH of the resulting solution can be calculated for appropriate combinations of equipment operation using generally accepted values of dissociation constants (Ref. 4). (This information should be cross-checked with Section 6.5.2.9 of the applicant's safety analysis report.) See also Standard Review Plan (SRP) 6.5.2 and SRP 6.1.3.

2. Radiation Environment

A radiation source term consistent with Regulatory Guides 1.3, 1.4, and 1.7 (Refs. 1, 2, 3) is assumed as appropriate to the air or water environment under consideration. If an independent calculation is desirable, the ORIGEN computer code (Ref. 5) may be used to calculate the core inventory as a function of burnup. The construction of the source term is based on the use of the maximum activity reached by each of the selected radionuclides. Calculations may be made independently for each environment (water and containment air) because conservative fission product assumptions for one environment may be nonconservative for another. The average energy of the fission product radiations and the total number of curies can be calculated from the information given in the ORIGEN output; this information is calculated for 0 to 30 days after shutdown in one-day increments. Separate energies for beta and gamma radiations are derived when this calculation is made.

When the IEEE standard is developed and reviewed by the staff, both the standard and position C.2 as given in the draft, dated April 7, 1975, of Regulatory Guide 1.89, Revision 1, will form the basis for evaluation. Individual review and independent calculation of the radiation environment at that point will be required only in exceptional cases.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and that the review and calculations support conclusions of the following type, to be included in the staff's safety evaluation report:

"The applicant's chemical and radiation source terms that define the environmental conditions to be used in design of the ESF mechanical and electrical equipment are appropriate for the postulated design basis accidents."

V. REFERENCES

1. Regulatory Guide 1.3, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Boiling Water Reactors," Revision 2.

2. Regulatory Guide 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Pressurized Water Reactors," Revision 2.

3. Regulatory Guide 1.7, "Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident."

4. "Handbook of Chemistry and Physics,: The Chemical Rubber Co., Cleveland, Ohio. (Any recent edition.)

5. M. J. Bell, "ORIGEN - The ORNL Isotope Generation and Depletion Code," ORNL-4628, Oak Ridge National Laboratory, May 1973.

6. T. Rockwell, "Reactor Shielding Design Manual," D. Van Nostrand Co., Princeton, New Jersey (1956).

7. R. E. Malenfant, "QAD - A Series of Point-Kernal General-Purpose Shielding Programs," LA-3573, Los Alamos Scientific Laboratories, October 1966.

8. R. Jaeger, Ed., "Engineering Compendium on Radiation Shielding. Volume 1, Shielding Fundamentals and Methods," Springer-Verlag, New York (1968).

SRP 4.2

SRP 4.2