CENPD - 255
Revision 1

CLASS IE QUALIFICATION

QUALIFICATION OF CLASS IE INSTRUMENTATION

JULY, 1980

POWER SYSTEMS
COMBUSTION ENGINEERING, INC

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ABSTRACT

Qualification of Combustion Engineering

Class 1E Instrumentation (CENPD-255)

This report describes the methods used to meet the requirements of IEEE Std. 323-1974 for qualification of Class 1E Combustion Engineering supplied instrumentation for nuclear power plants. The general scope of various qualification programs is discussed. The types of components included and data on these systems, modules and components are discussed. Type tests, analysis, and other methods of qualification are presented. Documentation for qualification is described with sample data sheets provided.

It is expected that this report will be referenced by NRC license applicants for the scope and methods employed for qualification of C-E supplied instrumentation.

QUALIFICATION OF CLASS 1E INSTRUMENTATION

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
APC	Auxiliary Protective Cabinet
ARC	Auxiliary Relay Cabinet
CEA	Control Element Assembly
CEAC	Control Element Assembly Calculator
CEDM	Control Element Drive Mechanisms
CEDMCS	Control Element Drive Mechanism Control System
CPC	Core Protection Calculator
CPIA	Control Element Assembly Position Isolation Assembly
CPPS	Compartmented Plant Protection Systems
CPU	Central Processing Unit
DIDA	Digital Isolation Device Assembly
DNBR	Departure from Nucleate Boiling Ratio
EMI	Electro-Magnetic Interference
ESFAS	Engineered Safety Features Actuation System
E/I	Voltage-to-Current
HWAS	Hard Wired Annunciators System
I/E	Current-to-Voltage
I/O	Input/Output
LOCA	Loss of Coolant Accident
LPD	Local Power Density
MSLB	Main Steam Line Break
NI	Nuclear Instrumentation
OCIS	Optical Communications Interface System
PMS	Plant Monitoring System

LIST OF ABBREVIATIONS (Cont'd.)

Abbreviation	Meaning
PPS	Plant Protection System
RCP	Reactor Coolant Pump
RCPSSS	Reactor Coolant Pump Shaft Speed Sensor
RIS	Remote Input Subsystem
RPS	Reactor Protection System
RSPT	Reed Switch Position Transmitter
RTD	Resistance Temperature Detectors
SAR	Safety Analysis Report
SER	Safety Evaluation Report
SPLA	Supplementary Protection Logic Assembly
SPS	Supplementary Protection System
SSAS	Solid State Actuation System
SSCCS	Solid State Component Control Systems
SSMUX	Safety Status Multiplexor
SSPPS	Solid State Plant Protection Systems
TID	Total Integrated Dose

QUALIFICATION OF CLASS IE INSTRUMENTATION

1.0 INTRODUCTION

1.1 Objectives

This report discusses the methods used to meet the requirements of IEEE Std. 323-1974 for qualification of Class 1E Combustion Engineering (C-E) supplied instrumentation for nuclear power plants. The report will discuss methods for environmental qualification. It is expected that this report will be referenced by NRC license applicants for the scope and methods employed for qualification. Qualification data and test results will be prepared by C-E using data forms provided in this report.

1.2 Background Information

Applicants for NRC licenses are required to demonstrate that Class 1E systems and equipment will perform their required Class 1E functions throughout their design life under the expected normal and postulated accident conditions. Qualification programs must consider the effects of seismic vibration, normal and accident environments, and the effects of long term exposure to radiation, temperature, pressure, humidity, and electromagnetic interference (EMI) as well as the natural aging process of the individual equipment. In order to develop a qualification program the following considerations should be addressed. (The number of the section in this report which discusses each item is shown in parentheses after the item).

Environments and exposure times involved. (3.3.2).

Equipment or modules included. (3.1).

Basic components involved. (3.1).

Effects on these components of long or short term exposure to these environments. (2.4).

Methods of observing or detecting these effects. (2.4).

Limits established for possible degradation effects. (2.4).

Simulation of environments or effects to determine qualification of individual components or modules. (2.4).

Performance or operating requirements for Class 1E equipment to demonstrate qualification. (3.3.3).

This report will address each one of these items as applied to C-E supplied instrumentation.

1.3 Criteria and Standards

The qualification program is established to meet the requirements of IEEE Std. 323-1974 (Reference 1).

This report may be referenced by applicants for plants whose Safety Analysis Reports commit to qualifications meeting IEEE Std. 323-1974 (Reference 1).

Justification for the applicability of these criteria and standards to C-E supplied equipment will be provided by individual applicants in Section 3.11 of their SAR.

1.4 Summary

A summary of the various sections of this report is given below.

Scope of Qualification Program (Section 2.0)

The general scope of supply and the various qualification programs planned are discussed. It is planned to cover all Class 1E instrumentation supplied by C-E, including sensors and signal processors, protective systems, panels, and miscellaneous Class 1E instrumentation.

Equipment Requiring Qualification (Section 3.0)

The types of components included and data on the systems, modules and components to be qualified are discussed. Information will be included on the location of equipment, qualification environment and operating requirements.

Methods of Qualification (Section 4.0)

The type tests, analysis and other methods of qualification are presented. The conservatism of the qualification parameters will be demonstrated.

Documentation (Section 5.0)

This section discusses the documentation for qualification. Typical data sheets will be provided for each type of equipment. Data, necessary to support the review on a particular applicant's docket, will be available for audit at C-E.

1.5 REFERENCES

1. IEEE Std. 323-1974, "IEEE Stan for Qualifying Class 1E Equipment for Nuclear Power G ..ing Stations", February 28, 1974.

2. TIS-5206, "Meeting the Latest Qualification Requirements for Class 1E Protection System Equipment - A Practical Approach," Daigle, R. P., and Breen, R. J., presented at American Power Conference, Chicago, Illinois, April 18-20, 1977.

3. "Aging Technology," Roberts, Charles W., Wyle Laboratories, August 24, 1976.

4. CENPD-182, "Seismic Qualification of C-E Instrumentation and Electrical Equipment," November 1975, C-E Power Systems.

5. "Aging of Class 1E Modules," McGrath, Thomas J., IEEE Transactions on Nuclear Science, Volume NS-22, February 1975.

6. Report F-C3906, "Qualification Test of Electrical Cables under Simulated Reactor Containment Service Conditions Including Loss of Coolant Accident While Electrically Energized," Franklin Institute Research Laboratories, July 1974.

7. NASA CR-1785, CR-1786, CR-1787, CR-1834, CR-1873 "Radiation Effects Design Manual", Vol. 1, 2, 3, 4, 5 1971.

8. IEEE Std. 384-1974, "Trial Use Standard Criteria for Separation of Class 1E Equipment and Circuits", March 15, 1974.

9. Regulatory Guide 1.75 (Rev. 0), "Physical Independence of Electric Systems". February, 1974.

10. TIS-4983, "The Practical Implementation of Regulatory Guide 1.75 on Nuclear Plant Instrumentation Systems," Davis, John W. and Schultze, Richard G., presented at symposium on Nuclear Power Systems, sponsored by IEEE, New Orleans, Louisiana, October 20-22, 1976.

11. MIL-HDBK-217B, "Military Standarization Handbook, Reliability Prediction of Electronic Equipment", Revised to Notice 2, March 17, 1978.

12. "Metallurgical Failure Modes of Wire Bonds", Harmon, George G., 12th Annual Proceedings, Reliability Physics, 1974, sponsored by IEEE, Las Vegas, Nevada, April 2-4, 1974; p. 137.

13. "Practical Applications of Accelerated Testing-Introduction", Peak, D.S., 13th Annual Proceedings, Reliability Physics, 1975, sponsored by IEEE, Las Vegas, Nevada, April 1-3, 1975; pgs. 253-254.

2.0 SCOPE OF QUALIFICATION PROGRAM

This section discusses the plants or applicants expected to reference this report, the general scope of supply and the various qualification programs planned. It is planned to cover all Class 1E instrumentation supplied by C-E, including sensors and signal processors, protective systems, panels, and miscellaneous Class 1E instrumentation.

2.1 PLANTS REFERENCING REPORT

It is expected that C-E designed plants whose SER for the PSAR was issued after July 1, 1974 will be able to refer to this report to describe the methods used to qualify C-E supplied equipment in accordance with IEEE Std. 323-1974 (Reference 1).

The responsibility for justifying applicability of this report to particular plants will rest with the applicant.

2.2 SCOPE OF SUPPLY AND INTERFACE REQUIREMENTS

The normal C-E scope of supply for Class 1E instrumentation for plants expected to reference this report is shown in Table A-1. In general, the C-E scope of supply for Class 1E instrumentation normally includes process detectors, signal converters or transmitters, control room indicators and recorders, signal isolators, plant protective and associated panels, power supplies and miscellaneous panels, cabinets and other equipment. C-E's scope does not include equipment such as environmental controls (heating, cooling and ventilation). Where qualification of this equipment is required to assure continued operation of C-E supplied Class 1E equipment, appropriate interface requirements are provided to the responsible party (usually the Customer or Architect Engineer). Qualification of other Class 1E electrical equipment such as pump motors or valve operators, is outside the scope of this report and will not be discussed by this report.

The systems and equipment discussed herein represent the generic design of many different plants. Plant specific equipment not referenced herein should be addressed in the applicants SAR.

2.3 QUALIFICATION PROGRAM

The qualification program is established to meet the requirements of IEEE Std. 323-1974 (Reference 1). In general, the qualification program will take the following form.

> Class 1E equipment located in the Containment Building, required to function during or after the design basis event, (LOCA, MSLB, seismic) will be type tested for the accident environment as specified in IEEE Std. 323-1974, Sections 6.1, 6.2, and 6.3. This will include Class 1E temperature, pressure, level, and flow transmitters, ex-core detectors and preamplifiers, CEDM reed switch position transmitters, cables and connectors, and reactor coolant pump shaft speed sensors.

Class 1E equipment located in the Auxiliary Building or Control Building will be qualified for the normal and abnormal local environment and the seismic event. This will include Class 1E plant protective system panels and modules, indicators, converters and recorders, miscellaneous electronic modules and some process instrumentation channels. There may also be some equipment located in the Auxiliary Building requiring qualification under accident conditions. A list of the types of equipment which will be qualified by this program, with the qualification requirements, is given in Table A-1.

2.3.1 Environmental

Class 1E equipment will be environmentally tested to levels at least as severe as the conditions specified in the Safety Analysis Report, Section 3.11.2, for normal and accident conditions. A summary of qualification parameters is given in Table B-1. Type test data sheets are shown in Exhibit 5.1-1.

2.3.2 Seismic

A description of the seismic qualification program and qualification results is contained in CENPD-182 (Reference 4).

This report will not discuss seismic testing methods or results, other than to reference CENPD-182.

2.3.3 Aging

The aging qualification program will be conducted in accordance with the guidelines of IEEE Std. 323-1974 (Reference 1). The method of qualification will follow the general approach given in Reference 2. This program can be described as follows:

Inaccessible equipment (process sensors, transmitters) will be subjected to accelerated aging techniques including thermal aging, radiation and cycling, as appropriate, and where a valid aging correlation can be made.

Complex, accessible equipment (plant protective system, panel mounted equipment) will be qualified using a preventive maintenance/surveillance program, including scheduled maintenance coupled with periodic testing, as described in Reference 2. This method of qualification is in keeping with Reference 3 in that equipment will be returned to an acceptable condition if periodic tests indicate degradation outside of operating limits. (See Section 4.3.1).

In addition, Class 1E electromechanical devices will be cycled before type testing.

Detailed information on aging methods is contained in Section 4.3 herein and Appendices C and D.

2.4 ENVIRONMENTAL CONDITIONS AND EFFECTS

The postulated environmental conditions, to which Class 1E equipment are exposed, generally include long time periods at either moderate or low levels of temperature, pressure, humidity, and radiation, followed by, for equipment located in the containment, exposure to high levels of these same parameters for relatively short periods of time. Operation under these high stress levels may be required in order to mitigate the effects of various accidents. The level of exposure may also be affected by the location of the particular module or component. References 3, 5, 6, and 7 provide background information.

Thus, a component located in the containment building may be exposed to moderate temperature, humidity, and radiation for long periods of time and then would be required to function for safety purposes under possible conditions of high temperature, pressure, humidity, radiation and chemical spray resulting from a Loss of Coolant Accident (LOCA) or Main Steam/Main Feed Line Break (MSLB, MFLB). The purpose of the qualification program is to demonstrate that equipment will perform its Class 1E function whenever required.

Plant specific environmental requirements which deviate from the generic requirements will be addressed in the applicants SAR.

2.4.1 Temperature

Long term exposure of most electrical or electronic devices to moderate temperature normally results in degradation of insulating capacity, shifts in calibration or performance levels or other minor changes in characteristics. In general, these changes have not been dramatic or sudden. These changes can usually be detected by periodic calibration, insulation or performance checks or trend plots over a period of time. Equipment failing to meet performance requirements or trending to established limits can be replaced or repaired to restore equipment performance within the acceptable conditions. Limits on degradation levels are established in the individual component or module performance specifications and margins used in the initial design.

Simulation of long term temperature effects on electrical and electronic equipment is not well defined. Because of the interactions of various components, definitive failure modes and prediction methods have not been established. Simple components such as cable have undergone extensive research and testing such that standards have been developed to qualify these types of components for long term moderate temperature environments. These qualification tests typically involve exposure to high temperatures for short periods. Standard methods can be used to predict the lifetime at low temperature based on short term high temperature exposure. The effect of long term moderate or low temperatures on complex electronic equipment such as bistables, semi-conductors and computer components has not been accurately evaluated to date. Thus, the state-of-the-art is such that degradation can only be monitored by periodic checks. Equipment can then be restored to an acceptable condition when required.

The effect of short term (accident) exposure at high temperatures can be observed by performance of type tests under accident conditions. Limits can also be established from the design specifications. Qualification for high temperature exposure will be demonstrated by environmental type testing of the component prior to operation.

2.4.2 Radiation

Exposure to long term, moderate and short term high radiation levels may produce degraded performance of instrumentation or equipment. Experience to date has shown that the effects cannot be precisely defined or predicted in advance. It is expected that degradation will be gradual and can be monitored by performance tests and trend plotting. Class 1E equipment receiving significantly high radiation doses will be qualified by exposure to the total integrated radiation dosage expected from normal and accident conditions.

Radiation testing for levels less than 10^3 Rads will not be performed since significant effects on equipment are not expected below this level of exposure (Reference 7).

2.4.3 Vibration

Vibration qualification is discussed in CENPD-182 (Reference 4).

2.4.4 Pressure

Class 1E equipment in C-E designed nuclear power plants is not normally exposed to high pressure environments. However, after a postulated accident, such as the LOCA or MSLB, components located in the Containment Building will be exposed to significant external pressure from a combined steam-air mixture. Equipment will be environmentally tested to these conditions prior to operation and performance requirements demonstrated during and after the test, where required.

2.4.5 Humidity

Equipment will be environmentally tested to short term high humidity levels prior to operation and performance requirements demonstrated during and after the test.

2.4.6 Chemical Spray

Class 1E equipment in C-E designed nuclear power plants are not normally exposed to chemical spray environments. However, after a postulated accident, such as the LOCA or MSLB, components located in the Containment Building may be exposed to a chemical spray from a solution used to remove iodine from the containment building atmosphere. Equipment will be environmentally tested to these conditions prior to operation and performance requirements demonstrated during and after the test, where applicable.

2.4.7 Electromagnetic Interference (EMI)

C-E has performed EMI site surveys at several nuclear power plants in an attempt to determine typical EMI environments. In addition, various EMI tests are performed on certain systems which are likely to have EMI induced noise problems.

3.0 EQUIPMENT REQUIRING QUALIFICATION

This section discusses the types of equipment to be qualified and provides data on these systems, subsystems and modules. Information will be included on the location of equipment, qualification environment and operating requirements.

3.1 SYSTEMS AND MODULES

The various Class 1E instrumentation systems and modules requiring qualification are described below. System design is described and a block diagram of each system is referenced, where necessary. Additional information on the functions of individual modules or panels is given in Appendices C and D.

3.1.1 Process Instrumentation

These systems typically consist of process detectors or transmitters, signal converters and panel mounted indicators or recorders. Types of channels include pressure, temperature, level and flow. A block diagram of a typical system is given in Figure 3.1-1. Isolation from non-Class 1E equipment is provided as described in Section 3.2.

3.1.2 Nuclear Instrumentation

This system consists of excore neutron detectors, preamplifiers and filters, and signal processing drawers. A block diagram is given in Figure 3.1-2. Isolation from non-Class 1F equipment is provided as described in Section 3.2.

3.1.3 Reactor Coolant Pump Shaft Speed Sensing System

This system consists of proximity probes, pulse transmitters and signal processors. No indicators or recorders are used. A block diagram is given in Figure 3.1-3.

3.1.4 CEA Position Indication System

This system consists of reed switch position transmitters and signal isolating devices. The isolating devices are used to separate and isolate position signals between channels of the Core Protection Calculators (CPC) and CEA Calculators (CEAC) where required. A block diagram is given in Figure 3.1-4. Isolation between Class 1E equipment is discussed in Section 3.2.3.

3.1.5 Plant Protective System (PPS) Cabinet

This system includes the Reactor Protective System (RPS) and the Engineered Safety Features Actuation System (ESFAS). These systems consist of trip bistable units, trip logic matrices, trip path channels and trip circuit breakers. They receive inputs from various redundant Class 1E sensing channels. Isolation from non-Class 1E equipment and redundant safety channels is discussed in Section 3.2.

The Plant Protective System (PPS) cabinet contains the following subsystems or modules:

Bistable Control Panel
PPS Power Supply Panel
Matrix Test Module
Actuation Reset Panel
Nuclear Instrumentation Panel
Initiation Relay Panel
Auxiliary Equipment Bin
Relay Card Rack Assembly

The cabinet contains Class 1E and associated equipment, including internal wiring, miscellaneous switches and indicating lights. The trip circuit breakers, which are the actuation devices, are discussed in Section 3.1.8. Isolation from non-Class 1E equipment is provided as discussed in Section 3.2.

3.1.6 ESFAS Auxiliary Relay Cabinet (ARC)

The ESFAS Auxiliary Relay Cabinet (ARC) houses the following subsystems or modules:

ESFAS Actuation Circuitry
ESFAS Test Modules

The cabinet contains only Class 1E or associated equipment, including internal wiring, miscellaneous switches and indicating lights. Isolation from non-Class 1E equipment is provided as discussed in Section 3.2.

3.1.7 DNBR/LPD Calculator System

This system consists of CPC I/O modules, CPC CPU and memory, CPC test panels. CEAC I/O modules, CEAC CPU and memory, signal isolators, operator's modules, and meters. It receives inputs from Class 1E sensing channels. A block diagram is given in Figure 3.1-5. Isolation between redundant Class 1E channels and from non-Class 1E equipment is provided as described in Section 3.2.

The CPCs and CEACs are located in the Auxiliary Protective Cabinet (APC) or the Compartmented Plant Protection System (CPPS) Cabinet. The APC or the CPPS Cabinet houses the following class 1E subsystems or modules:

Core Protection Calculator (CPC)
CEA Calculator (CEAC)
CEA Position Isolation Assembly (CPIA); (APC only)
RCP Shaft Speed Sensing Signal Processor
Plant Monitoring System Remote Input Subsystem (RIS)
Ex-core Nuclear Instrument Safety Channel (CPPS only)
Optical Communication Interface System (CPPS only)
Solid State Plant Protection System (CPPS only)
Digital Isolation Device Assembly (CPPS only)

This cabinet also houses certain Class 1E equipment which isolates signals for non-Class 1E use. This equipment is qualified to ensure that it does not impact or damage the other Class 1E equipment in this cabinet. Isolation of the non-Class 1E output signals is provided as discussed in Section 3.2.

3.1.8 Supplementary Protection System (SPS)

The Supplementary Protection Logic Assemblies (SPLAs) are the decision making elements of the Supplementary Protection System (SPS). Each SPLA receives a signal from a transmitter monitoring pressurizer pressure in the Nuclear Steam Supply System (NSSS). The SPLA compares this signal to an internally generated fixed set point signal. If the signal reaches the set point signal, the SPLA automatically generates an initiation signal. The initiation signals provided by the SPLAs are used to actuate external devices to effect a reliable and rapid reactor shutdown.

3.1.9 Miscellaneous Equipment

The following typical Class 1E or associated instrumentation is located in various panels or cabinets:

DNBR/LPD Operator's Modules
DNBR/LPD Remote Display Meters
PPS Remote Control Modules
PPS Local Status Panel
Cooling Fans

Isolation from non-Class 1E equipment is provided as discussed in Section 3.2.

3.2 ISOLATION

Class 1E and associated equipment and systems are isolated between redundant safety channels and from non-Class 1E equipment as required by IEEE Std 384 and Regulatory Guide 1.75 (References 8 and 9). In general, redundant safety channels are isolated by separating the entire process channels. In some cases interfaces to non-Class 1E equipment is required. In these cases qualified isolation devices are used. A detailed discussion of the use and handling of associated circuits is contained in Reference 10. In addition to normal isolation tests these devices are qualified as Class 1E for the isolation function for abnormal environmental and seismic conditions. Results of environmental qualification of these isolators will be reported as type tests.

Details on specific isolators are given below:

3.2.1 Remote Input Subsystem (RIS)

The Plant Monitoring System (PMS), a non-Class 1E system, receives many inputs from Class 1E equipment including process signals, and CPC/CEAC outputs. Isolation for some of these inputs is provided by a Remote Input Subsystem (RIS). A block diagram of the RIS is given in Figure 3.2-1. Output is in the form of "time-shared" output pulses on the digital output line to the non-class 1E computer systems. Feedback or adverse effects to the Class 1E systems from non-Class 1E systems is prevented by the RIS. The RIS will be demonstrated to meet the requirements of Regulatory Guide 1.75 (Reference 9).

3.2.2 CEA Position Isolation Assembly

These devices provide a means of separating and isolating signals from the CEA position indication reed switches on each CEA and of directing these signals to the redundant CPC/CEAC channels. Isolation is provided between channels. These isolators will be demonstrated to meet the requirements of Regulatory Guide 1.75 (Reference 9).

3.2.3 Process Signals

Isolation of some Class 1E equipment between channels and from non-Class 1E equipment may be accomplished by using isolation devices with no feedback effects on the input signals. These isolators will be demonstrated to meet the requirements of Regulatory Guide 1.75 (Reference 9).

3.2.4 Digital Isolation Device Assembly (DIDA)

The Digital Isolation Device Assembly (DIDA) is used in some applications for interfacing between Class-1E and Non-Class-1E equipment. The signals interfacing through the DIDA are not required for the performance of a safety function. The absence of these signals would not result in the failure of the Class-1E equipment to perform its intended safety function.

3.3 EQUIPMENT QUALIFICATION REQUIREMENTS

Data sheets have been developed for C-E supplied Class 1E equipment. These data sheets are prepared on a generic basis, providing location, normal and accident environments, operating requirements and interface criteria, where appropriate. Qualification requirements for Class 1E subsystems and modules in the C-E standard scope of supply are contained in the appropriate SAR. These requirements include location, normal and accident environment and operating time required under accident environments. A summary of environmental conditions for various categories of equipment is shown in Table B-1.

In order to understand the equipment qualification requirements some discussion of the relationships between location, normal and accident environments and operating requirements is necessary.

3.3.1 Location

The location will determine the normal and accident environment of the equipment. Equipment located in the Containment Building may be exposed to a normal, moderate temperature and radiation environment as well as a high temperature, pressure, radiation, humidity, and chemical spray accident environment, including a possible seismic event. Most equipment located outside of Containment would only be subjected to a possible seismic event. Because of its location, access to equipment in the Containment Building may be limited for periodic preventive maintenance or calibration.

3.3.2 Environment

The environment to which equipment is exposed is contingent on location as discussed above, as well as on the type of accident. For example, the LOCA would expose equipment to a different accident environment in the Containment Building than a Main Steam Line Break or a Seismic Event. The qualification requirements will impose the worst-case environment for each component, as applicable.

3.3.3 Operating Requirements

Operating requirements for specific equipment are established by the Safety Analysis for each accident. Some systems may be required to operate up to the initiation of the accident, others may be required to function during or after the accident and others may only be required to maintain structural integrity so as not to affect the operation of safety equipment.

Each of these factors has been considered in developing the qualification requirements for particular components in Appendix A.

Figure 3.1-1
TYPICAL PROCESS INSTRUMENTATION
CHANNEL BLOCK DIAGRAM

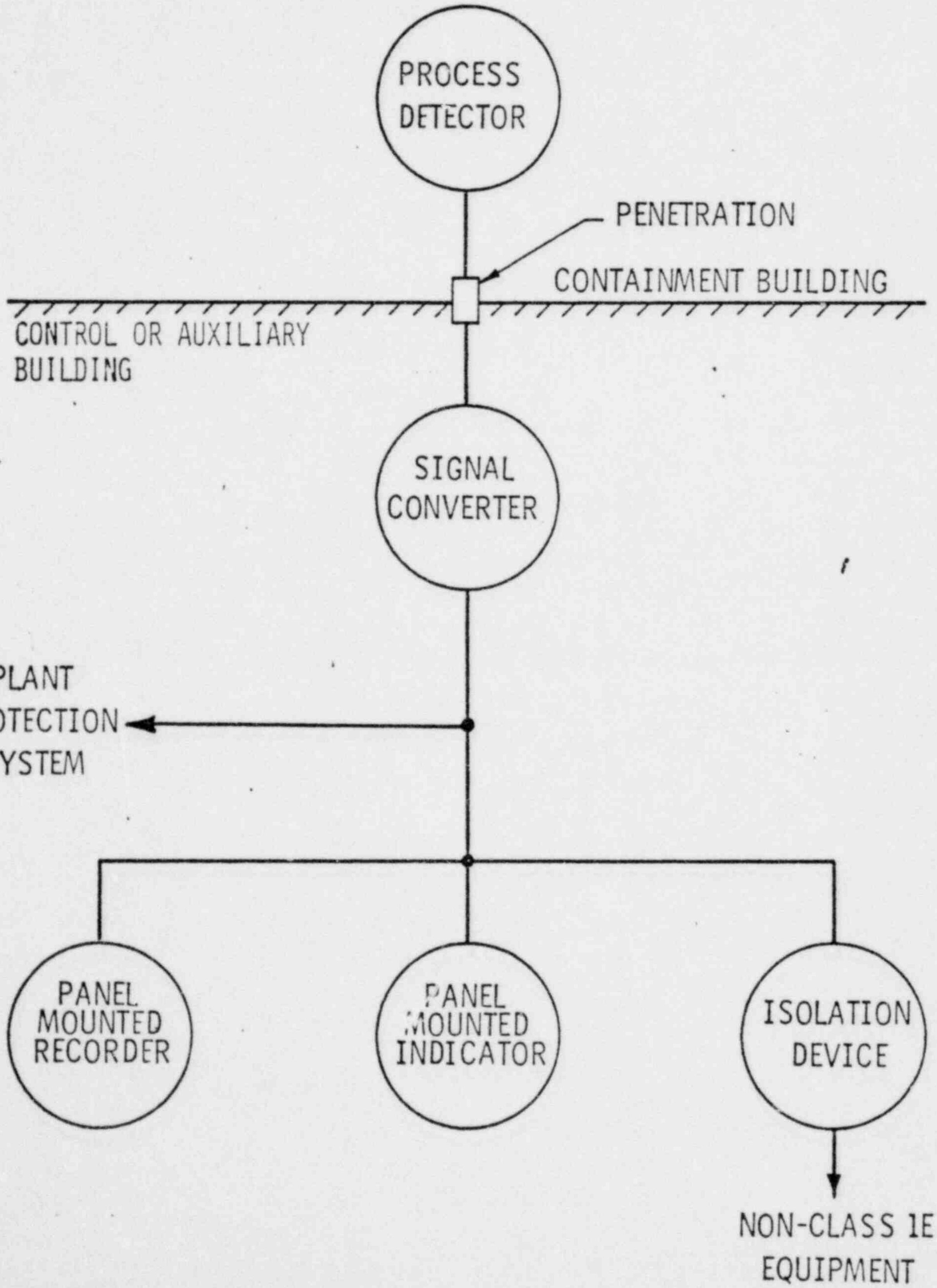


Figure 3.1-2
NUCLEAR INSTRUMENTATION SYSTEM
BLOCK DIAGRAM
SAFETY CHANNELS

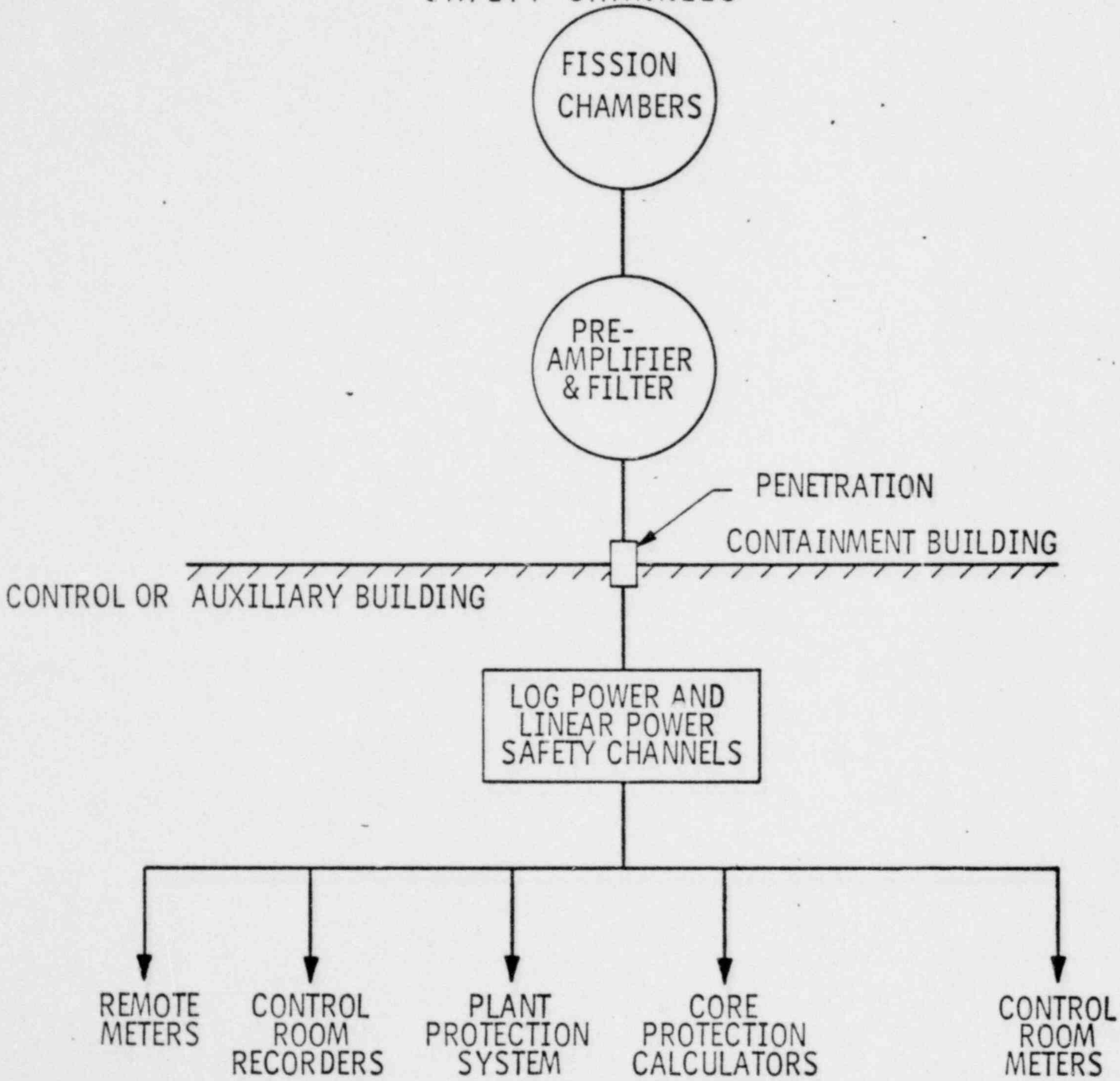


Figure 3.1-3

REACTOR COOLANT PUMP SPEED SENSING SYSTEM BLOCK DIAGRAM

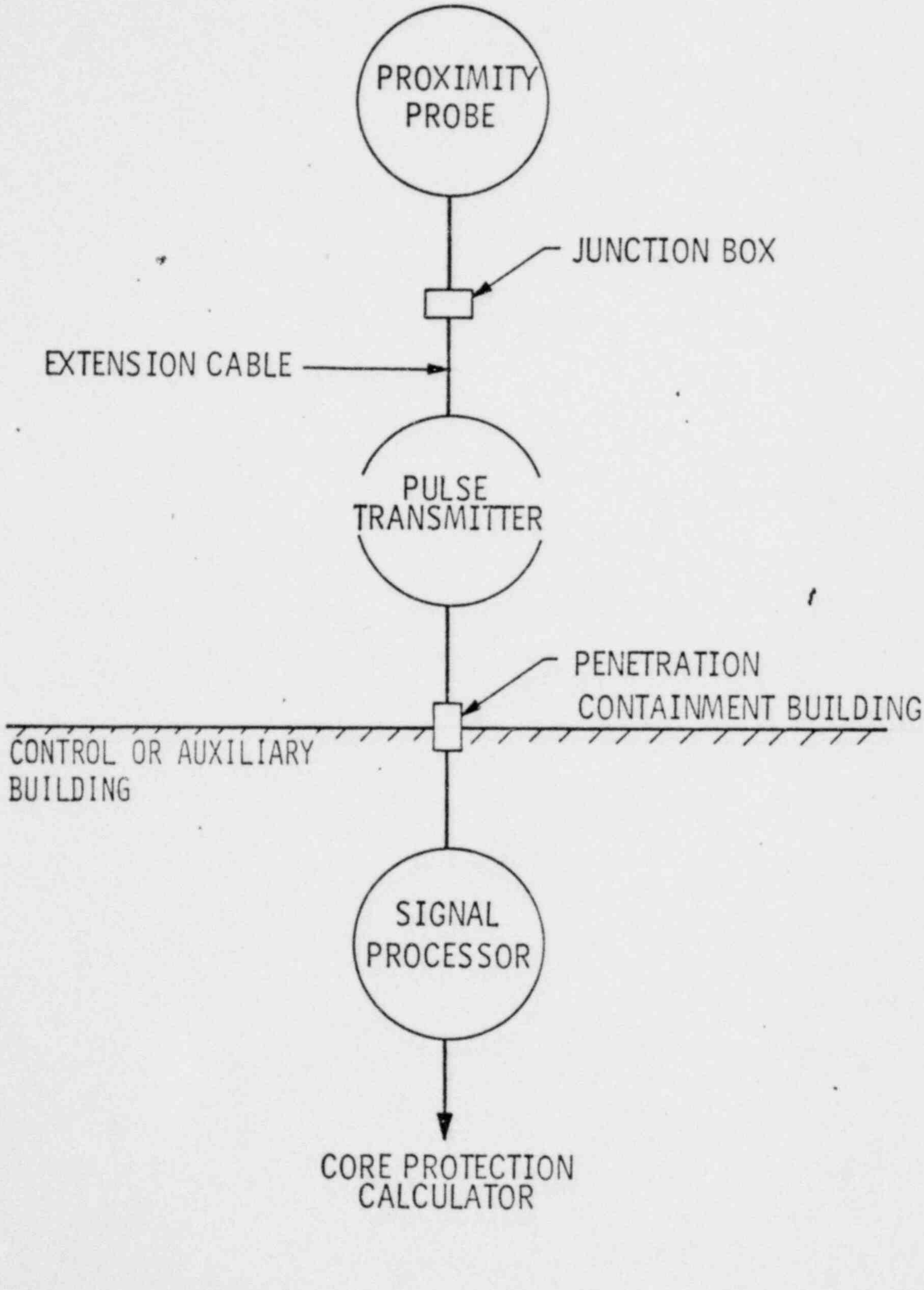
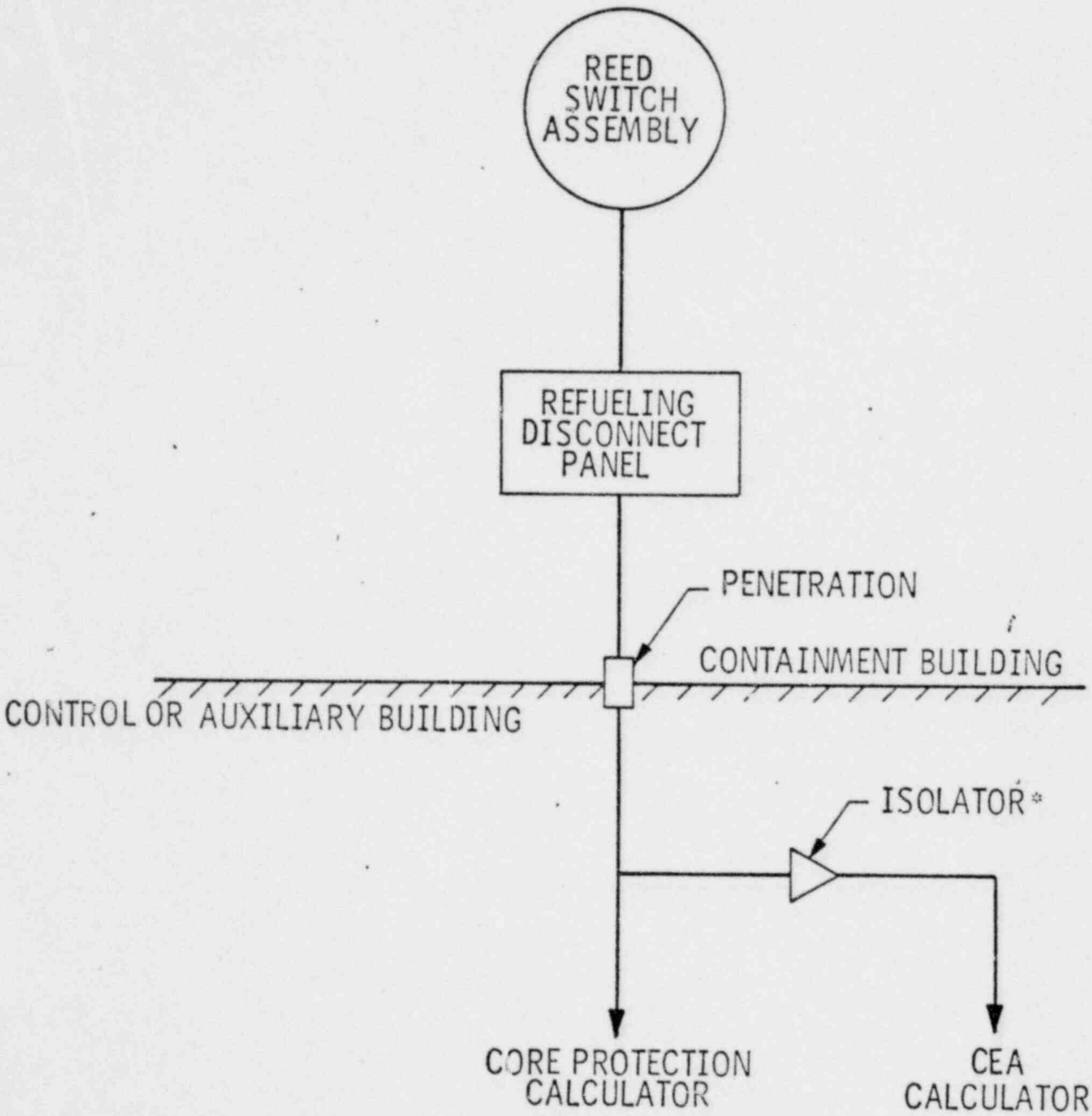


Figure 3.1-4
CEA POSITION INDICATING SYSTEM
BLOCK DIAGRAM



* USED WHEN CPC AND CEAC ARE NOT IN SAME CHANNEL

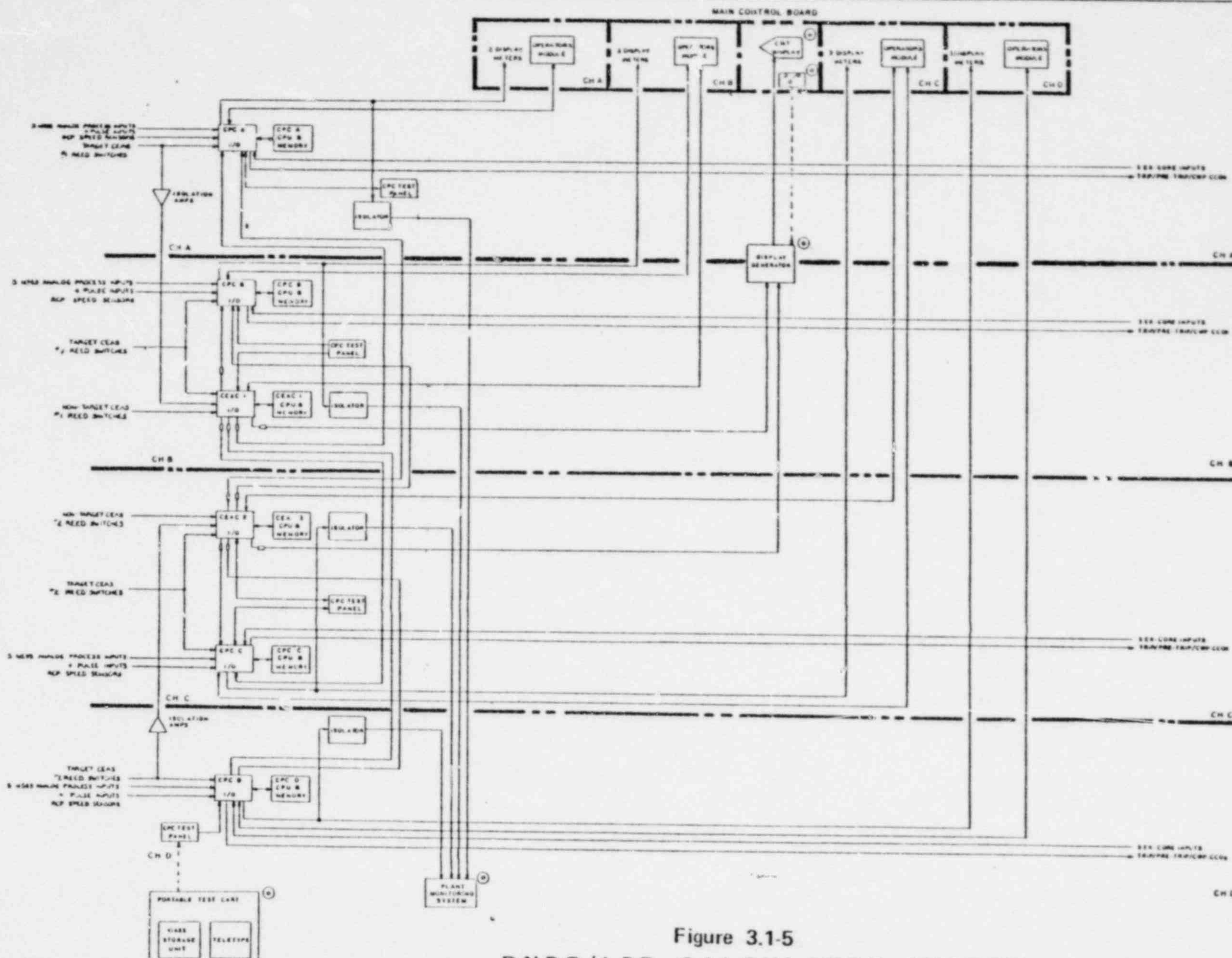
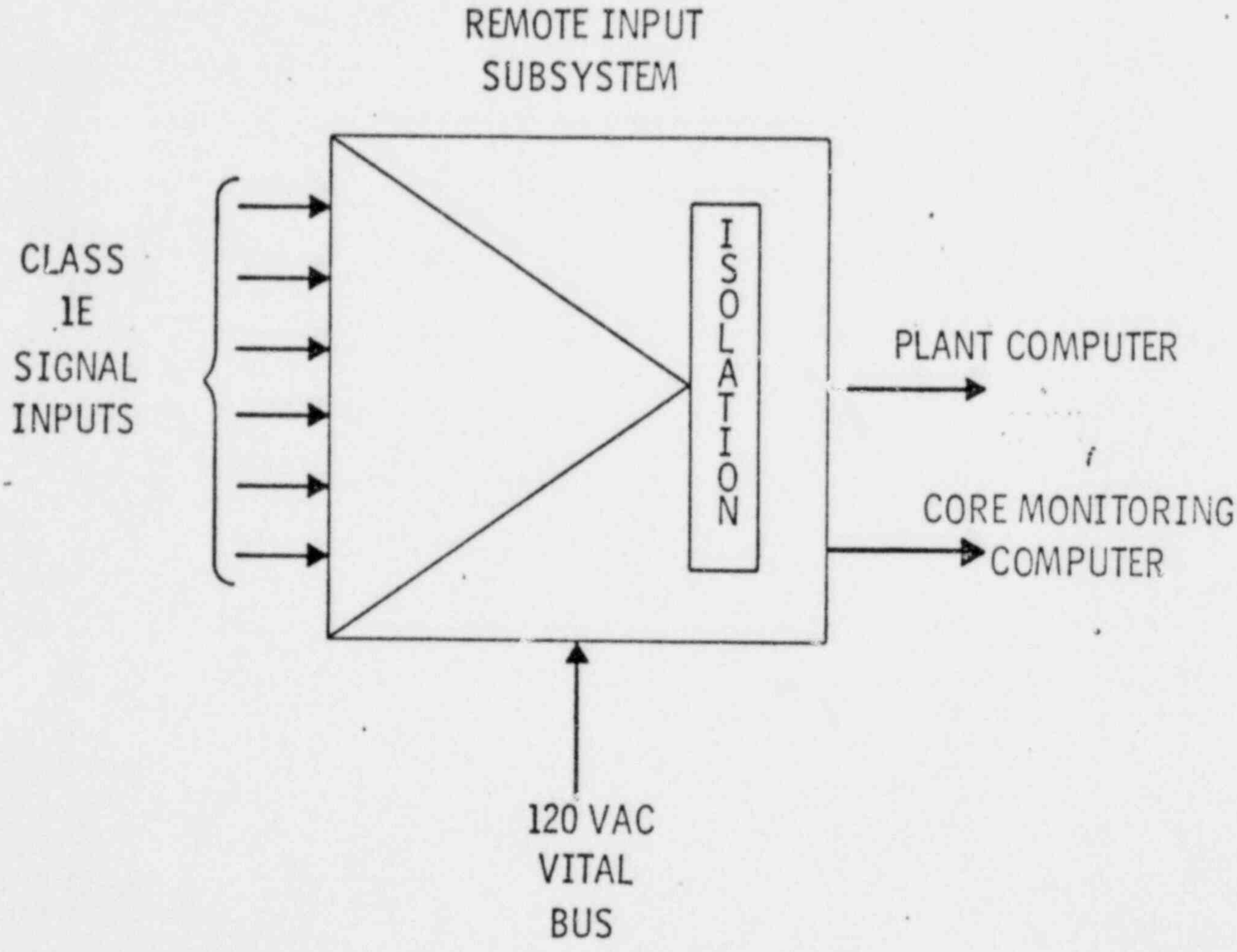


Figure 3.1-5
DNBR/LPD CALCULATOR SYSTEM
BLOCK DIAGRAM

Figure 3.2-1
PLANT MONITORING SYSTEM ISOLATION
BLOCK DIAGRAM



4.0 METHODS OF QUALIFICATION

This section discusses the type tests, analysis and other methods of qualification. Methods used for aging qualification are discussed. The conservatism of the qualification parameters is demonstrated.

4.1 TYPE TESTS

Type testing will be used to qualify Class 1E equipment under anticipated normal and accident environments. The Test Plan and Procedures will meet all requirements of IEEE Std. 323-1974, (Section 6.1, 6.2, 6.3.1 - 6.3.2, 6.3.4 - 6.3.7). Documentation will meet the requirements of IEEE Std. 323-1974 (Section 8.3). Equipment specifications require that all qualifications be conducted in accordance with IEEE Std. 323-1974.

4.1.1 Equipment Specification

Data sheets for information required by IEEE Std. 323-1974, Section 6, have been developed for Class 1E components. These data sheets are shown in Exhibit 5.1-1. These data sheets will be filled in with applicable data for each module qualified.

Class 1E equipment specifications include a description of the equipment, the Class 1E performance characteristics, design environmental conditions and, where appropriate, the effect of changes in environmental conditions upon Class 1E performance characteristics. Class 1E performance characteristics will be specified with nominal, maximum and minimum values, where applicable. A detailed list of typical performance specifications is given in Exhibit 5.1-1, Section II. Design environmental conditions, including energy supply, are specified with normal, abnormal, test, design basis event and post-design basis event ranges or conditions, where applicable. A detailed list of design environmental conditions is given in Exhibit 5.1-1, Section III. Miscellaneous data, such as significant sequences, rate of change, and combinations of environmental conditions, operating, energy and environmental cycles, qualified life and unusual environmental conditions are specified. A detailed list of these parameters is given in Exhibit 5.1-1, Section IV.

4.1.2 Type Test Methods

The type test demonstrates that the observed Class 1E performance characteristics of the equipment meet or exceed its specified Class 1E performance requirements. The type test will consist of a planned sequence of test conditions that meet or exceed the expected or specified service conditions, including margin, and will take into account both normal and abnormal service conditions.

Prior to performing the type test, a written procedure is prepared in accordance with IEEE Std. 323-1974.

Equipment is mounted in a manner and position which simulates its in-plant installation wherever possible.

The Class 1E performance characteristics of the equipment are determined at the nominal controlled environmental and energy supply reference operating conditions. Equipment is operated at rated load conditions over the range of its input and output parameters or other Class 1E functions.

The Class 1E performance characteristics of the equipment are determined for the significant portions of the design range of each of the significant environmental parameters or each significant combination thereof.

The test is monitored using equipment that provides sufficient resolution for detecting meaningful changes in the measured variables. The test equipment is calibrated against auditable calibration standards and will have documentation to support such calibrations. The monitoring of performance characteristics and environmental parameters are of such a frequency as to allow evaluation of the Class 1E performance characteristics of the equipment.

4.1.3 Margin

The qualification type testing includes, where appropriate, provisions to verify that margin exists. In defining the type test, increasing levels of testing, number of test cycles, or test duration are considered as methods of assuring that adequate margin does exist.

Typical factors which are applied as appropriate to service conditions for type testing are as follows:

Temperature: $\pm 15°$ F ($\pm 8°$C)

When qualification testing is conducted under saturated steam conditions, the temperature margin is such that the test pressure does not exceed the saturated steam pressure corresponding the peak service temperature by more than 10 psi.

Pressure: +10 percent of gauge, but not more than 10 psi (.703 kg/cm^2)

Radiation: +10 percent of accident dose (Excess margin will be equal to or greater than the uncertainty in measured dose).

Voltage: ±10 percent of rated value unless otherwise specified.

Time: +10 percent of the period of time the equipment is required to be operational following the design basis accident.

Environmental Transients:* The initial transient and the dwell at peak temperature are applied a least twice.

Note 1 Negative factors are applied when lowering the value of the service conditions increases the severity of the test.

Note 2 Margin need not be applied to more than one parameter at a time.

4.1.4 Test Sequence

The type tests are run on the equipment in a specified order. For most equipment and applications, the following constitutes the most severe sequence:

a. Inspection is performed to assure that a test unit has not been damaged due to handling since manufacture and to determine basic dimensions. This inspection will not be directed to select a specific unit for type testing.

* Accident transient only

b. The equipment is then operated under normal conditions to provide a data base for comparison with performance under more highly stressed conditions. Certain measurements such as rate of change with time of a parameter may be made at this time.

c. The equipment is operated to the extremes of performance characteristics given in the equipment specifications excluding design basis event and post design basis event conditions unless these data are available from other tests on identical or essentially similar equipment.

d. Where a significant aging mechanism or correlation is known, in-containment equipment is aged to put it in a condition which simulates, as required, its expected end-of-qualified-life condition. This includes the effect of radiation, if applicable (design basis event radiation may be included). If the required radiation level can be shown to produce less effect than that which would cause loss of the equipment's Class 1E function, radiation is not included as part of aging. Key measurements are made following aging to determine if the equipment is performing satisfactorily prior to subsequent testing.

e. The equipment is subjected to simulated seismic vibration.

f. The equipment is next operated while exposed to the simulated design basis event (radiation may be excluded if incorporated above). Those functions which must be performed during the simulated design basis event are monitored.

g. The equipment is then operated while exposed to the simulated post accident conditions (following exposure to accident conditions). Those functions which must be performed following the simulated design basis event are monitored during this simulation.

h. Equipment is inspected or disassembled to the extent necessary for the determination of the status and condition of the equipment and the findings recorded.

4.1.5 Type Test Report

Type test data used to verify the qualification of the equipment will be pertinent to the stated specifications and organized in an auditable form. The type test report will be consistent with the requirements of IEEE Std. 323-1974.

Data for subsystems or modules will be compiled in reports prepared at the completion of the qualification program, and will be made available for audit at C-E as discussed in Section 5.0. Reference will be made to appropriate test reports on the individual modules or system data sheets. The data sheets (Exhibit 5.1-1) will be filled in for each Class 1E module or assembly.

4.1.6 Environmental Test Profile

A typical test profile for equipment which is required to perform a Class 1E function during or after a design basis event and which is located in the Containment Building is shown in Figure 4.1-1. This profile provides for margin requirements and includes an additional peak transient, as required by IEEE Std. 323-1974, Section 6.3.1.5 and Appendix A. This profile provides for establishing the design basis event peak transient environmental conditions, reducing to normal environmental conditions, then repeating the peak transient environmental conditions for the period of time over which the equipment is required to perform its Class 1E function. Equipment will be exercised or monitored for its Class 1E function, as required.

Environmental test profiles with margin for equipment outside of the Containment Building will be developed based on normal and abnormal conditions. (See Table B-1). Equipment will be tested to the simultaneous temperature and humidity conditions for at least eight hours at the low and high temperature levels and at high humidity at normal temperatures.

Instrument accuracy requirements are established from the assumptions used in the particular Safety Analysis for which the equipment performs its Class 1E function. These requirements are reflected in the equipment specifications. The most conservative limits on time and accuracy requirements would be used for qualification. However, it may be necessary to qualify several instruments to various levels based on the particular applications.

For example, assume that a particular instrument has Class 1E operation and accuracy requirements as specified in Table 4.1-1. In this case, the most conservative requirements are:

> Operation for 20 minutes with +27, -81 psi accuracy. Thus the test temperature and pressure for this instrument would include the profiles shown in Figure 4.1-1 with the test continuing for the time period required (in this case, 20 minutes).

Equipment which is required to function for post-accident monitoring would be tested to the profile shown in Figure 4.1-1 since long-term cooling extends for at least the time period of the profile.

The Class 1E operation requirements for Class 1E equipment are given in Table A-1.

4.1.7 Acceptance Criteria

Acceptance criteria for qualification will be as follows:

- Test environments are at least as severe as, and representative of, the required environmental profile.

- Operation of the equipment under normal environmental conditions to the extremes of performance and electrical characteristics is within the limits of accuracy required in the equipment specifications.

- Equipment has been aged, as appropriate, and has been exposed to the expected end-of-life radiation dose if applicable prior to design basis accident testing.

- Equipment has been subjected to seismic vibration expected in service.

- Operation of the equipment in its Class 1E functions, while exposed to the design basis event environment is within the limits of accuracy required in the equipment specifications.

- Operation of the equipment in its Class 1E functions, while exposed to the post-design basis event environment, is within the limits of accuracy required in the equipment specifications.

- Post-test examination of the equipment reveals no conditions which might have interfered with the ability of the equipment to perform its Class 1E functions.

Documentation that these acceptance criteria have been met will be recorded in the Qualification Data Sheets as described in Section 5.1. Exceptions to, or deviations from, the acceptance criteria will also be recorded.

4.2 ANALYSIS

Analysis will be used, where appropriate, to demonstrate qualification as permitted by IEEE Std. 323-1974, Section 5.3. Qualification by analysis will consist of a mathematical or logical proof that the Class 1E performance of the equipment to be qualified meets or exceeds its specified requirements when subjected to its specified normal and design basis event environments. In general, this proof will be based on established principles, operating experience data, partial type test data, or combinations of these. All assumptions, including extrapolations that are made will be justified by established principles or verified test data; and the analysis shall be of a form that can be readily understood and verified by people qualified in the pertinent discipline of engineering or science.

Data for analysis will include:

The equipment performance specifications

The interface or boundary conditions of the equipment

The specific features, postulated failure modes, or the failure effects to be analyzed

The assumptions, empirically derived values, and mathematical models used together with appropriate justification for their use

Description of analytical methods or computer programs used

A summary of analytically established performance characteristics and their acceptability

Approval signature and date

Analysis will normally only be used to justify qualifications by similarity, etc.

4.3 AGING

The qualification for Class 1E equipment will be determined by two different methods. Equipment which is accessible during operation (in the Auxiliary Building or Control Building) will be qualified using a preventive maintenance/surveillance program including scheduled maintenance, coupled with periodic testing, as described in Reference [illegible] and Section 4.3.1. An accelerated aging program will be developed for non-accessible equipment as described in Reference 4 and Section 4.3.2.

4.3.1 Preventive Maintenance/Surveillance Program

The preventive maintenance/surveillance program applied to complex electronic modules and instrumentation will provide a schedule for periodic testing and maintenance and will estab [illegible] performance limits. Appropriate data and maintenance or testing requirements used in the program will be recorded on data sheets as shown in Exhibit 5.1-1.

The basis for this preven[illegible] maintenance/surveillance program is that modules located in environments which are unchanged during design basis accidents and which have adequate capability for periodic test (including failure trending or incipient failure detection), inspection, and maintenance, and whose condition can be established at reference operating conditions are not required to undergo advanced life conditioning during type test if the event requiring their use does not affect their environment.

This program will include guidelines and schedules for calibration and preventive maintenance. The requirements for the calibration and preventive maintenance will be based upon the plant's normal inservice inspection tests, and maintenance program.

The preventive maintenance will include, as appropriate:

Visual inspection
Mechanical inspection
Electrical testing
Electronics testing
Periodic tests - isolation
response time

It is anticipated that most of these tests are already included in Technical Specifications requirements.

A detailed description of aging methods is contained in Appendix D.

4.3.2 Accelerated Aging

Instrumentation located within the Containment Building includes a few basic types of electronic components including resistors, capacitors, transistors, diodes, etc. A detailed description of aging methods is contained in Appendix C.

This program will be conducted, as appropriate, in cooperation with equipment and component vendors.

Radiation and cycling will be included in the aging process, as appropriate. Assumptions, test reports and data used in the aging qualification will be recorded on data sheets as shown in Exhibit 5.1-1.

4.4 CONSERVATISM OF QUALIFICATION PARAMETERS

The levels of environmental qualification required are specified in Table B-1. These requirements are established based on assumptions in the appropriate Safety Analysis Report. Margins specified in IEEE Std. 323-1974, Section 6.3.1.5 will be documented in the Type Test Data Sheet, Exhibit 5.1-1. Comparison of the qualification requirements, plus margins, to the test environmental parameters will demonstrate conservatism of these parameters. Although the environmental requirements follow the general form of IEEE Std. 323-1974, Figure A1 and Table A1, it is expected that the environmental requirements of the Safety Analysis Reports will be more severe and thus more conservative than IEEE Std. 323-1974.

The responsibility for demonstrating the applicability of the qualification parameters will rest with the applicant.

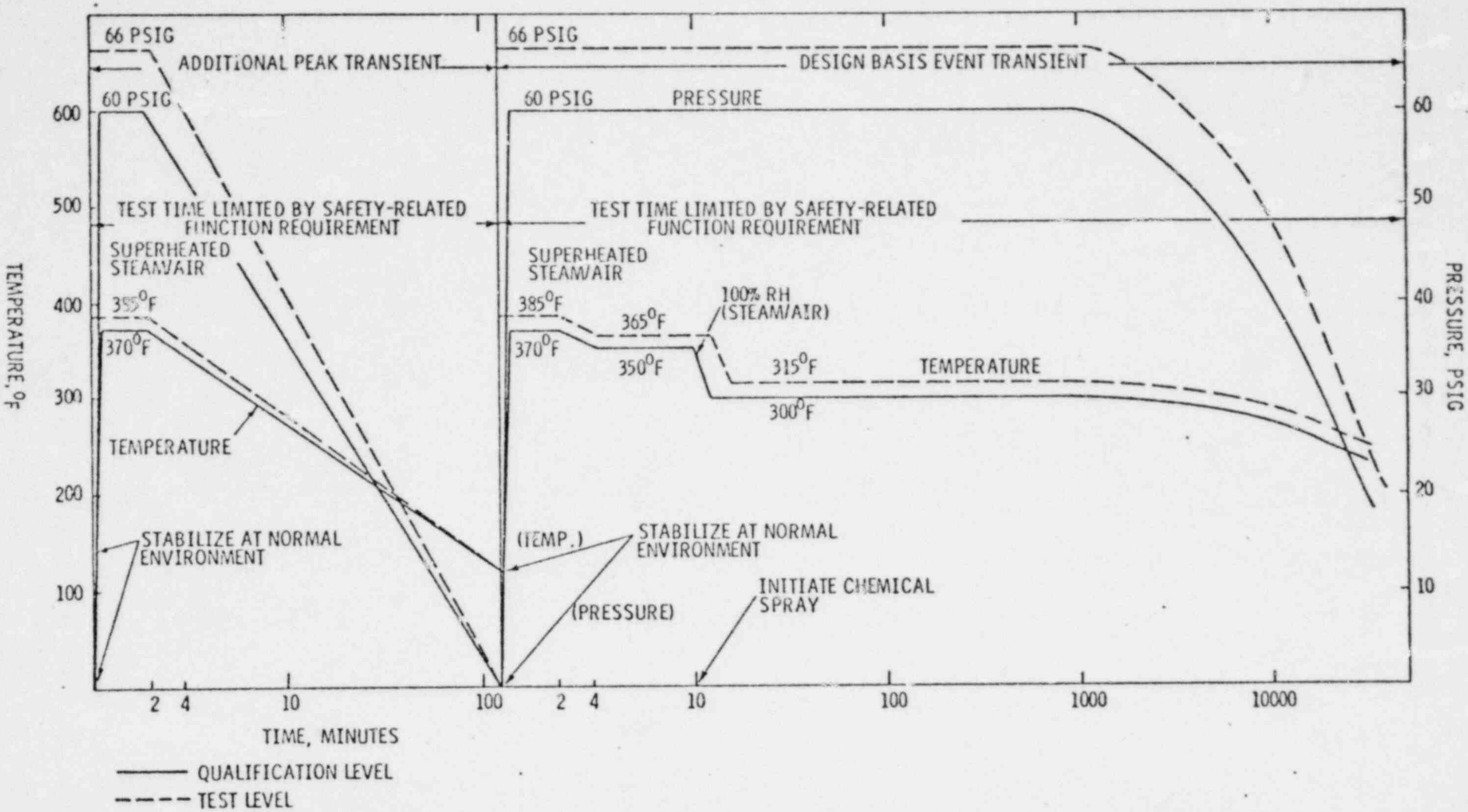
Table 4.1-1

Typical Operation and Accuracy Requirements*

Accident	Time	Accuracy
Small LOCA	20m.	+27, -81 psi
Large LOCA	2m.	+27, -114 psi
Steam Line Break	70s.	+27, -114 psi
CEA Ejection	20m.	+27, -81 psi

*See Section 4.1.6 for table discussion and utilization.

Figure 4.1-1
TYPICAL TEST PROFILE, CONTAINMENT BUILDING



5.0 DOCUMENTATION

This section discusses the documentation for qualification. Data sheets to be filled in for individual modules or systems will be prepared. Typical data sheets will be provided for each type of equipment. Data will be available for audit at C-E.

5.1 TYPE TEST DATA SHEET

The Type Test Data Sheet, Exhibit 5.1-1, will be completed for each Class 1E system, module, or assembly, as appropriate. A list of equipment with appropriate data on qualification requirements is given in Table A-1.

Data sheets will be completed and files maintained in accordance with the requirements of IEEE Std. 323-1974, Sections 8.1, 8.2 and 8.3.

5.2 ANALYSIS DATA

Data sheets for analysis used in qualification will be completed and files maintained in accordance with the requirements of IEEE Std. 323-1974, Section 8.5.

5.3 ADMINISTRATIVE PROCEDURES

5.3.1 Equipment Specification

The performance requirements are set forth in the equipment specification which is written by C-E. The requirements include normal, maximum and minimum values of performance parameters, and environmental conditions for normal and abnormal operation. The applicable standards for qualification are referenced by the specification. The specification is included in the engineering package which is sent to prospective vendors for bidding.

5.3.2 Vendor Design and Qualification Program

After the contract has been awarded, the vendor submits his design and qualification program to C-E for approval. The design is reviewed to ensure the equipment is capable of meeting performance and environmental requirements. The qualification program is reviewed for compliance with the requirements of the equipment specification and the referenced standard. In most cases, the qualification program is written by the qualification facility which has been retained by the vendor. In some cases C-E may choose to perform its own testing of vendor's hardware.

5.3.3 Qualification

Although the task of qualification is performed normally by C-E's vendor, C-E follows the progress of the qualification effort and, in conjunction with the vendor, interfaces with the qualification facility to insure that the equipment will be exposed to the proper qualification environment. The

Exhibit 5.1-1

QUALIFICATION DATA SHEET

DATA SHEET No. ____________
DATE ____________
REVISION No. ____________

I. EQUIPMENT IDENTIFICATION

COMPONENT ____________ DESIGNATION ____________

MANUFACTURER ____________ MODEL ____________ SERIAL NUMBER ____________

II. EQUIPMENT PERFORMANCE SPECIFICATIONS

PARAMETER	NOM	MAX	MIN
INPUT SIGNAL RANGE			
OUTPUT SIGNAL RANGE			
ACCURACY			
LINEARITY/CONFORMITY			
SENSITIVITY			
DEADBAND			
REPEATABILITY			
DRIFT/STABILITY			
HYSTERESIS			
REPRODUCIBILITY			
TRANSFER FUNCTION			
FREQUENCY RESPONSE			
RESPONSE TIME			
SATURATION CHAR.			
INPUT OVERRANGE CHAR.			
INPUT IMPEDANCE			
OUTPUT IMPEDANCE			
LOAD CAPABILITY			
PULSE CHAR.			
OUTPUT RIPPLE			
COMMON MODE REJECTION			
ISOLATION CHAR.			
RANGE/CHAR. OF AJD			
THER/ELECT. INSUL. CHAR.			
POWER REQUIREMENTS			
CONTACT RATING			
WARM-UP TIME			
SIGNAL/NOISE RATIO			
HEAT REJECT RATE			

III. DESIGN ENVIRONMENTAL CONDITIONS

PARAMETERS	NOMINAL	ABNORM.	CONT. TEST	DBE	POST DBE
TEMP (OPER/STRGE)					
PRESSURE					
REL. HUM. (OPER/STRGE)					
PWR. SRCE. QUAL. - VLT					
FREQ.					
HRM					
ELECT. INTER. (SHLDG. REQ.)					
SPRAY/JET					
CHEMICALS					
MOUNTING CONSTRAINTS					
ELECTRICAL SURGES					
PROC. FLUID CONNS.					
IRRAD. (RATE/DOSE)					
RAD. ENERGY SPECT.					
RAD. TYPE - α					
β					
γ					
n					

IV. MISCELLANEOUS DESIGN DATA

REQUIRED SEQUENCE ____________
RATE OF CHANGE ____________
COMBINATIONS ____________
ENERGY SUPPLY LIMITS ____________
TIME W/ADVERSE ENERGY/ENVIR. ____________
OPER. CYCLES (DESCRIP/ #) ____________
ENERGY CYCLES (#) ____________
ENVIRONMENTAL CYCLES (#) ____________
QUALIFIED LIFE ____________
UNUSUAL ATMOS. CONTAMINATION ____________

V. OPERATING REQUIREMENTS

ACCIDENT	TIME	ACCURACY	FUNCTION

VI. QUALIFICATION REQUIREMENTS

TEMPERATURE, PRESSURE, CHEMICAL SPRAY

TEMP., °F	PRESS., PSIG	HUMID., %
500	100	100
400	80	80
300	60	60
200	40	40
100	20	20

RADIATION, RADS

NORMAL - RATE ____________
- DOSE ____________
ACCIDENT - DOSE ____________
TOTAL - DOSE ____________

VIBRATION

SEISMIC (CENPD-182) Sht ____________

LEGEND:

——— TEMPERATURE
—·— PRESSURE
- - - - HUMIDITY
X X X REQUIRED
O O O ACTUAL

CHEMICAL SPRAY

BORON ____________
HYDRAZINE ____________
SODIUM PHOSPHATE ____________
SODIUM HYDROXIDE ____________

DATA SHEET No. ____________
DATE ____________
REVISION No. ____________

Exhibit 5.1-1 (Continued)

VII. TEST EQUIPMENT

MFR	MODEL #	ACCURACY

VIII. DETAILED TEST INSTRUCTIONS

MODULE DESCRIPTION ________
NUMBER/SER. No. TESTED ________
MOUNTING/CONNECTION REQUIREMENTS ________
AGING SIM. PROC. ________
SERVICE COND. SIMUL. ________
PERF/ENVIR VARIABLES MEAS. ________
TEST EQUIP. REQ'MENTS/ACCUR ________
ENVIRON., OPER., MEAS. SEQ. ________
CALIBR/ADJUST. PROC. ________
FAILURE DEFIN./ACCEPT. CRIT. ________
TEST DURATION ________

IX. MARGIN

	REQ'D	ACTUAL
TEMPERATURE		
PRESSURE		
RADIATION		
VOLTAGE		
FREQUENCY		
TIME		
ENVIRON. TRANS		

X. MISCELLANEOUS TEST DATA

ACCEPT. CRITERIA
CALCULATIONS ________
ASSUMPTIONS ________

DATA REDUCTION METHOD
REDUCING ________
PRESENTING ________

DATE OF TEST ________
PERFORMED BY ________

SPECIAL CONDITIONS ________

XI. AGING

ENVIRONMENTAL CYCLING
TEMP (NORM/DAILY) ________
HVAC (#TRANS/YRLY) ________
ENERGY (# OUR LOSS/YR) ________
MAINT (TEMP/ENERGY) ________
TRANSIENTS (ENVIR/ENERGY) ________
OPERATIONAL CYCLING ________

TOTAL ENVIRONMENTAL CYCLES/DES LIFE ________

ELEVATED STRESS ________

PACING TEST ________

PERIODIC SURVEILLANCE ________

XII. TEST SEQUENCE

		COMPLETE	DATE	INIT
RANDOM SELECTION				
VISUAL EXAM, BASELINE CONDITIONS				
CONFIGURATION CONNECTION				
CALIBRATION				
OPERATION -	REFERENCE OPER. COND.			
	EXTREME DES. RANGE			
CYCLING -	OPERATING			
	ENERGY/ENVIRON.			
AGING -				
VIBRATION -	SEISMIC			
RADIATION EXPOSURE				
WORST CASE ENVIRONMENT (DBE)				
POST-DBE OPERATION				
VISUAL EXAM/BASELINE COND.				
EVALUATION				

XIII. TEST REPORT

REFERENCE TEST REPORT			
APPROVED			
LOCATION			

XIV. COMMENTS

APPENDIX A

CLASS 1E QUALIFICATION

COMPONENT DATA

APPENDIX A

CLASS 1E QUALIFICATION COMPCNENT DATA

A.1 PURPOSE

The purpose of this appendix is to list types of Class 1E equipment, post accident operating requirements, location, design basis environments, and interface requirements. A detailed list of modules and panels, with post-accident operating times, is given in the appropriate SAR, Section 3.11.

A.2 DATA

Class 1E Qualification Component Data is given in Table A-1.

Table A-1

Class 1E Qualification Component Data

Module or Component	Operating Requirements(12)(7)(1) LOCA	MSLB	SEIS	SSD	Location(2)	Envir(3)	Interface
PPS	X	X	X	X	CR/AB	H	(9),(10),(11)
Aux. Rel. Cab.	X	X	X	X	CR/AB	H	(9),(10),(11)
N.I. Det. and Cable	X(8)	X	X		CB(4)	A2	(11)
N.I. Preamp.	X(8)	X	X		CB(5)	A2	(11)
N.I. Sig. Procr.	X(8)	X	X		CR	H	(9),(10),(11)
RPS Tr. Swgr.	X	X	X	X	AB/CR	D	(9),(11)
RCPSSS Sft. Sp. Sensor		X	X		CB(6)	A2	(11)
RCPSSS Ext. Cable		X	X		CB(6)	A2	(11)
RCPSSS Pulse Transmitter		X	X		CB(5)	A2	(11)
RCPSSS Proc'r		X	X		CR	H	(9),(10),(11)
Reed Sw.		X	X		CB(4)	A2	(11)
CEA P.I. Cable		X	X		CB(4)	A2	(11)
CEA P.I. Conntr.		X	X		CB(4)	A2	(11)
CEA P.I. Isoltr.		X	X		CR	H	(9),(10),(11)
Press. Xmtr	X	X	X	X	CB(5)/AB	A1,A2,D,E	(11)
SPS Press. Xmtr			X		CB(5)	B	(11)

Table A-1 (Cont'd)

Module or Component	Operating Requirements(12)(7)(1) LOCA	MSLB	SEIS	SSD	Location(2)	Envir(3)	Interface
Signal Convrtr	X	X	X	X	AB/CR	D,E,H	(9),(10),(11)
Indicator	X	X	X	X	CR	H	(9),(11)
Test Circuit	X	X	X	X	AB/CR	D,E	(9),(11)
Level Xmtr	X	X	X	X	CB(5)/AB/OS	A1,A2,D,E,I	(11)
Recorder	X	X	X	X	CR	H	(9),(10),(11)
Temp. Detctr	X	X	X	X	CB(6)/AB	A1,A2,D,E	(11)
Flow Xmtr	X	X	X	X	AB	D,E	(11)
Press. Sw.			X	X	AB	C	(11)
SSPPS(13)	X	X	X	X	CR	H	(9),(10),(11)
SSCCS(13)	X	X	X	X	CR	H	(9),(10),(11)
SSAS(13)	X	X	X	X	CR	H	(9),(10),(11)
CPPS Cabinet(13)	X	X	X	X	CR	H	(9),(10),(11)
DIDA(13)	X	X	X	X	CR	H	(9),(10),(11)
SSM(13)	X	X	X	X	CR	H	(9),(10),(11)
OCIS(13)	X	X	X	X	CR	H	(9),(10),(11)
HWAS Isolation Cabinet(13)	X	X	X	X	CR	H	(9),(10),(11)

Table A-1 (Cont'd)

Module or Component	Operating Requirements(12)(7)(1) LOCA	MSLB	SEIS	SSD	Location(2)	Envir(3)	Interface
CEDMCS Auxiliary Cabinet		X	X		CR	H	(9),(10),(11)
Supplementary Protection Logic Assembly			X		AB	C	(9),(10),(11)

NOTES

(1) LOCA - Loss of Coolant Accident
MSLB - Main Steam Line Break
SEIS - Seismic Event
SSD - Safe Shutdown

(2) CR - Control Room or Control Building
AB - Auxiliary Building
CB - Containment Building
OS - Outside

(3) See Appendix B

(4) Inside primary shield

(5) Outside secondary shield

(6) Inside secondary shield

(7) Specific operating requirements determined by safety analysis

(8) CEA Ejection

(9) Class 1E ventilation, C-E supplies heat loads and temperature requirements

Table A-1 (Cont'd)

NOTES (Cont'd)

(10) Class 1E power supply, C-E supplies power requirements

(11) C-E Supplies mounting and location requirements and interfacing environmental requirements as appropriate.

(12) Length of time required to perform safety related functions is determined by safety analysis

(13) Not supplied on all plants.

APPENDIX B

DEFINITION OF ENVIRONMENTAL CATEGORIES
AND
QUALIFICATION REQUIREMENTS

APPENDIX B

DEFINITION OF ENVIRONMENTAL CATEGORIES AND QUALIFICATION REQUIREMENTS

B.1 PURPOSE

The purpose of this appendix is to provide data on the Class 1E environmental categories.

B.2 ENVIRONMENTAL CONDITIONS

Table B-1 lists the applicable locations, operating requirements and typical parameters for the various environmental conditions.

B.3 DEFINITION OF ENVIRONMENTAL CATEGORIES

CATEGORY	DEFINITION
A-1	Structures, components or Class 1E features of components within containment; a. Which perform a safety function following a LOCA; b. Which act as all or part of a related service system(1) or actuation system(2) for a system, structure, or component included in a. above; or c. Whose failure(3) during or following a LOCA could prevent a system, structure, or component included in a. or b. above from performing its design safety function.
A-2	Structures, components or Class 1E features of components within containment which fall within the definition of category A-1 when "MSLB"(4) is substituted for "LOCA".
B	All structures or components within containment
C	All structures or components in the auxiliary, turbine, and annulus buildings.
D	Structures, components, or Class 1E features of components in the auxiliary and turbine buildings which fall within the definition of Category A-1 a., b., or c.

CATEGORY	DEFINITION
E	Class 1E structures, components, and Class 1E features of components which are part of the Main Steam and Feedwater Systems and the Emergency (or Auxiliary) Feedwater System in the auxiliary and turbine buildings which fall within the definition of Category D when "MSLB" is substituted for "LOCA". Further, this is restricted to structures, components and/or Class 1E features of components which are in the vicinity of high energy piping of other systems or these systems. High energy piping is defined as piping that during normal plant conditions is either in operation or maintained pressurized under conditions where either or both of the following are present: a. Maximum temperature exceeds 200°F, or b. Maximum pressure exceeds 275 psig All other components shall be qualified per the requirements of Category D.
F	Structures, components, or Class 1E features of components in an annulus building which fall within the definition of Category A-1 a., b., or c.
G	Structures, components, or Class 1E features of components in an annulus building which fall within the definition of Category F when "MSLB" is substituted for "LOCA".
H	Structures, components, or Class 1E features of components in the control room, including any integral extensions thereof; a. Which perform a safety function following either any LOCA or any SLB b. Which act as all or part of a related service system for a system structure or component included in a. above or c. Whose failure during or following either LOCA or SLB could prevent a system structure or component included in a. or b. above from performing its design safety function.
I	Structures, components, or Class 1E features of components located outside plant buildings and which perform a safety function following a Condition of Design II, III, or IV event.(5)

CATEGORY	DEFINITION
J	Structures, components or Class 1E features of components located in the control room which are not in category H.
K	Structures, components or Class 1E features of components located outside plant buildings which are not in Category I.

Footnotes:

(1) Related service systems are those systems which provide services necessary to a system, structure, or component which enable it to perform its intended safety function. Examples of related service systems for the emergency core cooling system include component or process cooling systems, electric power supply system, and emergency core cooling system equipment ventilation system.

(2) Actuation systems are the electrical and mechanical devices involved in generating signals associated with the accomplishment of safety functions. The signals include those that actuate reactor trip and actuate engineered safety features. Examples of safety functions are containment isolation, core spray, safety injection, pressure reduction, and air cleaning.

(3) An example is paint on a component or structure that could peel under extreme environmental conditions. If it were to fall into the containment sump, it might significantly affect the performance of the ECCS in the recirculation mode. If the ECCS is not required to perform in the recirculation mode following a design basis event, the paint need not be qualified for the environmental conditions for that design basis event.

(4) MSLB is used as a limiting case for all secondary line breaks (SLB).

(5) Condition II, III or IV events are the design basis events for the plant which are classified as incidents of moderate frequency, infrequent incidents, and limiting faults, respectively.

B.4 QUALIFICATION REQUIREMENTS

Structures and components in each of the environmental qualification categories are designed and qualified in accordance with the following.

CATEGORY	REQUIREMENT
A-1	One time service during the conditions specified for Category A-1, up to the point in time at which they are required to function, unless plant environmental control systems, physical separation, barriers, or other features make such design and qualification unnecessary. Continuous service during the conditions specified for Category B.
A-2	One time service during the conditions specified for Category A-2, up to the point in time at which they are required to function, unless plant environmental control systems, physical separation, barriers or other features make such design and qualifications unnecessary. Continuous service during conditions specified for Category B.
B	Continuous service during the conditions specified for Category B.
C	Continuous service during the conditions specified for Category C.
D	One time service during the conditions specified for Category D, up to the point in time at which they are required to function, unless plant environmental control systems, physical separation, barriers or other features make such design and qualification unnecessary. Continuous service during the conditions specified for Category C.
E	One time service during the conditions specified for Category E, up to the point in time at which they are required to function, unless plant environmental control systems, physical separation, barriers or other features make such design and qualification unnecessary. Continuous service during the conditions specified for Category C.
F	One time service during the conditions specified for Category F, up to the point in time at which they are required to function, unless plant environmental control systems, physical separation, barriers or other features make such design and qualification unnecessary. Continuous service during conditions specified for Category C.

CATEGORY	REQUIREMENT
G	One time service during the conditions specified for Category G, up to the point in time at which they are required to function, unless plant environmental control systems, physical separation, barriers or other features make such design and qualification unnecessary. Continuous service during conditions specified for Category C.
H	Continuous service under conditions specified for Category H.
I	Continuous service under conditions specified for Category I.
J	Continuous service under conditions specified for Category J.
K	Continuous service under conditions specified for Category K.

TABLE B-1

SUMMARY OF LOCATION, OPERATING REQUIREMENTS, AND TYPICAL ENVIRONMENTAL CONDITIONS[f]

CATEGORY	LOCATION	OPER.[i] REQMTS	NORM. ENVIR	TEMP. °F	PRESS.,[e] PSIG	TIME	HUMID	RAD'N, RADS	CHEM
A-1	CB	LOCA	B	Fig. 1A	Fig. 1B	Fig. 1A Fig. 1B	SH STM/ AIR	Fig. 4 & 5	(a)
A-2	CB	MSLB	B	Fig. 3	Fig. 1B	12 MIN	SH STM/ AIR	$4.5 \times 10^4 \gamma$	(a)
				Fig 1A	Fig. 1B	Fig. 1A	SAT STM/ AIR		
B	CB		B	55-122	0-5	CONTIN	20-90% RH	(c)	NA
C	AB/TB/ANB		C	55-104	ATM	CONTIN	20-90% RH (b)	(c)	NA
D	AB/TB	LOCA	C	120 104 104-55	ATM ATM ATM	4 HR 4-24 HRS CONTIN	20-90% RH 20-90% RH (b) 20-90% RH (b)	(d)	NA
E	AB/TB	MSLB	C	55-330 104-55	3 ATM	3 MIN CONTIN	100% RH (b)	$2.7 \times 10^1 \gamma$	NA
F	ANB	LOCA	C	Fig. 2	ATM	Fig. 2	SAT STM/ AIR	(d)	NA
G	ANB	MSLB	C	Fig. 2	ATM	Fig. 2	SAT STM AIR	$3.1 \times 10^4 \gamma$	NA
H	CR	LOCA/MSLB	J	55-104	ATM	(h)	20-90% RH (b)	NA	NA
I	OUTSIDE	DES II,III,IV (g)	I	-30-122	ATM	CONTIN	100% RH	NA	NA
J	CR		J	65-85	ATM	CONTIN	40-60% RH	NA	NA
K	OUTSIDE		K	-30-120	ATM	CONTIN	(b)	NA	NA

NOTES

(a) 4400 ppm BORON AS H_3BO_3, 50-100 ppm HYDRAZINE, SODIUM PHOSPHATE SOLUTION pH 4 TO 10, SODIUM HYDROXIDE

(b) >80°F, DEWPOINT OF 77°F

(c) DOSE VARIES WITH COMPONENT (SEE CESSAR-F, TABLE 3.11 B-2)

(d) UNCONTR. ACC.-$10^4 \gamma$, CONTR. ACC.-$4 \times 10^6 \gamma$, CAT. D-$4 \times 10^6 \gamma$

(e) NORMAL OR ACCIDENT CONDITIONS

(f) SEE APPENDIX B FOR DETAILED ENVIRONMENTAL CATEGORIES

(g) SEE APPENDIX B p. B-3

(h) 8 HOURS MAX.

(i) See Table A-1 for discussion of operating requirements.

Table B-1 (Cont'd)

TYPICAL POST ACCIDENT ENVIRONMENTAL CONDITIONS

Fig. 1A

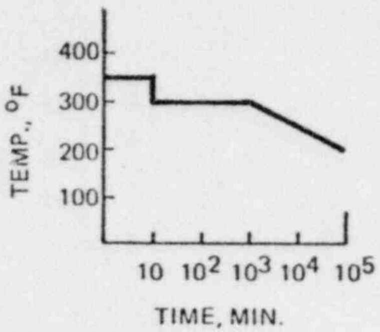


Fig. 1B

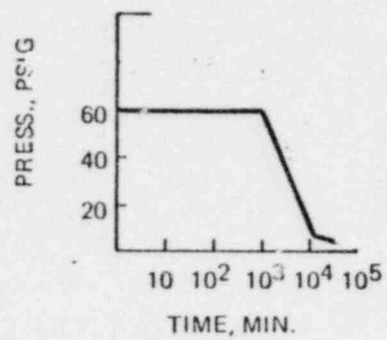


Fig. 2

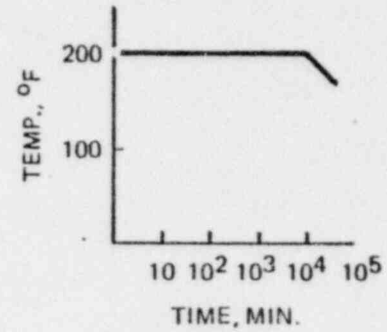


Fig. 3

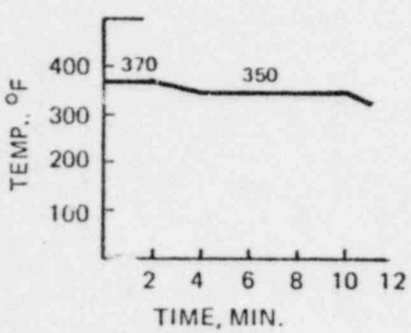


Fig. 4

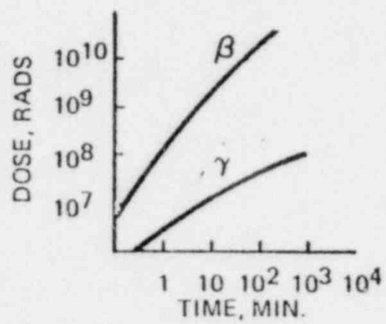
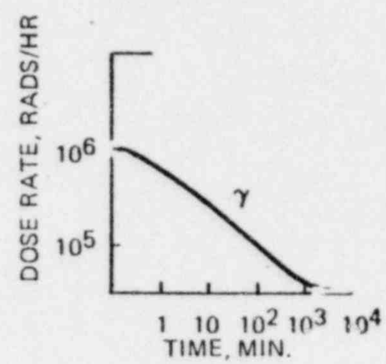


Fig. 5



APPENDIX C

QUALIFICATION PLAN
FOR
CLASS 1E EQUIPMENT
IN THE
CONTAINMENT BUILDING

APPENDIX C

QUALIFICATION PLAN FOR CLASS 1E EQUIPMENT IN THE CONTAINMENT BUILDING

C.1 PURPOSE

The purpose of this Appendix is to describe the Class 1E function, aging and qualification program and acceptance criteria for Class 1E equipment located in the Containment Building.

C.2 EQUIPMENT

This Appendix is concerned with the following types of equipment, located in the Containment Building:

Pressure Transmitters (gauge, differential, and absolute)

RCP Shaft Speed Sensors and Pulse Transmitters

Ex-Core Detectors and Preamplifiers

RTD Temperature Detectors

CEDM Reed Switch Position Indicators

C.3 TESTING SEQUENCE

Testing will be conducted sequentially on production units as follows:

Base Line Testing

Accelerated Aging

Seismic Testing

Design Basis Accident Type Testing

Post-Test Inspection

C.4 ACCEPTANCE CRITERIA

Acceptance criteria will be established based on the required Class 1E function. In general, these criteria will take the form of instrument accuracies, or required actuation functions during and after specified periods under accident stress conditions. These accuracies or functions and operating time values will be used as the basis for assumptions and results in the Safety Analysis in the SAR.

C.5 TEST UNITS

Test units will undergo all aging and testing. Where differences exist between models of a product line, qualification will be demonstrated by analysis or similarity to the tested unit.

C.6 AGING

Aging of Class 1E equipment in the Containment Building will include one or a combination of the following methods. Aged equipment will not be shipped to the site.

C.6.1 Natural Aging

Equipment which has been used in service conditions similar to that anticipated will be replaced and type tested.

C.6.2 Thermal Aging

Equipment will be exposed to temperatures above normal operating temperatures for an accelerated aging process. The correlation between aging time and qualified life will be determined using the "Arrhenius Method" based on activation energies for aging mechanisms or failure rate equations for identical or similar components. Thermal aging will normally be performed on a module level but will depend to some degree on the method used and the specific aging characteristics of assemblies in question. The choice of the method will be based upon available quantitative and qualitative data on the aging characteristics of instrumentation and control equipment with the goal of choosing the method that will lead to the most accurate age simulation.

If the Arrhenius Method is used electronic circuits will be aged on the module level with the circuit boards energized. If the Failure Rate Equation Method is used, aging will be performed on non-operating components. Additional temperature will be applied to the non-operating components to account for the self-heating effects in operating components.

C.6.2.1 Arrhenius Method

One method of accelerated thermal aging is based upon the Arrhenius equation which defines the rate of chemical degradation of materials as a function of ambient temperature and activation energy. The familiar form of the Arrhenius equation is:

$$\text{Reaction Rate} = dR/dt = A \exp(-E/kT) \qquad \text{(C-1)}$$

where: A = Frequency Factor
E = Activation Energy (eV)
k = Boltzman's Constant (8.617×10^{-5} eV/K°)
T = Temperature (°K)

The Arrhenius rate equation is a general equation which describes many chemical reactions, such as: solid state diffusion, chemical bond breakdown, tempering of steel, grain growth, creep rate, recrystallization, etc. In most organic materials several aging mechanisms may be occurring simultaneously. The aging rate, or the rate at which each aging mechanism proceeds in a material, at a given service temperature, is inversely related to the activation energy for each mechanism. The activation energy is that threshold molecular kinetic energy which is required to initiate a reaction. Raising the bulk temperature of a material will increase the relative number of molecules which have an energy greater than the threshhold activation energy. Thus aging will proceed at a greater rate. This is the basis for accelerated thermal aging.

A prediction of the amount of age acceleration may be obtained with a modified form of the Arrhenius equation:

$$\ln t_2 = \ln t_1 + \frac{E}{K}\left[\frac{1}{T_2} - \frac{1}{T_1}\right] \qquad \text{(C-2)}$$

where: t_2 = Aging time
t_1 = Age Simulation (Qualified Life)
T_2 = Aging Temperature (°K)
T_1 = Normal Operating or Service Temperature (°K)
E = Activation Energy (eV)
K = Boltzman's Constant = 8.617×10^{-5} eV/°K

If a component has several different aging mechanisms with different activation energies or if a circuit assembly contains components with dominant aging mechanisms of different activation energies aging will be most conservative if based upon the lowest activation energy. This can be seen by substituting different activation energies in the modified Arrhenius equation (C-2) at a given aging time, aging temperature, and service temperature. The simulated age will be greater for components with high activation energies compared to components with low activation energies. This demonstrates that electronic assemblies with components or aging mechanisms of different activation energies cannot be uniformly simultaneously aged in an accelerated aging program. However a qualified life will be conservatively determined by basing the age simulation on the component or aging mechanism with the lowest activation energy. Aging temperatures will be at or below the maximum rated operating temperatures of the devices.

C.6.2.2 Failure Rate Equations

Failure rate equations may also be used to determine aging times and temperatures. Failure rate equations generally model the aging characteristics of a component in terms of the operating conditions and the environment it is to be exposed to during service. The goal of the "failure rate equation method" is to modify the environment of a component for a short period of time so that the same number of failures would be achieved as with the service environment and operating conditions for a longer period of time. Failure rate models or data will be obtained from reference 11 and/or manufacturer's reliability analysis.

Aging times will be calculated with a manipulation of failure rate equations. The base failure rate equation or model is usually a function of the operating temperature and operating electrical stress.

Base Failure Rate
$$(\text{Failures}/10^6 \text{ hrs}) = \lambda_b = f(T,S) \qquad \text{(C-3)}$$

where:
- T = Temperature
- S = Electrical Stress

The base failure rate will be further modified, by environments, other than temperature, to which the component is subjected. These other environments are characterized by π factors.

Part Failure Rate

$$\left(\frac{\text{Failures}}{10^6 \text{ hrs}}\right) = \lambda_p = \lambda_b\ (\pi_E x \pi_A x \pi_{S2} x \pi_C x \pi_Q) = f(T,S,\pi) \qquad \text{(C-4)}$$

where:
- λ_b = Base failure rate
- π_E and other π factors characterize environmental applications and other parameters that affect the part reliability.

The number of part failures expected under service conditions for the qualified life is equated to the number of part failures expected under accelerated conditions for an aging time. Aging temperatures will be based upon rated temperatures of the components - so the aging time is the only unknown that remains to be calculated.

$$\lambda_p\ (S)\ X\ \frac{\text{Qualified Life}}{10^6 \text{ Hrs.}} = \lambda_p\ (A)\ X\ \frac{\text{Aging Time}}{10^6 \text{ Hrs.}} \qquad \text{(C-5)}$$

where:

λ_p (S) = Part Failure Rate (Failure/10^6 Hrs) as a function of Service Environments (Service Temperature, Service Electrical Stress, Other Service Environments)

λ_p (A) = Part Failure Rate (Failures/10^6 Hrs) as a function of Accelerated Aging Environments (Aging Temperature, Aging Electrical Stress, Other Aging Environments)

$$\text{or: Aging Time} = \frac{\lambda_p\ (S)}{\lambda_p\ (A)} \times \text{Qualified Life} \qquad \text{(C-6)}$$

C.6.3 Mechanical Cycling

Electromechanical devices will be cycled for the number of cycles expected in service. Cycled components will be replaced prior to final shipment to the site.

C.6.4 Radiation Aging

Devices will be exposed to the total integrated dose (TID) expected in service for the qualified life. Radiation aging may also include the LOCA dose, if applicable.

C.5 QUALIFICATION PLAN

Additional information on the Qualification Plan for each type of equipment is given in Tables C-1 through C-5.

Table C-1

EQUIPMENT QUALIFICATION PLAN

RCP SHAFT SPEED SENSOR AND PULSE TRANSMITTER

A. Description

The speed sensor consists of a notched disc attached to the RCP shaft and a proximity probe on the motor housing. The pulse transmitter consists of an electronics module located outside of the secondary shield.

B. Function

The speed sensor scans the rotating notched discs generating a voltage pulse signal. The pulse transmitter provides input voltage for the sensor and transmits the pulses to the pulse shaper in the Control Room.

C. Aging

The speed sensor and pulse transmitter will undergo thermal aging that is based on a conservative activation energy for at least a 10 year qualified life and radiation aging for the 40 year accumulated dose. There are no electromechanical parts requiring cycling.

D. Acceptance Criteria

The speed sensor and pulse transmitter are required to operate continuously under normal conditions and for limited periods of time under abnormal conditions. This system is not required after a LOCA but is required for a short period of time during a MSLB. Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std 323-1974 (Reference 1)

Normal Environment	Temperature, Humidity, Radiation
Aging	Thermal, Radiation (TID)
Seismic Event	
Design Basis Event	MSLB - Temperature Pressure

Design Basis Event testing will be continued for the length of time the Class 1E function of the equipment is required.

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table C-2

EQUIPMENT QUALIFICATION PLAN

PRESSURE TRANSMITTERS

A. Description

Several different types of pressure transmitters are utilized in the containment building. A description of three transmitters is as follows:

One type of pressure transmitter consists of a mechanical device (bourdon tube or diaphragm) which moves in response to a change in process system pressure. Signal processing electronics packages are located outside of the Containment Building. A second type of transmitter consists of capacitance plates moved in response to system pressure. Electronics for this transmitter are located on the module. A third type of transmitter consists of a force balance system with related electronics.

B. Function

Pressure transmitters are used to generate signals proportional to absolute, gauge or differential pressure. Signal outputs are used for input to high pressure trip, ESFAS actuation, low steam generator or pressurizer level trips or for pressure interlocks.

C. Aging

Electronic circuit boards will be thermally aged based on a conservative activation energy. Radiation aging will also be performed for the 40 year accumulated dose plus the LOCA dose.

D. Acceptance Criteria

Pressure transmitters are required to operate continuously under normal conditions and for limited periods of time under abnormal conditions. Depending on the application, transmitters may be required after a LOCA or MSLB for extended or short periods of time. Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

Normal Environment	Temperature, Humidity
Aging	Thermal, Mechanical Cycling, Radiation (TID & Accident)

Seismic Event	
Design Basis Event	LOCA/MSLB - Temperature, Pressure, Chemical Spray

Design Basis Event testing will be continued for the length of time the Class 1E function of the equipment is required.

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table C-3

EQUIPMENT QUALIFICATION PLAN

TEMPERATURE DETECTORS

A. Description

The temperature detectors consist of resistance temperature detectors located in wells in the Reactor Coolant System piping.

B. Function

The RTD generates an output signal proportional to temperature. Input voltage is provided by signal processors located outside of the Containment Building.

C. Aging

The RTD will either be thermally aged based on activation energies and MIL-HDBK-217B data or by analysis. Radiation aging will be performed for the 40 year accumulated dose plus short term post MSLB dose.

D. Acceptance Criteria

The RTD is required to operate continuously under normal conditions and for short periods of time under abnormal conditions. The RTD is required to function during and after an MSLB for an extended period of time (post-accident monitoring). Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

Normal Environment	Temperature Humidity
Aging	Thermal, Thermal Cycling, Radiation (TID & Accident)
Seismic Event	
Design Basis Event	LOCA/MSLB - Temperature Pressure, Chemical Spray

Design Basis Event testing will be continued for the length of time the Class 1E function of the equipment is required.

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table C-4

EQUIPMENT QUALIFICATION PLAN

EX-CORE SAFETY CHANNEL DETECTOR AND
PREAMPLIFIER/FILTER

A. Description

The ex-core safety channel detector assembly consists of three fission chambers with integral cable stacked vertically outside of the reactor vessel. The preamplifier/filter consists of an electronics package inside a housing. The preamplifier/filter is located outside of the secondary shield.

B. Function

The detector senses incident thermal neutron flux and generates an output signal proportional to flux level. The preamplifier receives pulse signals and transmits a signal to the safety channel electronics. The filter provides high voltage to the detectors and transmits the DC current signal to the linear range safety channels.

C. Aging

Organic materials (connectors, gaskets, insulation) will be thermally aged using Arrhenius plots. Electronic components subject to age degradation (capacitors, diodes, FET's, transistors, etc.) will be thermally aged using reliability data from MIL-HDBK-217B (Reference 11.) Electromechanical devices will be cycled for anticipated usage. Thermal cycling will also be performed. Radiation aging (neutron and gamma) will be completed for the total accumulated dose. Aging will be completed for a qualified life of 10 years.

D. Acceptance Criteria

The ex-core detectors, preamplifier and filter are required to operate continuously under normal conditions and under abnormal conditions for limited periods of time. The system is not required after a LOCA. The detector and filter are required for a short period of time after the MSLB. Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

Normal Environment	Temperature, Humidity
Aging	Thermal, Thermal Cycling, Mechanical Cycling, Radiation (TID)

Table C-4 (Cont'd.)

Seismic Event

Design Basis Event MSLB - Temperature Pressure

Design Basis Event testing will be continued for the length of time the Class 1E function of the equipment is required.

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table C-5

EQUIPMENT QUALIFICATION PLAN

REED SWITCH POSITION TRANSMITTER

A. Description

The Reed Switch Position Transmitter (RSPT) consists of a series of reed switches in a voltage divider network. The RSPT is located within the CEDM outer housing and outside the CEDM pressure housing. The reed switches are actuated by a permanent magnet attached to the top of the CEA.

B. Function

The RSPT transmits a signal proportional to CEA position. This signal output is used for input to the CPC/CEAC system.

C. Aging

Aging of the RSPT will include thermal aging, based on an Arrhenius plot for the insulating material, and radiation aging for the 40-year accumulated dose.

D. Acceptance Criteria

The RSPT's are required to operate continuously during normal conditions and for short periods of time under abnormal conditions. The RSPT's are not required after a LOCA but are required for a short period of time after a MSLB. Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

Normal Environment	Temperature, Humidity
Aging	Thermal, Radiation (TID)
Seismic Event	
Design Basis Event	MSLB - Temperature Pressure

Design Basis Event testing will be continued for the length of time the Class 1E function of the equipment is required.

During each of the tests the equipment will be operated and its performance monitored and recorded.

APPENDIX D

QUALIFICATION PLAN
FOR
CLASS 1E EQUIPMENT
OUTSIDE OF THE
CONTAINMENT BUILDING

APPENDIX D

QUALIFICATION PLAN FOR CLASS 1E EQUIPMENT OUTSIDE OF THE CONTAINMENT BUILDING

D.1 PURPOSE

The purpose of this Appendix is to describe the Class 1E functions, aging and qualification program and acceptance criteria for Class 1E Equipment located outside of the Containment Building.

D.2 EQUIPMENT

This Appendix is concerned with the following types of equipment located outside of the Containment Building:

- Pressure Transmitters
- Temperature Detectors
- Panel Mounted Indicators
- Panel Mounted Recorders
- PPS/SSPPS Modules and Panels
- ESFAS Auxiliary Relay Cabinet/SSCCS, SSAS
- Auxiliary Protective Cabinet/CPPS Cabinet
- Isolators
- Process Protective Cabinet
- Reactor Trip Switchgear
- Supplementary Protection Logic Assembly
- Miscellaneous Modules and Panels

D.3 TESTING SEQUENCE

Testing will be conducted sequentially on production units as follows:

- Baseline Testing
- Cycle Life Testing (if applicable)
- Environmental Testing (normal and abnormal)
- Seismic Testing
- Post-Test Inspection

D.4 ACCEPTANCE CRITERIA

Acceptance criteria will be established based on the required Class 1E function. In general, these criteria will take the form of instrument accuracies or actuation functions during and after specified periods under stress conditions. These accuracies or functions and operating time values will be used as the basis for assumptions and results in the Safety Analysis in the SAR.

D.5 TEST UNITS

Test units will undergo all aging and testing. Redundant equipment in cabinets or panels will have one of the bays tested. Where differences exist between models of a product line, qualification will be demonstrated by analysis or similarity to the tested units.

D.6 AGING

An evaluation has demonstrated that aging prior to qualification type testing is unnecessary for most Class 1E instrumentation outside of containment since natural aging of the equipment will not result in a common mode failure during the Design Basis Event (DBE) (Reference 2). If a common mode failure were to occur, the failure mode would be a result of the vibration of a Safe Shutdown Earthquake, (SSE) the recognized DBE outside of containment. The following evaluation focuses on the differential effects of seismic vibration between new and aged Class 1E instrumentation. The qualification program discussed in Section 4.2.1 will be applied.

D.6.1 Electronic Components

The various known aging mechanisms of electronic components have been considered. Electronic components, in general, are of relatively small mass and have relatively short supporting structures (lead lengths). The seismic vibration excitation frequences expected during the SSE are significantly below the resonant frequencies of these devices. (Reference 12). Thus significant internal stresses would not be included in these components during an SSE. Since the resonant frequencies of all modes of vibration are above the seismic vibration excitation frequencies, there will be no significant internal stresses that could break components or break lead wire or contact interfaces. In addition few aging mechanisms exist in electronic components that may degrade lead wire bond or contact interfaces under the relatively benign environments outside of the Containment Building. (References 12, 13). Those that do exist have high activation energies, or the aging proceeds at minimal rate compared to the rate of other component aging mechanisms. (Reference 13). Thus common mode vibrationally induced failures are not predicted during the design life of the equipment.

D.6.2 Wire

Aging mechanisms of some components, in particular wire and electromechanical devices, could lead to common mode failures during a SSE. Thus age qualification of these components will be considered.

Wire and cable that have been generically aged by a wire manufacturer will be used in Class 1E instrumentation whenever practicable. Wire will be age qualified through the specification of IEEE Std. 383-1974.

Wire installed in non-custom, "off-the-shelf" equipment, such as power supplies, will not be aged because of the non-availability of age qualified wire in these modules.

D.6.3 Electromechanical Components

Electromechanical components will be cycled to the number of cycles expected in service and under the electrical load expected in service.

D.6.4 Preventive Maintenance/Surveillance Program

Class 1E equipment outside of the containment is within the scope of the preventive maintenance/surveillance program regardless of whether or not a qualified life has been established for the equipment. This program consists of preventive maintenance and periodic testing to assure proper operation of the equipment throughout its design life. Preventive maintenance will include periodic adjustment, cleaning, and calibration of the equipment. The philosophy of the program is to assure, to a high degree of confidence, that the equipment will not degrade to the point where it could fail during a seismic event.

D.7 QUALIFICATION PLAN

Additional information on the Qualification Plan for each type of equipment is given in Tables D-1 through D-11.

Table D-1

EQUIPMENT QUALIFICATION PLAN

PRESSURE TRANSMITTERS

A. Description

Pressure transmitters will be similar to pressure transmitters used in the Containment Building (See Table C-2).

B. Function

Pressure transmitters are used to generate signals proportional to absolute, gauge or differential pressure. Signal outputs are used for input to ESFAS interlocks, or ESFAS process indicators and recorders.

C. Aging

Electromechanical devices will be cycled, where applicable.

D. Acceptance Criteria

The pressure transmitters are required to operate continuously under normal conditions and for limited periods of time under abnormal conditions. Equipment is not exposed to increased stress during LOCA or MSLB.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

Cycling	
Normal/Abnormal Environment	Temperature/Humidity
Seismic Event	

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table D-2

EQUIPMENT QUALIFICATION PLAN

TEMPERATURE DETECTORS

A. Description

Temperature detectors will be similar to temperature detectors used in the Containment Building (See Table C-3).

B. Function

The RTD generates an output signal proportional to temperature. Signal outputs are used for input to ESFAS interlocks, or for ESFAS process indicators and recorders.

C. Aging

The RTD will either be thermally aged based on activation energies and MIL-HDBK-217B data or by analysis.

D. Acceptance Criteria

The temperature detector is required to operate continuously under normal conditions and for limited periods of time under abnormal conditions. Equipment is not exposed to increased stress during LOCA or MSLB. Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

Aging	
Normal/Abnormal Environment	Temperature/Humidity
Seismic Event	

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table D-3

EQUIPMENT QUALIFICATION PLAN

PANEL MOUNTED INDICATORS

A. Description

The panel mounted indicators consist of standard electronic meters.

B. Function

The meters are used to display the le   of various process parameters. Some parameters may be required for long term post accident monitoring.

C. Aging

Electromechanical devices will be cycled.

D. Acceptance Criteria

The panel mounted indicators are required to operate continuously under normal conditions and for limited periods of time under abnormal conditions. Equipment is not exposed to increased stress during LOCA or MSLB. Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

Cycling	
Normal/Abnormal Environment	Temperature/Humidity
Seismic Event	

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table D-4

EQUIPMENT QUALIFICATION PLAN

PANEL MOUNTED RECORDERS

A. Description

The panel mounted recorders consist of standard continuous strip recording mechanisms.

B. Function

The recorders are used to record the level of various process parameters. Some parameters may be required for long term post accident monitoring.

C. Aging

Electromechanical devices will be cycled.

D. Acceptance Criteria

The panel mounted recorders are required to operate continuously under normal conditions and for limited periods of time under abnormal conditions. Equipment is not exposed to increased stress during LOCA or MSLB. Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

Cycling	
Normal/Abnormal Environment	Temperature/Humidity
Seismic Event	

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table D-5

EQUIPMENT QUALIFICATION PLAN

PPS/SSPPS MODULES AND CABINETS

A. Description

The PPS cabinets consist of redundant panels containing the following PPS modules:

PPS Bistable Control Panel
PPS Power Supply
PPS Matrix Test Module
PPS Initiation Reset Panel
Nuclear Instrumentation Panel
PPS Initiation Relay Panel
PPS Relay Card Rack Assembly

The PPS cabinet includes the cabinet structure, intermodule wiring cooling fans (as required) and module attachment racks. The PPS modules consist of complex electronic and electromechanical assemblies. The SSPPS contains panels which perform the same functions using solid state electronics.

B. Function

The PPS/SSPPS modules and cabinets receive input from Class 1E parameter sensors, evaluate signals, and generate reactor trip signals and ESFAS initiation signals.

C. Aging

Electromechanical devices will be cycled. Where feasible, intermodule wiring will be age qualified through the specification of IEEE Std. 383-1974.

D. Acceptance Criteria

The PPS/SSPPS Modules and Cabinets are required to operate continuously under normal conditions and for limited periods of time under abnormal conditions. Equipment is not exposed to increased stress during LOCA or MSLB. Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

Aging	Cycling, Age Qualified Wire

Normal/Abnormal Environment	Temperature/Humidity
Seismic Event	

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table D-6

EQUIPMENT QUALIFICATION PLAN

ESFAS AUXILIARY RELAY CABINET/SSCCS/SSAS

A. Description

The ESFAS Auxiliary Relay Cabinet contains the ESFAS actuation circuitry and test modules. The Auxiliary Relay Cabinet includes the cabinet structure, and intermodule wiring. The actuation circuitry and test modules consist of complex electronic and electromechanical assemblies. The SSCCS and SSAS panels contain modules which perform similar functions using solid state electronics.

B. Function

The ESFAS Auxiliary Cabinet/SSCCS/SSAS receives input signals from PPS initiation signals, evaluates the signals, and generates engineered safety features actuation output signals.

C. Aging

Class 1E electromechanical devices will be cycle-life tested. Where feasible, intermodule wiring will be age qualified through the specification of IEEE Std. 383-1974.

D. Acceptance Criteria

The ESFAS Auxiliary Relay Cabinet/SSCCS/SSAS is required to operate continuously under normal conditions and for limited periods of time under abnormal conditions. Equipment is not exposed to increased stress during LOCA or MSLB. Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

	Cycling, Age Qualified Wire
Normal/Abnormal Environment	Temperature/Humidity
Seismic Event	

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table D-7

EQUIPMENT QUALIFICATION PLAN

AUXILIARY PROTECTIVE CABINET/CPPS CABINET

A. Description

The Auxiliary Protective Cabinet typically contains the following modules:

CPC I/O Modules
CPC CPU and Memory
CPC Test Panels
CEAC I/O Modules
CEAC CPU and Memory
CPC/CEAC Signal Isolators
CEA Position Isolation Assemblies
RCP Speed Sensing Signal Processors
Plant Monitoring System Remote Input Subsystems
Miscellaneous Modules and Panels

The Auxiliary Protective Cabinet includes the cabinet structure, intermodule wiring, and module attachment racks. The various modules consist of complex electronic and electromechanical assemblies. The CPPS cabinet contains modules which perform similar functions using solid state electronics. In addition, the CPPS Cabinet contains:

SSPPS Modules
Ex-core Nuclear Instrument Safety Channel
Digital Isolation Device Assemblies
Optical Communication Interface System

B. Function

The modules in the Auxiliary Protective Cabinet/CPPS receive input signals from Class 1E parameter sensors, perform calculations using that data, and provides various 1E and non-1E inputs.

C. Aging

Electromechanical devices will be cycled. Where feasible, intermodule wiring will be age qualified through the specification of IEEE Std. 383-1974.

D. Acceptance Criteria

The Auxiliary Protective Cabinet/CPPS Cabinet is required to operate continuously under normal conditions and for limited periods of time under abnormal conditions. Equipment is not exposed to increased stress during LOCA or MSLB. Accuracy requirements are defined in the equipment specifications.

E. <u>Qualification Testing</u>

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

Cycling, Age Qualified Wire

Normal/Abnormal Environment	Temperature/Humidity

Seismic Event

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table D-8

EQUIPMENT QUALIFICATION PLAN

ISOLATORS

A. Description

Isolators consist of relays, signal processors (E/I, I/E converters), digital isolators, optical isolators, voltage follower circuits or multiplexing circuits.

B. Function

Isolators are used to separate Class 1E from non-1E equipment or to segregate two redundant Class 1E channels. Perturbations such as application of the maximum credible voltage, shorts, opens and grounds for Class 1E to Class 1E isolators must isolate from both output to input and input to output. Class 1E to non-1E isolators need only isolate from output to input. Non-1E to 1E isolators must isolate from input to output.

C. Aging

Electromechanical devices will be cycled.

D. Acceptance Criteria

The isolators are required to perform their isolation function continuously under normal conditions and for limited periods of time under abnormal conditions. Equipment is not exposed to increased stress during LOCA or MSLB. Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

Aging	Cycling
Normal/Abnormal Environment	Temperature/Humidity
Seismic Event	

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table D-9

EQUIPMENT QUALIFICATION PLAN

PROCESS PROTECTIVE CABINET

A. Description

The Process Protective Cabinet consists of panels containing signal processors, power supplies, isolators and interlocks. The cabinet includes the cabinet structure, intermodule wiring, cooling fans (as required) and the module attachment racks. The modules in the cabinet consist of complex electronic and electromechanical assemblies.

B. Function

The signal processors receive input from process transmitters and convert the signal as required for input to the PPS or ESFAS, or miscellaneous meters and recorders. Functions of power supplies and isolators are self evident. Functions of the isolators are described in Table D-8. Interlocks are used for protective action to prevent certain operations (e.g. opening SI tank valves when below operating pressure).

C. Aging

Electromechanical devices will be cycled.

D. Acceptance Criteria

The process protective cabinet is required to operate continuously under normal conditions and for limited periods of time under abnormal conditions. Equipment is not exposed to increased stress during LOCA or MSLB. Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

Cycling	
Normal/Abnormal Environment	Temperature/Humidity
Seismic Event	

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table D-10

EQUIPMENT QUALIFICATION PLAN

REACTOR TRIP SWITCHGEAR

A. Description

The reactor trip switchgear includes circuit breakers and associated actuating circuitry. This equipment consists of complex electronic and electromechanical devices.

B. Function

The reactor trip switchgear receives input signals from the PPS. Upon receipt of a trip signal the breakers open, interrupting power to the CEDM holding coils.

C. Aging

Electromechanical devices will be cycled.

D. Acceptance Criteria

The reactor trip switchgear is required to perform a trip function continuously under normal conditions and for limited periods of time under abnormal conditions. Equipment is not exposed to increased stress during LOCA or MSLB. Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

Cycling	
Normal/Abnormal Environment	Temperature/Humidity
Seismic Event	

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table D-11

EQUIPMENT QUALIFICATION PLAN

SUPPLEMENTARY PROTECTION LOGIC ASSEMBLY (SPLA)

A. Description

The SPLA provides diverse equipment for initiating a reactor trip based on high pressurizer pressure. The SPLA is chiefly comprised of the following elements:

SPLA Cabinet Enclosure
Input/Comparator Module
Output Relay
Test Module
Annunciator Module
Power Supply Assembly

B. Function

The SPLA's augment reactor protection by providing a separate and diverse trip logic from the Reactor Protection System for initiation of reactor trip.

C. Aging

Electromechanical devices will be cycled. Where feasible, intermodule wiring will be age qualified through the specification of IEEE Std. 383-1974.

D. Acceptance Criteria

The SPLA's are required to operate continuously under normal conditions and for limited periods of time under abnormal conditions. Equipment is not exposed to increased stress during LOCA or MSLB. Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1).

Aging	Cycling, Age Qualified Wire
Normal/Abnormal Environment	Temperature/Humidity
Seismic	

During each of the tests the equipment will be operated and its performance monitored and recorded.

Table D-12

EQUIPMENT QUALIFICATION PLAN

MISCELLANEOUS MODULES AND PANELS

A. Description

Miscellaneous modules and panels include the following:

DNBR/LPD Operator's Modules
PPS Remote Control Modules
PPS Local Status Panel
Main Control Board
Remote Shutdown Panel
Hardwired Annunciator System Isolation Cabinet
CEDMCS Auxiliary Cabinet
Digital Isolation Device Assemblies
SSPPS Remote Control Modules
SSAS ESF Test Panels
Optical Communication Interface system

This equipment contains various complex electronic and electromechanical devices.

B. Function

These modules or panels function to provide the operator with information on safety system and plant status or to support operation of safety systems.

C. Aging

Electromechanical devices will be cycled. Where feasible, intermodule wiring will be age qualified through the specification of IEEE Std. 383-1974.

D. Acceptance Criteria

The miscellaneous modules and panels are required to perform their Class 1E function continuously under normal conditions and for limited periods of time under abnormal conditions. Equipment is not exposed to increased stress during LOCA or MSLB. Accuracy requirements are defined in the equipment specifications.

E. Qualification Testing

Qualification testing will be performed as follows in accordance with IEEE Std. 323-1974 (Reference 1)

Cycling, Age Qualified Wire

Normal/Abnormal Environment	Temperature/Humidity
Seismic Event	

During each of the tests the equipment will be operated and its performance monitored and recorded.