SAFETY EVALUATION REPORT OF COMBUSTION ENGINEERING EQUIPMENT QUALIFICATION DOCUMENTATION CENPD-255-A REVISION 3 AND AMENDMENT 9 TO CESSAR CHAPTER 3

ENVIRONMENTAL QUALIFICATION OF CLASS 1E ELECTRICAL EQUIPMENT

1. INTRODUCTION

Equipment which is used to perform a necessary safety function must be demonstrated to be capable of maintaining functional operability under all service conditions postulated to occur during its installed life for the time it is required to operate. This requirement, which is embodied in General Design Criteria 1 and 4 of Appendix A and Sections III, XI, and XVII of Appendix B to 10 CFR 50, is applicable to equipment located inside as well as outside containment. More detailed requirements and guidance relating to the methods and procedures for demonstrating this capability has been set forth in 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants," and NUREG-0588, "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment." This NUREG supplements IEEE Standard 323, and various NRC Regulatory Guides and industry standards.

2. BACKGROUND

NUREG-0588 was issued in December 1979 to promote a more orderly and systematic implementation of equipment qualification programs by industry and to provide guidance to the NRC staff for its use in ongoing licensing reviews. The positions contained in this report provide guidance on (1) how to establish environmental service conditions, (2) how to select methods which are considered appropriate for qualifying equipment in different areas of the plant, and (3) other areas such as margin, aging, and documentation.

In February 1980 the NRC requested certain near term Operating License (OL) applicants to review and evaluate the environmental qualification documentation for each item of safety related electrical equipment and to identify the degree to which their qualification programs comply with the staff positions discussed in NUREG-0588. IE Bulletin 79-01B "Environmental Qualification of Class 1E Equipment," issued January 14, 1980, and its supplements dated February 29, September 30, and October 24, 1980 established environmental qualification requirements for operating reactors. This bulletin and its supplements were provided to OL applicants for consideration in their review.

A final rule on environmental qualification of electric equipment important to safety for nuclear power plants became effective on February 22, 1983. This rule, Section 50.49 of 10 CFR Part 50, specifies the requirements to be met for demonstrating the environmental qualification of electrical equipment important to safety located in a harsh environment.

The qualification requirements for mechanical equipment are principally contained in Appendices A and B of 10 CFR 50. The qualification methods defined in NUREG-0588 can also be applied to mechanical equipment.

2.1 Purpose

The purpose of this Safety Evaluation Report (SER) is to evaluate the adequacy of the Combustion Engineering (CE) Equipment Qualification Program, as stated in the Combustion Engineering Topical Report CENPD-255-A, (Revision 3) and Amendment 9 to Chapter 3 of CESSAR (section 3.11).

This report was evaluated by the Equipment Qualification Branch of the Nuclear Regulatory Commission. The criteria mentioned in Section 1 and Section 2 of this report form the basis for evaluation.

This will assure that a general methodology exists and can be applied to specific Combustion Engineering supplied safety related electrical equipment such that the requirements identified previously are met. The staff position relating to any identified open items in the April 10, 1983 SER is provided in this report.

2.2 Scope

The scope of this report is limited to an evaluation of environmental qualification methodologies and its potential application to specific equipment items. No plant specific information is presented, so margin adequacy is not evaluated.

2.3 General Summary of CENPD-255-A Revision 3

CENPD-255-A, (Revision 3) with Amendment 9 to Chapter 3 of CESSAR (section 3.11) describes the methods used to qualify class 1E combustion engineering supplied electrical equipment. These documents includes equipment in harsh and non-harsh environments. Included in the reports are the following general topics.

The scope of supply for a generic plant design is listed. This equipment is then assigned a typical environment depending on its plant location. Harsh environment qualification procedures are outlined, with type testing of age conditioned equipment as the method selected. The test sequence is that recommended by IEEE 323-1974.

Non-harsh environment qualification addresses normal and abnormal environments as well as seismic events. An aging analysis, which may result in accelerated aging being performed, is conducted prior to testing. As with harsh environment items, typical environments are postulated.

Other material related to qualification is presented, including treatment of radiation degradation, Ahrenius methodology assumptions and conservatisms, thermal analysis methods and operating time derivation techniques.

2.4 Summary

This report details the results of a review of Combustion Engineering Equipment Qualification Program as outlined and reported in CENPD-255-A (Revision 3) with Amendment 9 to Chapter 3 of CESSAR (section 3.11). The review was performed by the Equipment Qualification Branch of the Nuclear Regulatory Commission (NRC). The conformance of the Combustion Engineering Qualification Program to current NRC requirements determines its usefulness to licensees or applicants in establishing qualification adequacy on an individual plant basis. The review process consisted of formal and informal question rounds, meetings with CE and NRC representatives exchanging industry and NRC positions, report modifications as a result of these exchanges, and a final approval of specific subtopics.

It is concluded that CENPD-255-A (Revision 3) with Amendment 9 to Chapter 3 of CESSAR (section 3.11) describes an adequate qualification program that conforms to present NRC requirements.

It is concluded that the generic approach to environmental qualification of safety-related electrical equipment set forth in CENPD-255-A (Revision 3) with Amendment 9 to Chapter 3 of CESSAR (section 3.11) is acceptable and meets the requirements of 10 CFR 50.49 as well as NUREG-0800 and its associated standards.

3. EVALUATION OF METHODOLOGY DOCUMENTS

The evaluation was based on the following criteria:

Harsh Environment--Safety Related Electrical Equipment

The criteria described in NUREG-0588 Category 1, as defined in 10 CFR 50, Section 50.49, form the basis for the staff evaluation of acceptability. NUREG-0588 is supplemented by IEEE 323-1974 augmented by Regulatory Guide 1.89. NUREG-0800, Revision 2, was also used as a review guide.

Non-Harsh Environment--Safety Related Electrical Equipment

The criteria for environmental qualification of all electrical equipment located in a non-harsh environment are:

The "Design/Purchase" specifications for each equipment item shall contain a description of the functional requirements for its specific environmental zone during normal and abnormal environmental conditions. A well supported maintenance and surveillance program shall be established to assure that equipment that meets the "design/purchase" specifications is qualified for the designed life.

The maintenance/surveillance program data and records shall be reviewed periodicially (18 months or less) to ensure that the equipment has not suffered thermal and cyclic degradation triggered by abnormal environmental conditions and normal wear due to its service condition. Engineering judgment shall be used to modify the replacement program and/or replace the equipment as deemed necessary.

These criteria are expanded in NUREG-0800 Section 3.11.

3.1 Class 1E Safety Related Equipment Covered

CENPD-255-A (Revision 3) lists typical safety related electrical equipment that will be supplied by Combustion Engineering. Every plant referencing CENPD-255-A (Revision 3) will have a specific list of CE supplied equipment. This list can be found in the applicants Safety Analysis Report (SAR).

Appendix A of CENPD-255-A (Revision 3) lists and categorizes CE supplied equipment required to mitigate a DBE or to obtain a safe shutdown. A general listing, covering several variations of supply scope and building design, cannot be complete. As a result, each individual applicant must ascertain, through application of appropriate interface criteria, that the complete listing of NSSS scope of supply and balance of plant items does identify all CE equipment associated with systems that are important to safety. The individual applicant must also verify that equipment environmental and seismic conditions and locations are correct on a plant specific basis.

3.2 Service Conditions

NUREG-0588 defines the methods to be utilized for determining the environmental conditions associated with loss-of-coolant accidents or high energy line breaks, inside and outside containment. This document provides the option of establishing a bounding pressure and temperature condition based on plant specific analysis or based on general profiles using the methods identified in these documents. Since CENPD-255-A (Revision 3) is a generic document, typical profiles have been developed which will envelop most of the specific plants expected environmental conditions. Appendix B of CENPD-255-A (Revision 3) contains these typical profiles, for inside as well as outside containment. These profiles, subject to the conditions specified in the conclusion of this report, are regarded as adequate for the intended purpose. In addition, assumed normal and abnormal operating conditions are supplied for all areas where Class 1E equipment is utilized. However, no judgment is intended on the validity of the typical profiles. Each specific plant

calculates its normal, abnormal, and accident environmental profile, and must compare those profiles with equipment specific tested profiles to ascertain qualification.

3.3 Temperature, Pressure and Humidity Conditions Inside Containment

Environmental conditions for normal and abnormal operation inside containment are specified.

Typical Loss of Coolant Accident (LOCA) and Main Steam Line Break (MSLB) profiles are furnished, with a peak LOCA temperature of 350°F and a peak MSLB temperature of 370°F. Peak pressure in both cases is 60 psig, with superheat conditions postulated for a maximum of ten minutes and saturated conditions following. These postulated accident condition profiles are combined in Figure B-7 of Appendix B of CENPD-255-A (Revision 3) and is a typical combined LOCA/MSLB test envelope. This test profile incorporates the recommended IEEE-323-1974 double peak at 385°F and 66 psig. Temperature and pressure margins are adequate. A temperature profile utilizing the saturation temperature associated with peak projected containment pressure, is included. The staff's conclusion, that Figure B-7, in conjunction with an approved thermal analysis technique entitled "Thermal Equivalence," is acceptable with the following restrictions:

The general method of temperature qualification by "Thermal Equivalence" is acceptable with the understanding that the containment temperature transients will be reviewed on a plant-specific basis. CE will also provide a detailed description of the analytical modeling techniques and application of the thermal equivalence approach, including the basis for selecting the parameters. The following restrictions are part of the general application of the methodology and conformance shall be documented in each test report:

1. Application of the thermal equivalence approach shall be justified on each piece of equipment, including any judgments regarding the survivability limits of the equipment.

2. Describe the specific heat transfer modeling and justify that the critical surface or surfaces are limiting both in time and location.

3. Multiple temperature measurements of the critical surface for testing shall envelope the calculated critical surface(s) temperature transient, including the initial temperature ramp. Soaking will not be permitted.

4. The margin between the minimum measured surface temperature and the calculated surface temperature shall exceed the uncertainties associated with design, production, testing, and operability time, or a temperature margin of 15° by reference to the guidelines of IEEE 323-1974 shall be applied.

5. Application of the thermal equivalence approach will be restricted to the limiting superheated steam harsh environment. The limiting environment and operability time shall consider a spectrum of breaks.

The open item on "Thermal Equivalence" methodology identified in the SER dated April 10, 1983 has been described in CENPD-255-A (Revision 3) and is considered acceptable by the staff.

The typical curves specified must be verified by the individual applicant to satisfactorily envelop plant specific postulated conditions.

3.4 Temperature, Pressure and Humidity Conditions Outside Containment

CENPD-255-A (Revision 3) has developed a series of environmental condition categories, most of which are for outside containment locations. These locations include areas affected by High Energy Line Break (HELB) conditions. Equipment in those areas will be qualified to these typical conditions. Other categories include non-harsh environment conditions, with normal and abnormal extremes being specified. These categorical conditions must be reviewed by the specific applicant to determine applicability, however this general approach is considered adequate.

3.5 Submergence

When submergence qualification is necessary because of flood level and equipment location analysis, CENPD-255-A (Revision 3) states that qualification will be performed by type test or partial type test and analysis. The effect of containment pressure during submergence is considered. This is an adequate approach.

3.6 Chemical Spray

Typical values of chemical spray are stated as 4400 ppm boron and 50 to 100 ppm, hydrazine with a pH of 4 to 10. Actual values will be determined through single failure analysis of the spray system to determine the most severe spray composition. Chemical spray simulation during in containment testing starts 10 minutes after the start of the second transient. Each applicant must assure that the value used envelops the conditions postulated at his specific plant. This is an adequate general approach.

3.7 Aging for Harsh and Non-harsh Environments

As stated in CENPD 255-A (Revision 3) and Amendment 9 to Chapter 3 of CESSAR (section 3.11) the aging portion of the qualification program is defined based upon whether or not equipment is located in a harsh or non-harsh environment. Equipment located in a harsh environment will undergo an aging analysis and an accelerated age conditioning program. Equipment located in a non-harsh environment will undergo an aging analysis that focuses on the identification of known aging mechanisms that significantly increase the equipments susceptibility to its design basis event (seismic event only for non-harsh environments). If no known significant aging mechanisms are found, a surveillance/preventive maintenance (S/PM) program will be developed to monitor for degradation trends that suggest increasing seismic susceptibility. If an aging mechanism is found that is known to significantly increase the equipments seismic susceptibility with time, that mechanism will be analyzed to determine whether an accelerated aging program or a periodic part replacement program is appropriate.

These general aging methodologies conform to the requirements of NUREG-0588 and IEEE 323-1974 and, coupled with sound engineering judgment, provide an acceptable treatment of aging.

3.8 Radiation for Harsh and Non-harsh Environment Equipment

Equipment will be designed for the types and levels of radiation associated with normal operation plus the radiation associated with the limiting Design Basis Accident (DBA). These levels are defined in Appendix 3.11A.

Equipment which is exposed to radiation above 10^4 Rads will be irradiated to its anticipated Total Integrated Dose (TID) prior to type testing unless it is determined by analysis that radiation does effect its ability to perform its required function. Where the application of the accident dose is planned during DBA testing, it need not be included during the aging process.

Equipment which will be exposed to radiation levels of 10^4 Rads or below will be analyzed to determine whether low level radiation could impact its ability to perform its required function. Where analysis supported by partial type test data cannot demonstrate proper operation at the required radiation levels, type testing will be performed. Additionally, Electronic Equipment exposed to low level radiation will be addressed by an Aging Analysis which focuses on the identification of semi-conductor (organic material) components that are considered to be age-sensitive in 40 years. For electronic components that are age-sensitive a surveillance/preventive maintenance program will be developed. CENPD-255-A (Revision 3) outlines this methodology.

Mechanical/Electrical Equipment will be qualified to the typical radiation environments defined in Appendix 3.11A. If more than one type of radiation is significant, each type may be applied separately.

Gamma

Cobalt-60 is considered an acceptable gamma radiation source. Other sources may be found acceptable, and will be justified. Electrical Equipment will be tested to typical gamma radiation levels defined in Appendix 3.11A.

Beta

Equipment exposed to beta radiation will be identified and an analysis will be performed to determine if the operability of the equipment is affected by beta radiation ionization and heating effects. Qualification will be performed by test unless analysis demonstrates that the safety function will not be degraded by Beta exposure. Equipment will be tested and/or analyzed to the beta radiation levels defined in Appendix 3.11A. Where testing is recommended, gamma equivalent radiation source will be used.

Neutron

Equipment exposed to neutron radiation will be identified and neutron radiation levels defined. When actual neutron dose qualification testing is not performed, an equivalent gamma radiation dose will be used for qualification testing to simulate neutron exposure. The basis for establishing an equivalent gamma radiation dose will be provided.

Paints/Radiation Effects

An analysis will be performed addressing paint exposure to beta and gamma radiation. Qualification of painted equipment will be by test if analysis indicates that the safety function of the equipment could be impaired by failure due to radiation.

The radiation aging methodology described conforms to the positions of IEEE 323-1974 and NUREG-0588 which provides an acceptable treatment of radiation. Each applicant must ensure that, for each equipment item and location, the plant specific postulated radiation dose is enveloped by the dose specified for that item.

3.9 Test Sequence

The test sequence employed for equipment subject to operation in a HELB environment is that sequence outlined in IEEE-323-1974. As allowed by this standard, performance extremes testing may be done on separate equipment.

The test sequence stated in CENPD-255-A (Revision 3) is acceptable.

3.10 Margin

CENPD-255-A (Revision 3) approaches margin in several ways, depending on the parameter.

Derivation of the in-containment temperature and pressure envelopes for testing purposes have 15°F and 10 psi added to ensure adequate margin. The margin available in specific plant applications will vary.

A commitment to a radiation margin of 10% of the accident dose is included, unless the radiation dose is calculated based on NUREG-0588, Appendix D. In this case, additional margin will not be added.

The above applications of margin are adequate, remembering that each individual applicant must verify acceptable margin based on plant specific information.

CENPD-255-A (Revision 3) approaches time margin in two ways. The first, to be employed in a majority of cases, utilizes the standard "10% or 1 hour, whichever is greater" margin mandated by NUREG-0588.

The second margin approach, entitled "Unusual Time Margin" deviates from this standard. Discussions with the staff resulted in an acceptance of C.E.'s methodology subject to the following:

In the event it is necessary to use time margin evaluation techniques, the following information, as a minimum, will be documented.

1. Application of time margins less than one hour will be justified for each piece of equipment, including any judgments regarding the survivability limits of the equipment.

2. The maximum operability time will be justified with consideration for a spectrum of breaks and the potential need for the equipment later in an event or during recovery operations.

3. It will be demonstrated that failure of the equipment after the maximum operability time will neither mislead the operator to take an improper action nor further degrade the event by causing a failure in systems necessary for mitigation of the event.

4. The margin applied to the minimum operability time when combined with other test margins will account for the uncertainties associated with the design, production tolerances, testing techniques, and the number of units tested.

The open item on "Unusual Time Margin" identified in the SER dated April 10, 1983 has been described in CENPD-255-A (Revision 3) and in considered acceptable by the staff.

5 Conclusions

The methodology used by Combustion Engineering to qualify NSSS safety related electrical equipment is outlined in CENPD-255-A (Revision 3). It is expected that this report may be referenced by license applicants for the scope and methods employed for qualification of individual equipment items.

The qualification program reported in CENPD-255-A (Revision 3) is a generic program, with parameters developed to envelop a range of different plant and containment designs. Accordingly, each applicant must insure that the time dependent environmental parameters used in the testing of each equipment item, as well as assumed normal and abnormal conditions used in analysis, envelop the corresponding values developed by plant specific analysis.

It is concluded that with the caution noted above, the general approach to environmental qualification of safety-related electrical equipment is acceptable and meets the requirements of 10 CFR 50 Section 50.49 and its associated standards.