WCAP 8587 Revision 3

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Methodology for Qualifying Westinghouse WRD Supplied NSSS Safety Related Electrical Equipment

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FOREWORD

Historically, safety related electrical equipment has been tested under the severe environmental conditions expected to occur in the event of a design basis accident. This testing provided a high degree of confidence in the safety system performance under the limiting environmental conditions. However, in keeping with the advancing state of the art, qualification criteria were revised in 1974 by revision of IEEE-323-1974 and by Regulatory Guide 1.89 which endorses this IEEE Standard. The concept of aging was highlighted in IEEE-323-1974 and interpretation of the scope of aging and implementation methods were soon urgently required. Some guidance on the scope of applicability of aging considerations was subsequently provided by the NPEC-7-24-75 "Nuclear Power Engineering Committee Position Statement to Foreword of IEEE Standard 323-1974".

Shortly after IEEE-323-1974 was issued, Westinghouse WRD formed an engineering task group to interpret new requirements and to recommend implementation methods. The qualification procedures described throughout this topical report are the result of this task group's efforts and subsequent evolution. The task group members were also assisted greatly by discussions with experts from other divisions of the company and the nuclear industry as well as from NRC Staff and IEEE committee personnel. The Westinghouse WRD program for qualification to IEEE-323-1974 is consistent with the interpretation set forth by the NPEC position mentioned above.

Meetings with the NRC staff have been held to discuss qualification methods since Revision 0 of this report was issued in September, 1975. Revision 0 was written to respond to NRC Staff concerns on environmental qualification to IEEE-323-1974 relative to the Westinghouse RESAR-41 application. In the last three years, the program has been revised based on evolution of the state-of-the-art and interaction with NRC and industry representatives. The topical report's title has been changed to reflect the fact that the report, in its present from, represents general qualification methods to be utilized for qualification and not the qualification results themselves. Also, it was desirable to define the title in terms of Westinghouse's WRD Supplied NSSS scope equipment so that no mistake could be made that the contents of the topical report represent any other sister division's BOP qualification methods.

Revisions 2 and 3 of the topical have been made to include additional detail now available as a result of general program development and some reformating of the report has been introduced to allow the discussion contained in this report to follow the format headings of the Equipment Qualification Data Packages (EQDP's) now issued as Supplement 1 to this report. This reformatting permits easy cross reference between the methodology defined in this report and the detailed plans contained in the Supplement.

TABLE 2-1

SAFETY RELATED EQUIPMENT IN W WRD SCOPE OF SUPPLY

EQUIPMENT	SYSTEM	PLANT LOCATION**	EQDP REFERENCE
Safety Related Valve Electric Motor Operators	CVCS	i/O	HE-1 and 4
	SIS	i/O	
	CCS	O	
	RHR	i/O	
Safety Related Solenoid Valve	CVCS	i/O	HE-2 and 5
	SIS	i/O	
	RCS*	i/O	
	WPS*	O	
	SS*	i/O	
	SGBP*	O	
	RHR	i/O	
Safety Related Externally Limit Switches	CVCS	i/O	HE-3 and 6
	SIS	i/O	
	CSS	O	
	RHR	i/O	
	RCS*	i/O	
	WPS*	O	
	SS*	i/O	
	SGBP*	O	
Pressure Transmitters	RPS/PAM	i/O	ESE-1 and 2
Differential Pressure Transmitters	RPS/PAM	i/O	ESE-3 and 4
Resistance Temperature Detectors	RPS/PAM	i	ESE-5, 6 and 7
Excore Neutron Detectors	RPS	i	ESE-8 and 9
Nuclear Instrumentation System (NIS)	RPS	O	ESE-10
Source Range Preamplifier	RPS	i/O	ESE-11 and 36
Main Control Board Switch Modules	RPS/ESF	O	ESE-12

TABLE 2-1 (Continued)

SAFETY RELATED EQUIPMENT IN W WRD SCOPE OF SUPPLY

EQUIPMENT	SYSTEM	PLANT LOCATION**	EQDP REFERENCE
Process Protection Sets	RPS	0	ESE-13
Indicators and Recorders	PAM	0	ESE-14 and 15
Solid State Protection Systm. Logic and actuation Trains - (Auxiliary Safeguards cabinets where Applied) and ESF on-Line Test Cabinet	RPS/ESF	0	ESE-16 and 17
Instrument Power Supply (Static Invertor)	Electrical Power Supply	0	ESE-18 and 35
Instrument Bus Distribution Panel	Electrical Power Supply	0	ESE-19, 33 and 34
Reactor Trip Switchgear	RPS	0	ESE-20 and 26
Pressure Sensor	RPS	i	ESE-21
4 Section Excore Neutron Detector	RPS	i	ESE-22
Loop Stop Valve Cabinet	RPS	0	ESE-23
RCP Speed Sensor	RPS	0	ESE-24
Main Control Board Primary Control Console Secondary Control Console Safety Center	RPS/ESF/PAM	0	ESE-25
Nitrogen-16 Detector	RPS	i	ESE-27
Rod Position Detector	RPS	i	ESE-28
Rod Position Data Cabinet	RPS	i	ESE-29
Integrated Protection Cabinet	RPS	0	ESE-30
Integrated Logic Cabinet	RPS	0	ESE-31
Field Termination Cabinet	RPS	0	ESE-32
PAMS Demultiplexer	PAM	0	ESE-37
Control Board Multiplexer	RPS/ESF	0	ESE-38

TABLE 2-1 (Continued)

SAFETY RELATED EQUIPMENT IN W WRD SCOPE OF SUPPLY

EQUIPMENT	SYSTEM	PLANT LOCATION**	EQDP REFERENCE
Fiber Optic Cable	RPS/ESF	0	ESE-39
Hydrogen Recombiner	ESF	i	SP-1
Safety Related Pump Motors	CVCS	0	AE-1 thru 4
	SIS	0	
	EBS	i	
	RHRS	0	
	CCWS	0	

NOTES:

0 = Outside containment

i = Inside containment

* = Containment Isolation valves only

** = For the Equipment listed below, the Applicant will be responsible for locating this equipment in a plant area which has environmental conditions within the equipment's normal, abnormal, and accident environments (specified in each EQDP).

CVCS = Chemical Volume Control System

SIS = Safety Injection System

WPS = Waste Processing System

SGBP = Steam Generator Blowdown (Waste) Processing (System)

RHR = Residual Heat Removal (System)

PAM = Post Accident Monitoring

RPS = Reactor Protection System

ESF = Engineered Safeguard Feature

N/A = Not Applicable

RCS = Reactor Coolant System
SS = Sampling System
CSS = Containment Spray System
EBS = Emergency Boration System
CCWS = Component Cooling Water System

4.0 DOCUMENTATION PLAN

The overall qualification documentation plan consists of WCAP-8587 as the parent document and the qualification specifications, program plans and results documented in a series of a separate Equipment Qualification Data Packages (EQDP's) for each item of equipment listed in Table 2-1. Each EQDP follows the format outlined in Appendix A. Figure 4-1 graphically demonstrates how WCAP-8587 acts as the parent methodology document for the daughter EQDP's that are separately documented in Supplement 1 to this report. Each EQDP currently defines the equipment performance specification and the qualification program plan. On completion of a particular equipment qualification program, the appropriate EQDP will be updated to contain a summary of the completed program and will identify the supporting test reports. All test reports written for this program will be identified as supplements to WCAP-8587 and coded to the appropriate EQDP reference number. All information necessary to demonstrate the equipments ability to perform its intended safety function(s) under normal, abnormal, accident and post accident environments will be provided. If maintenance, refurbishment or replacement of the equipment is necessary to ensure the ability to perform the equipments safety function, then this information will also be included in the EQDP. The completed EQDP will be made available to the NRC staff for audit. Westinghouse WRD will provide, as input to the applicant's SAR, references to the applicable qualification documentation.

The performance specification, contained in Section 1 of each EQDP, constitutes interface requirements to the applicant who references the EQDP in his license application. The Owner/AE will be responsible for demonstrating that qualified equipment is utilized and located such as not to prejudice the performance specification contained in Section 1 of the EQDP. The NRC review of the SAR will ensure that the equipment qualification is satisfactory when compared to the plant specific environment and functional requirements. This entire process, described above, is graphically presented in Figure 4-2.

Analysis (6.5) - Qualification by analysis alone is not employed by Westinghouse WRD. Analysis is employed to supplement testing or to provide verification that the test results are applicable. The assumptions and models utilized will be described and with the results of the analysis and conclusions will be documented in Section 4.0 of the EQDP.

On-Going Qualification (6.6) - On going qualification as described in Section 6.6 of IEEE 323-1974 is not employed by Westinghouse WRD as a method for qualification.

Criteria of Failure (6.7) - The equipment will be judged unsuitable when the qualification results fail to demonstrate that the equipment will perform the safety function required by the particular functional requirements as specified in Section 1.7 of the EQDP. It is possible for equipment to be suitable and qualified to perform some safety functions but unsuitable for others. The suitability to perform a safety function for a particular plant will be demonstrated in individual plant Safety Analysis Reports by comparing the qualification demonstrated by the Equipment Qualification Data Package to the plant specific requirements of the function for which the equipment is used (See Figure 4-2).

Modifications (6.8) - The criteria for modification, if applicable, will be delineated in the individual test procedures.

Documentation (6.9) - Documentation of specific equipment qualification will be provided via the Equipment Qualification Data Packages (See Appendix A).

5.4 REGULATORY GUIDE CONFORMANCE

Regulatory Guides describe methods acceptable to the NRC staff for implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents or to provide guidance to applicants. In the area of seismic and environmental qualification of safety related electrical equipment, the NRC has issued the following Regulatory Guides:

Regulatory Guide 1.40, "Qualification Tests of Continuous-Duty Motors Installed Inside the Containment of Water Cooled Nuclear Power Plants" - This guide endorses, with certain modifications, IEEE 334-1971. Westinghouse WRD does not currently supply equipment within the scope of this guide.

Regulatory Guide 1.63, "Electric Penetration Assemblies in Containment Structures for Water-Cooled Nuclear Power Plants - This Regulatory Guide endorses, with certain qualifications, IEEE 317-1972. However, since Westinghouse WRD does not supply containment penetrations, this guide is not applicable.

Regulatory Guide 1.73, "Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants" - Regulatory Guide 1.73 endorses, with certain qualifications, IEEE 382-1972. Westinghouse employs the recommendations of the Regulatory Guide in part in specifying the qualification program plans contained in Supplement 1 to this report and specifies additional requirements to ensure conformance with IEEE 323-1974.

Regulatory Guide 1.89, "Qualification of Class 1E Equipment for Nuclear Power Plants" - This guide endorses IEEE 323-1974 with certain qualifications, i.e. the use of IEEE 344-1971 (see below) and source terms. Westinghouse employs the recommendations of Regulatory Guide 1.89 by the following:

1. The recommendations of IEEE 323-1974 are met by the methods discussed in Sections 6, 7 and Appendix A of this WCAP.

2. The radiation source terms used in qualification are described in Section 6 of this WCAP and meet the recommendations of Regulatory Guide 1.89.

3. The seismic qualification requirements employ the recommendations of IEEE-344-1975 as described in Section 7 of this WCAP.

Regulatory Guide 1.100, "Seismic Qualification of Electrical Equipment for Nuclear Power Plants" - This guide endorses, with certain qualifications, IEEE 344-1975. Westinghouse employs the recommendations of by Regulatory Guide 1.100 as described in Section 7 of this topical report.

1. Normal/Abnormal - the specifications for accuracy and response times are the same for both these conditions with the difference being that the specs under normal conditions are met by periodic calibration and maintenance while a time restriction is specified for operation under abnormal conditions (where the specs must be met without any special calibration or maintenance effort).

2. Containment Test - Westinghouse does not suppy equipment that is located inside containment and required to function during a containment pressure test. Nevertheless, for equipment located inside containment, the requirement is specified that the equipment shall not sustain any damage as a result of exposure to the high pressure conditions existing during this test.

3. Accident - Performance specifications include the effects of both radiation and steam/temperature conditions that exist after a high energy line break (HELB). The addition of errors at the same point in time from the radiation test and the steam/temperature test must not exceed the performance requirements for that point in time after the event.

4. Seismic - Performance specifications include the deviation allowed from normal specifications due to seismic events only and are plant and location dependent. Since high energy lines inside containment are designed for seismic events, seismic and environmental errors are not additive for breaks in these lines.

6.8 ENVIRONMENTAL CONDITIONS

The environmental conditions considered in the qualification of NSSS safety related equipment can be separated into three categories: normal, abnormal, and accident conditions. "Normal Conditions" are those sets and ranges of plant conditions that are expected to occur regularly and for which plant equipment is expected to perform its safety function, as required, on a continuous, steady-state basis. "Abnormal" refers to the operating range in which the equipment is designed to operate for a period of time without any special calibration or maintenance effort. "Accident conditions" refers to an operating limit to which the equipment may be subjected without impairment of its operating characteristics. Equipment operated within the accident condition operating limit may require that tests, inspections, and maintenance to be performed on the equipment, prior to return to normal operating conditions.

The following sections define the basis for the normal, abnormal, accident and post accident environmental conditions specified in EQDP Section 1.8 and to be assumed by Westinghouse for qualification of safety related electrical equipment. These conditions have been conservatively derived to allow for possible alternative locations of equipment within the plant.

6.8.1 NORMAL OPERATING CONDITIONS

Pressure, Temperature, Humidity

In defining the normal operating environmental parameters to be employed, maximum use has been made of available Architect Engineering interface information and the draft recommendations of the IEEE concerning environmental parameters (Ref. 1). The assumed values for temperature, pressure and humidity during normal operation are specified in Table 6-1 as a function of in-plant location.

Radiation Dose

The normal operating dose rates, and consequent 40 year doses, assumed at various locations inside containment are specified in Table 6-2. These values have been derived from theoretical calculations assuming 40 years of continuous operation with a reactor power of 4100 MWth and steady state operating conditions. Equivalent data at various locations outside containment are specified in Table 6-3. The 40 year doses quoted are consistent with the draft IEEE recommended environmental parameters (Ref 1).

6.8.2 ABNORMAL OPERATING CONDITIONS

Abnormal environments are defined to recognize possible plant service abnormalities which could lead to short-term changes in equipment environments. Figure 6-1 presents the assumptions made in defining potential abnormal environments due to loss of air conditioning or ventilation systems. The specified values are consistent with available Architect Engineering interface information and the draft recommendations of the IEEE (Ref 1). Table 6-1 defines the abnormal environments as a function of equipment location. The assumed duration of the abnormal conditions specified in Table 6-1 are consistent with current operating practices and Technical Specification limits. For certain plant applications, qualification for abnormal environments will not be necessary when equipment is located in an air conditioned environment controlled by a class 1E system.

6.8.3 CONTAINMENT TEST ENVIRONMENT

Reg. Guide 1.18 specifies that containment integrity shall be demonstrated at 1.15 times design pressure. The maximum design pressure of containments employed with PWR system designs is of the order of 60 psig. Consequently, the assumed pressure for the containment test, as specified in Section 1.8 of the EQDP, is 1.15 x 60 psig $\cong$ 70 psig. Other environmental parameters (temperature, humidity, etc.) obtaining during the test are adequately enveloped by other aspects of the qualification program and will therefore be assumed to be the normal operating values.

6.8.4 ACCIDENT AND POST ACCIDENT ENVIRONMENTS

Section 1.7 of the EQDP separately specifies the performance requirements for those accidents for which the equipment is claimed to perform a safety related function and which have a potential for changing its equipment environment due to increased temperature, pressure, humidity, radiation or seismic effects. The consequent environmental conditions for those design basis events are defined in EQDP Section 1.8 on the basis of the assumptions described in the following discussion:

High Energy Line Break Accidents (HELB) - In Containment

1. The accidents to be addressed are the Loss of Coolant Accident (LOCA), Steamline Break (SLB) and Feedline Break (FLB). In order to retain the option of qualifying equipment for a single applicable HELB condition, separate in-containment environmental design envelopes have been specified for the higher irradiation/lower saturated temperature conditions of LOCA (Figure 6-2) as against the lower irradiation/short term superheated temperature conditions associated with the steamline break (Figure 6-3). In order to limit the number of basic envelopes to be employed, this latter envelope is conservatively employed to define the incontainment envelope following a feedline break.

   Since Westinghouse is conducting generic testing, the environmental envelopes specified in figures 6-2 and 6-3 for HELB accidents have been defined to encompass the results of available preliminary containment analyses, in many cases completed by the Architect Engineer, for Westinghouse NSSS plants committed to qualifying equipment to IEEE Std 323-1974. Current indications are that the specified envelope for the steamline break (Figure 6-2), which defines the limiting short-term temperature peak, is highly conservative. Analyses completed by Westinghouse to-date employing the NRC interim proposed containment analysis model yield peak temperatures no greater than 370°F. Furthermore, equivalent analyses employing the Westinghouse containment analysis model described in References 5 through 11 yield peak temperatures no greater than 350°F. When final calculations for these plants become available, should the envelope conditions described in Figures 6-2 and 6-3 prove to be excessively conservative in either magnitude or duration, the envelope(s) may be reduced to bound the final calculations in order to avoid unnecessary penalty in equipment design and procurement.

2. The specification for chemical spray solution is 2500 ppm boron buffered with 0.88% dissolved sodium hydroxide to maintain a pH of 10.5.

3. For LOCA, the radiation sources associated with an equivalent core meltdown accident are consistent with those set forth in TID-14844, "Calculation of Distance Factors for Power and Test Reactor Sites", and are conservative estimates of the recommendations of Regulatory Guide 1.89, November, 1974. The exposure inside the containment is estimated by considering the dose in the middle of a PWR containment based on the following analytical assumptions:

TABLE 6-2

40 YEAR NORMAL OPERATING DOSES - INSIDE CONTAINMENT

Location	γ Dose rate R/hr	40 yr γ dose (R)
RCL pipe center	820	3.0×10^8
RCL pipe ID	470	1.6×10^8
RCL pipe OD (contact)	165	5.8×10^7
RCL - general area	50	$<2.0 \times 10^7$
Outside loop compartment wall	<0.1	$<3.5 \times 10^4$
Detectors located next to R.V.	5×10^4	1.8×10^{10} [(a)]

(a) 40 year dose from neutrons > 1 Mev is 5×10^{18} n/cm^2.

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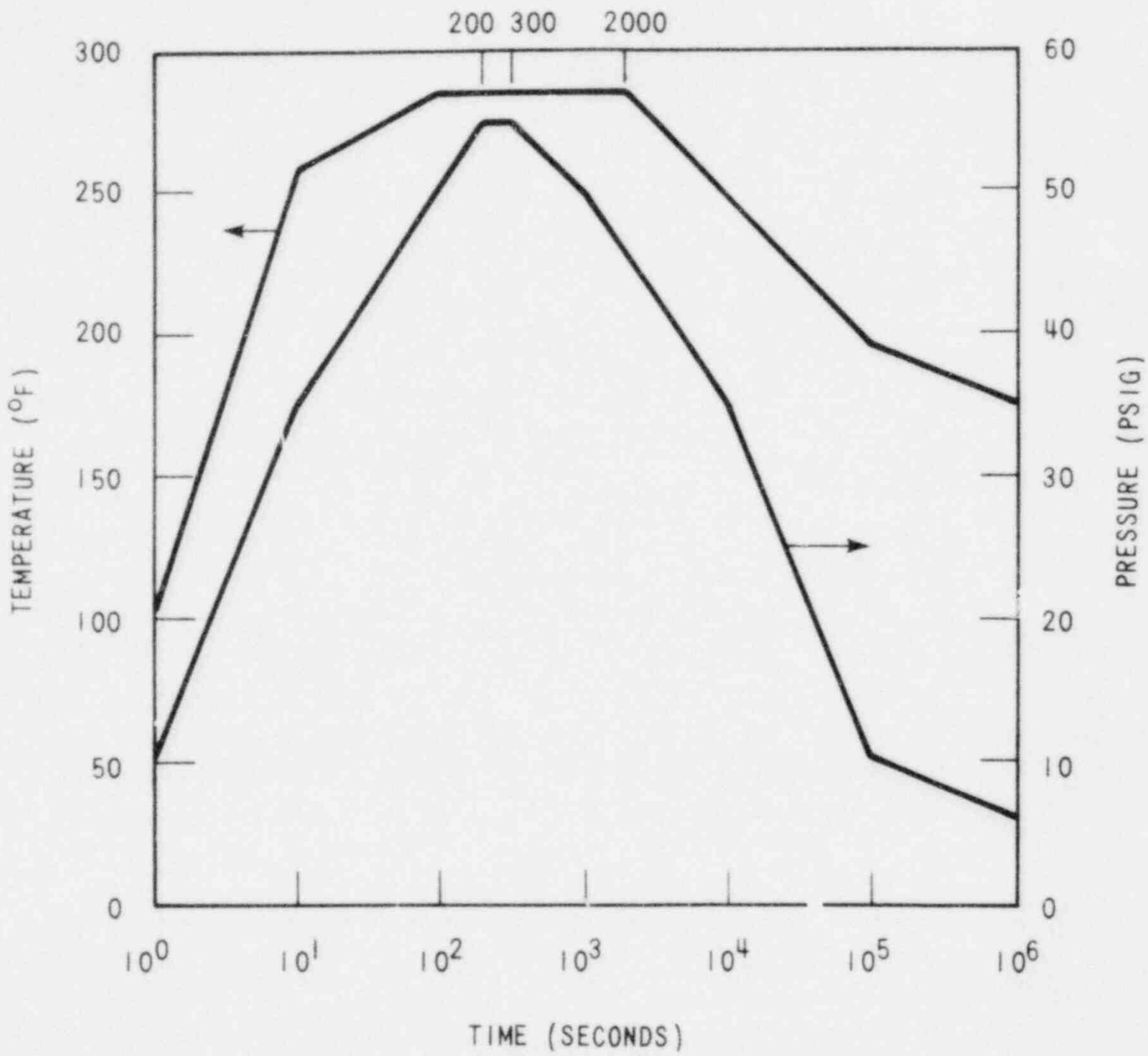

Figure 6-2 Containment Environmental Design Conditions
—LOCA—

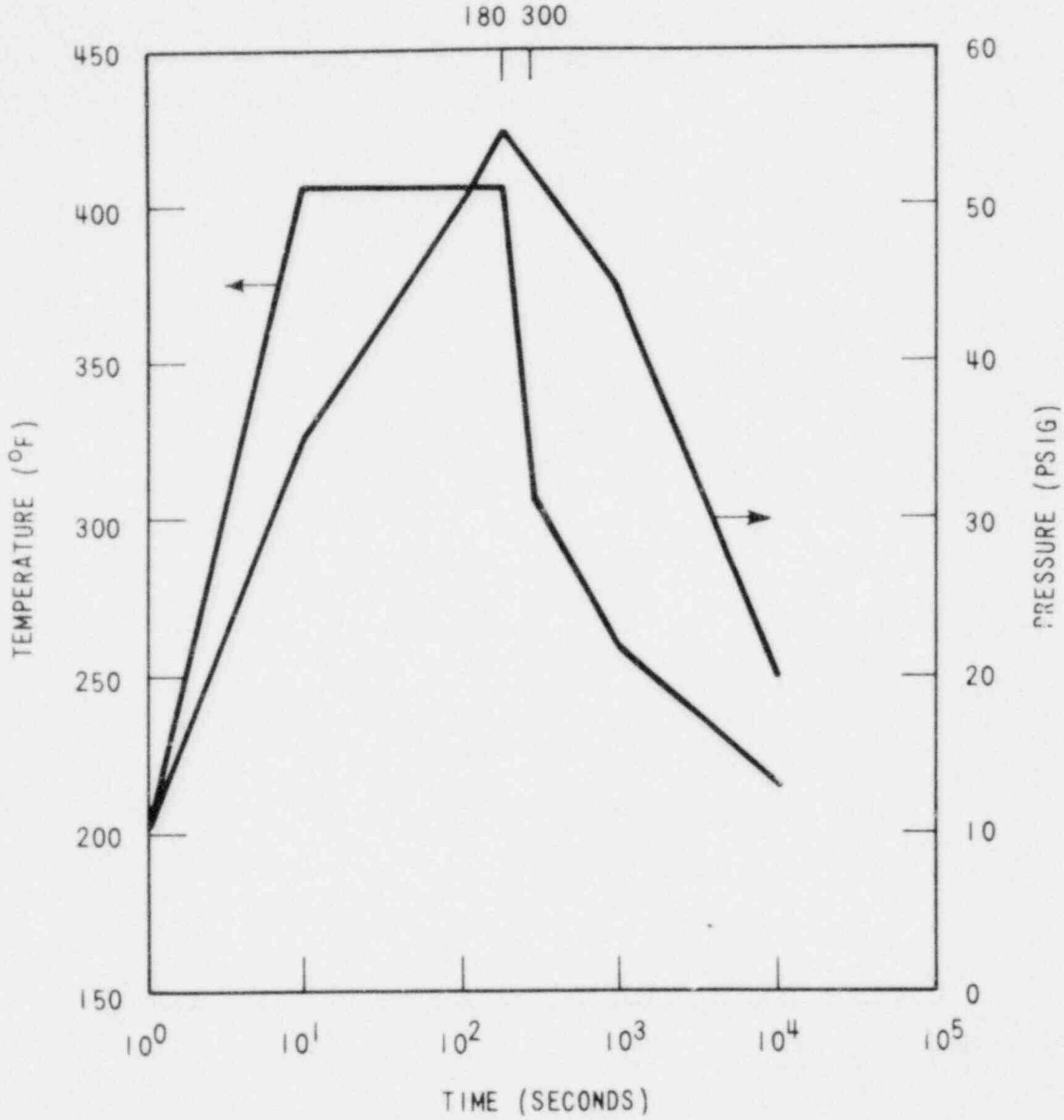

Figure 6-3 Containment Environmental Design Conditions
– Main Steam Line Break and Feedline Break –

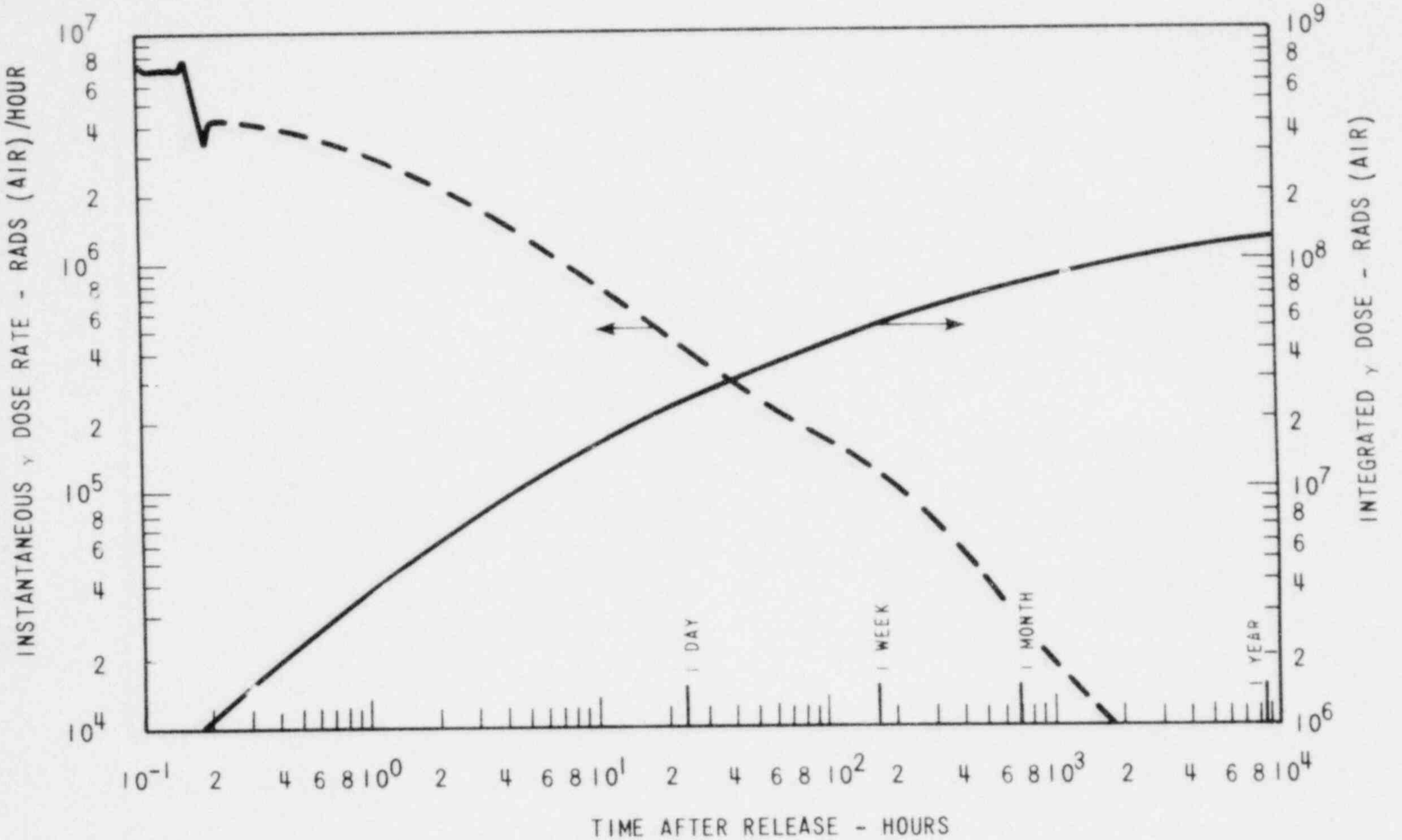

Figure 6-4 Gamma Dose and Dose Rate Inside the Containment as a Function of Time After LOCA

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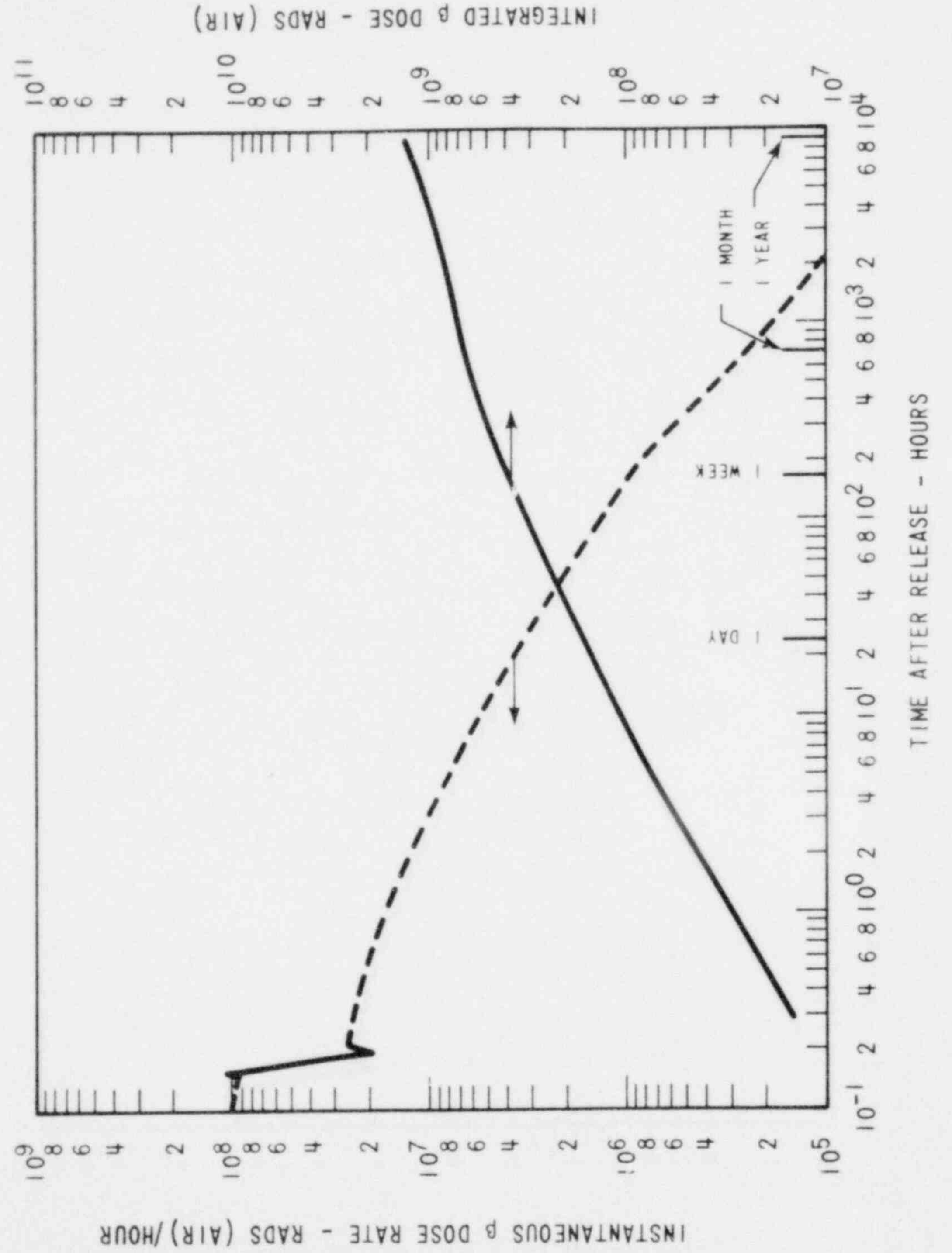


Figure 6.5 Beta Dose and Dose Rate Inside the Containment as a Function of Time After LOCA

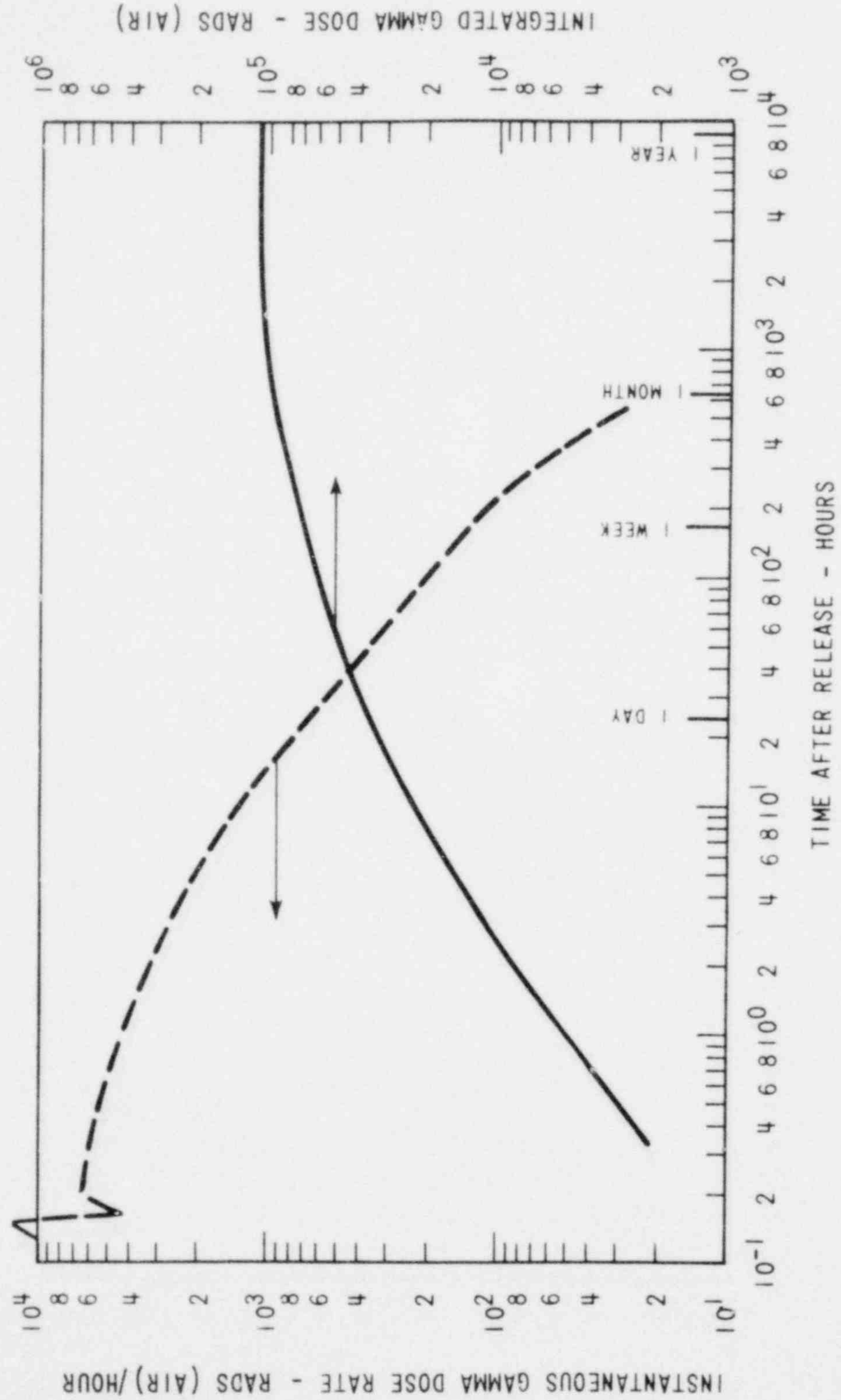


Figure 6-6 Gamma Dose and Dose Rate Inside the Containment as a Function of Time After a Steam Line Break Accident.

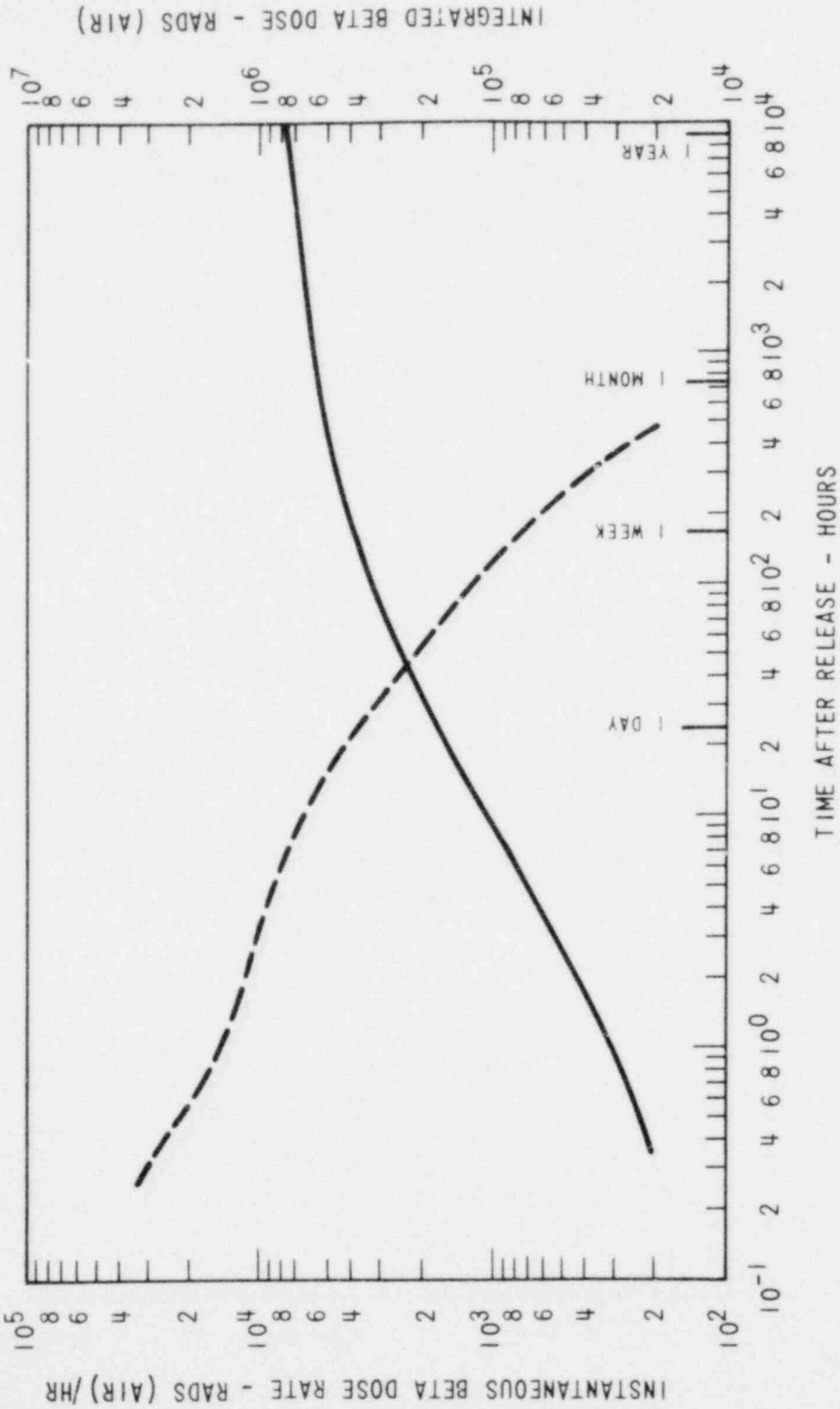


Figure 6-7 Beta Dose and Dose Rate Inside the Containment as a Function of Time After a Steam Line Break Accident

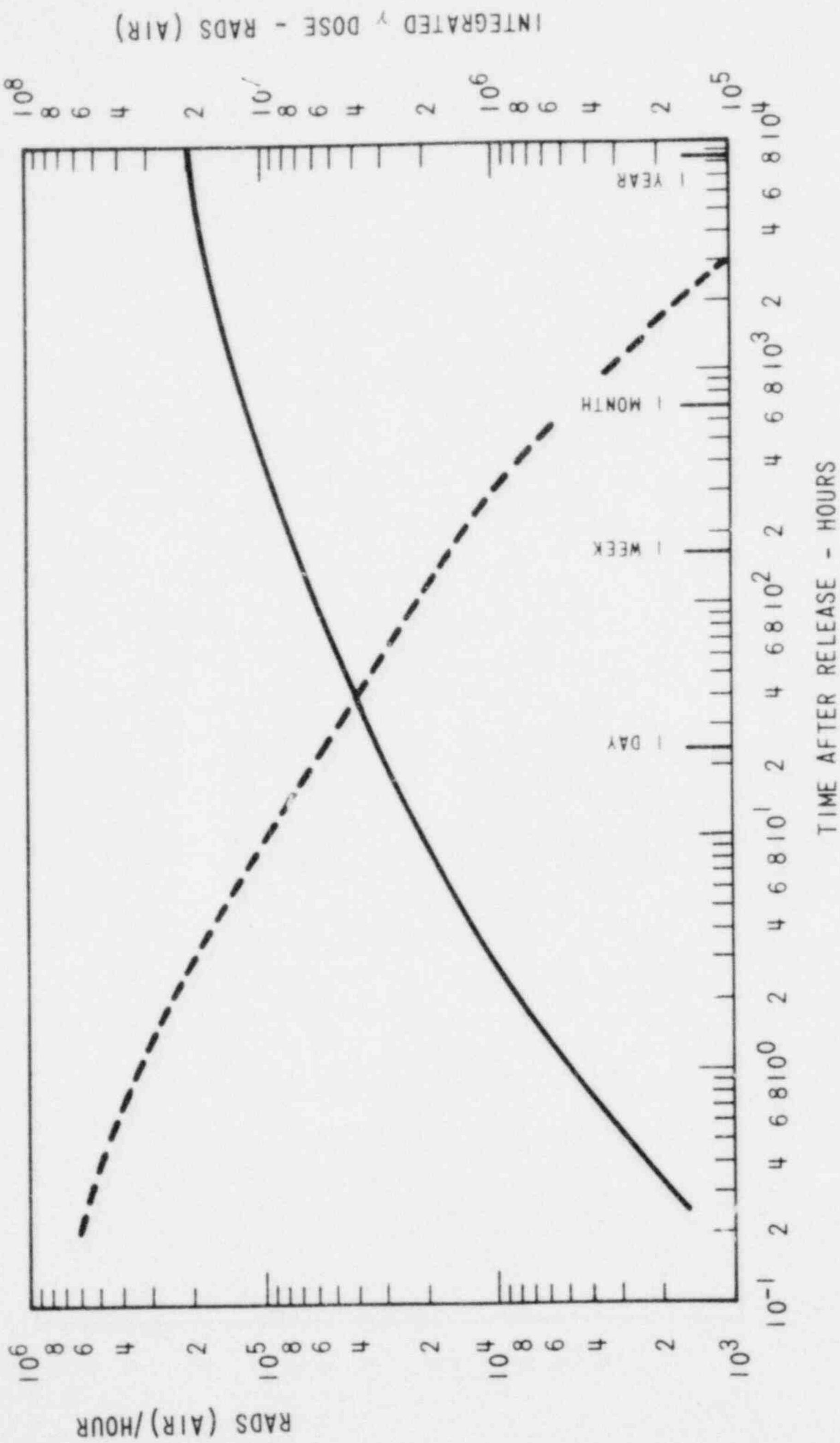


Figure 6-8 Gamma Dose and Dose Rate in Center of Piping Carrying Sump Water as a Function of Time After LOCA

7.0 QUALIFICATION METHODS

The recognized methods available for qualifying safety-related electrical equipment are established in IEEE-323 as being; type testing, operating experience, analysis, on-going or a combination of these methods. The choice of qualification method to be employed by Westinghouse, for a particular item of equipment, is based upon many factors including; practicability, complexity of equipment, economics, availability of previous qualification to earlier standards, etc. The qualification method to be employed for this program is identified in the individual Equipment Qualification Data Packages (EQDP's); whether by test (Section 2), experience (Section 3), analysis (Section 4) or by some combination of these methods. The Westinghouse WRD program does not currently employ on-going qualification and only utilizes experience as supportive to analysis and/or test.

7.1 MARGIN

IEEE 323-1974 (Section 6.3.1.5) recommends that margin be applied to the most severe specified service conditions in order to establish the conditions for qualification. This margin is required to account for normal variations in commercial production of equipment and reasonable errors in defining satisfactory performance. Westinghouse incorporates margin, in defining qualification parameters, as follows:

7.1.1 NORMAL AND ABNORMAL EXTREMES

As indicated in Section 7 of IEEE 323-1974, the application of margin is directed at specifying adequate qualification requirements for the most severe service conditions represented by the design basis event accidents (i.e. HELB accidents and seismic events). As a consequence, Westinghouse does not apply any systematic margin to the normal and abnormal service conditions in defining the qualification conditions. However, for equipment to be qualified to operate in a high energy line break (HELB) environment, qualification to the severe HELB conditions demonstrates ample margin for acceptable performance under any specified normal and abnormal service conditions. For electronic equipment not qualified to operate in a HELB environment, additional margin is included by requiring that the equipment be operated through a double cycle of normal and abnormal service condition extremes, as indicated in Figure 7-1, which at least equals the specified range of service condition parameters. An exception occurs for transmitters where a performance verification is completed at 130°F to encompass the specified maximum abnormal conditions.

7.1.2 AGING

No specific margin is applied to the time component in deriving appropriate aging parameters. Rather, margin is included in deriving the accelerated aging parameters to be employed for simulating each applicable aging mechanism, as described in Appendix B.

7.1.3 SEISMIC CONDITIONS

The seismic parameters specified for this program are designed to encompass all plants referencing this program, including a number of high seismic plants. As a consequence, for most applications, considerable margin exists with respect to the acceleration levels employed and the width of the response spectra. When requested by the applicant, Westinghouse will identify the margin available on a particular plant application with respect to the plant specific response spectra and equipment configuration.

7.1.4 HIGH ENERGY LINE BREAK (HELB) CONDITIONS

The envelopes specified for high energy line breaks, in Figures 6-2 and 6-3, have been selected to encompass the transients resulting from a spectrum of reactor models, break sizes and locations and differing containment designs. As a consequence, these design envelopes already contain significant margin with respect to any transient corresponding to a single break on a specific plant application. Nevertheless, Westinghouse requires that the qualification envelopes be derived with a margin of 15°F on temperature and 10 psi on pressure with respect to the design envelopes in Figures 6-2 and 6-3. No additional margin is specified in defining the radiation doses to be employed for qualification since the assumptions employed in establishing the dose requirements in Sections 6.8.1 and 6.8.4 already contain extreme conservatism. The margin on dose will be identified in the applicants FSAR by comparision of the plant specific dose requirements and the Westinghouse qualification parameters. The alkalinity of the caustic spray is increased by 10% with respect to that identified for any plant referencing this program.

7.2 QUALIFICATION BY TEST (EQDP SECTION 2)

Qualification by test is, in general, selected as the primary method of qualification for complex equipment, not readily ameanable to analysis, and/or for equipment required to perform a safety related function in a high energy line break (HELB) environment. The proposed test plan is identified in EQDP Section 2.0 and, where supportive experience and/or analysis is claimed as an integral part of the qualification program, cross reference is provided to Section 3.0 (Experience) and/or Section 4 (Analysis) for those aspects of the qualification not covered by the test plan. The following sections establish the basis on which the information specified in EQDP Section 2.0 (Test) is selected.

7.2.1 EQUIPMENT DESCRIPTION

The equipment to be qualified is identified including, where applicable, the type and model number, in EQDP Section 2.1.

7.2.2 NUMBER TESTED

The number of identical items of equipment, as described under the equipment description, to be tested is defined in EQDP Section 2.2.

7.2.3 MOUNTING

The method of mounting the equipment for the test is identified in EQDP Section 2.3. Care is taken to ensure that the in-plant installation requirements, as specified by the supplier under EQDP Section 1.2, are fully represented.

7.2.4 CONNECTIONS

The equipment connections necessary to be able to demonstrate safety related functional operability during testing, are identified in EQDP Section 2.4.

7.2.5 AGING SIMULATION PROCEDURE

Potential aging mechanisms resulting from any significant in-service thermal, electrical, mechanical, radiation and vibration sources are identified in EQDP Section 2.5. When aging is addressed as part of the test sequence, the method to be employed for aging the equipment is indicated and is chosen to conservatively simulate the potential aging effects resulting from the operating cycles and environmental conditions specified in EQDP Section 1, Performance Specification. A detailed description of the methods employed by Westinghouse WRD to address potential aging mechanisms is provided in Appendix B to this report.

7.2.6 SIMULATED SERVICE CONDITIONS

The service conditions to be simulated by the test plan are identified in EQDP Section 2.6. In general, the parameters employed are selected to be equal to (normal and abnormal) or have margin (accident and post accident) with respect to the specified service conditions of EQDP Section 1.0 as recommended by IEEE 323-1974.

Pressure, Temperature, Humidity and Chemical Spray

Equipment not subject to high energy line break (HELB) environments is qualified against normal and abnormal (where applicable) conditions employing a cyclic test sequence at environmental and electrical extremes. A typical test profile, including voltage and frequency cycling, is shown in Figure 7-1.

Qualification tests to HELB conditions are designed to address the applicable specified environment(s) (Figure 6-2 and/or Figure 6-3) with a margin of 15^{o} on temperature and 10 psig on pressure. The actual test envelope (i.e., Figure 7-2) may not encompass the short term temperature peak defined in the specification (Figure 6-3), in which case the superheated steam transient will be addressed by analysis as discussed in Section 7.3.

The HELB testing will employ a chemical spray, for the first 24 hours of test, consisting of 2500 ppm boron buffered with 0.9% dissolved sodium hydroxide to maintan a pH of approximately 10.7. This spray concentration results in an increase in alkalinity of at least 10% compared to the concentration defined in the Specification (Section 6.8.4).

Radiation

The total integrated dose (TID) employed for testing is a combination of normal and accident doses (where applicable) and is defined to equal or exceed the maximum radiation dose contained in the Specification (EQDP Section 1.8.4). Margin is implicitly included in defining the integrated doses for testing, since the calculation methods, described in Sections 6.8.1 and 6.8.4, already contain extreme conservatism. Normal operating and accident gamma doses are simulated using a cobalt-60 source. The test dose is applied at a rate approximate to the initial phase of the accident dose rate shown in Figure 6-4 (i.e., typically 2 to 2.5 MR/hr). Where exposed organic material is to be evaluated by test for the effect of (accident) beta radiation, a beta source will be employed or, alternatively, a cobalt-60 source to impart the same dose using gamma radiation.

Vibration and Seismic Acceleration

In service vibration as a potential aging mechanism is discussed in Appendix B. Test requirements to simulate vibration, if significant, will be specified in EQDP Section 2.6.

Seismic qualification will be demonstrated by one of the following:

1. For equipment which has been previously qualified by the single axis sine beat method and included in the NRC seismic audit of Westinghouse safety related electrical equipment and, where required by the NRC audit, the Seismic Demonstration Program (Ref: NS-CE-692), no additional qualification testing will be required to demonstrate acceptability to IEEE 344-1975 provided that:

   a. The Westinghouse aging evaluation program for aging effects on complex electronic equipment located outside containment demonstrates there are no deleterious aging phenomena. In the event the aging evaluation program identifies materials that are marginal, either the materials will be replaced or the projected qualified life will be adjusted.

   b. Any changes made to the equipment due to a. above or due to design modifications does not significantly affect the seismic characteristics of the equipment.

   c. The previously employed test inputs can be shown to be conservative with respect to applicable plant specific response spectra.

2. For new equipment (i.e., new design, equipment not previously qualified or previously qualified equipment that does not meet a, b, and c above) seismic qualification will be performed in accordance with IEEE 344-1975. Where testing is utilized multifrequency multiaxis inputs will be developed by the general procedures outlined in Reference 2. The test results will demonstrate that the measured Test Response Spectrum envelopes the Required Response Spectrum of the Specification (Section 6.8.4). Alternative test methods, such as single frequency, single axis inputs, will be used in selected cases as permitted by IEEE-344-1975 and Regulatory Guide 1.100.

7.2.7 MEASURED VARIABLES

The parameters that must be measured during the specified test sequence, in order to demonstrate qualification against the performance specification (EQDP Section 1), are individually listed in EQDP Section 2.7.

7.2.8 TEST SEQUENCE PREFERRED

The preferred test sequence specified in EQDP Section 2.8 is that recommended by IEEE 323-1974.

7.2.9 TEST SEQUENCE ACTUAL

The test sequence actually employed is specified in EQDP Section 2.9. Where the proposed test sequence deviates from that recommended by IEEE 323-1974, the deviation is indicated. Deviations to the IEEE 323-1974 recommended test sequence, to be employed by Westinghouse, are discussed below.

1. Burn-In Test

   For electronic equipment, a burn in test is completed, prior to operational testing of the equipment, to eliminate infant failures. The test consists of energizing the equipment for a minimum of 50 hours at nominal voltage and frequency under ambient temperature conditions. Any malfunction observed during these tests will be repaired and the 50 hour burn-in repeated for the repaired portion of the equipment.

2. Performance Extremes Test

   For equipment where seismic testing has previously been completed (Table 7.1) employing the recommended methods of IEEE 344-1975, seismic testing will not be repeated. Testing of the equipment to demonstrate qualification at performance extremes will be separately performed as permitted by IEEE 323-1974 Section 6.3.2(3).

3. Aging Simulation and Testing

For equipment not required to perform a safety related function under environmental conditions associated with a High Energy Line Break (Table 7.2) aging will be addressed, as described in Section 7.3 and Appendix B, by separate testing and/or analysis to demonstrate either that aging of components is not significant during the qualified life of the equipment and therefore, testing of unaged equipment is valid or, that aged components/modules are still capable of performing the specified safety related function(s) under applicable service conditions.

7.2.10 TYPE TEST DATA

On completion of the qualification tests, Section 2.10 of the EQDP will be completed to provide a summary of the qualification tests and results. The applicable test reports will be directly referenced in EQDP Section 2.10 and maintained available by WRD for audit.

7.2.11 ACCEPTANCE CRITERIA

The basic acceptance criteria is that the qualification test program shall demonstrate the ability of the equipment to meet with appropriate margin the safety related functional requirements defined in EQDP Section 1.7 while subjected to the environmental conditions specified in EQDP Section 1.8.

7.2.12 TREATMENT OF FAILURES

The primary purpose of equipment qualification is to reduce the potential for common mode failures due to anticipated environmental conditions. The redundancy, diversity and periodic testing of nuclear power plant safetyrelated equipment are designed to accommodate random failures of individual components. Where an adequate test sample is available, the failure of one component/device together with a successful test of two identical components/devices will be taken to indicate a random failure mechanism, subject to an investigation concluding the observed failure is not common mode. Where insufficient test samples prevent such a conclusion being reached, any failures will be investigated to ascertain whether the failure mechanism is of common mode origin. Should a common mode failure mechanism be identified as having caused the failure, a design change will be implemented to eliminate the problem and supplemental or repeat tests completed to demonstrate compliance with the acceptance criteria.

7.3 QUALIFICATION BY EXPERIENCE (EQDP SECTION 3.0)

Qualification by experience is not employed by Westinghouse WRD as a prime method of qualification. Operating experience may be provided as supportive evidence to the prime method of qualification. Where such information is provided, Westinghouse will demonstrate that the experience is applicable to the functional requirements for which the equipment is being qualified. This applicability determination will include an evaluation of operating environments, mountings, performance requirements and performance history. Documentation of supportive information based on operating experience is provided in EQDP Section 3.0.

7.4 QUALIFICATION BY ANALYSIS (EQDP SECTION 4.0)

Qualification by analysis alone is not employed by Westinghouse WRD. Analysis is employed to supplement testing or to provide verification that the test results are applicable. The following sections outline the primary analytical methods to be employed as described in EQDP Section 4.0.

7.4.1 SAFETY RELATED PUMP MOTORS (EQDP-AE-1 THROUGH 4)

The structural integrity of the motor will be established by a static seismic analysis in accordance with IEEE 344-1975, with justification. Should analysis fail to show the resonant frequency to be significantly greater than 33Hz, a test will be performed to establish the motor resonant frequency. Motor operability during a seismic event will be demonstrated by calculating critical deflections, loads, and stresses under various combinations of seismic, gravitational, and operating loads. The worst case (maximum) values calculated are tabulated against the allowable values. In combining these stresses, the most unfavorable possibilities are considered for the following areas: 1) maximum rotor deflection, 2) maximum shaft stresses, 3) maximum bearing load and shaft slope at the bearings, 4) maximum stress in stator core welds, 5) maximum stress in stator core bar to frame welds, 6) maximum stress in motor mounting bolts, and 7) maximum stress in motor feet.

7.4.2 QUALIFICATION BY DEMONSTRATION OF SIMILARITY (EQDP-ESE-23 AND 25)

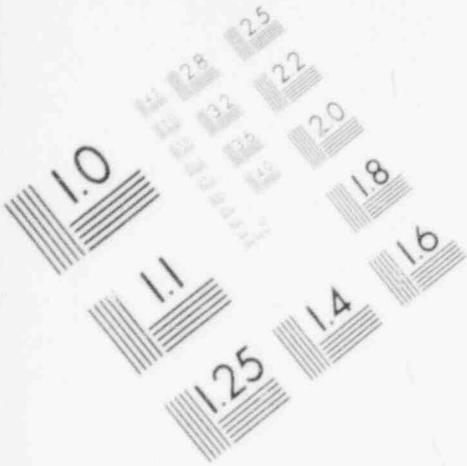
Where minor differences exist between items of equipment, analysis may be employed to demonstrate that the test results obtained for one piece of equipment are equally applicable to a similar piece of equipment.

7.4.3 DIFFERENCES BETWEEN TEST AND QUALIFICATION TEMPERATURE LEVELS

The qualification test envelope for HELB conditions may, in some cases, not encompass the short term temperature peak defined by the specification (Figure 6-3), in which case the superheated steam transient will be addressed by analysis. The analysis will employ a thermal response model of the equipment derived from the physical characteristics of the equipment and measurements taken during the qualification test. This model will then be employed to demonstrate that the equipment is insensitive to the short term superheated temperature peak defined by the specification (Figure 6-3). The analytical procedures and models to be employed are consistent with those discussed in References 3 and 4.

7.4.4 AGING

A detailed description of the Westinghouse Aging Evaluation Program is provided in Appendix B. Analysis will be employed in this program to define, from available test data, accelerated aging parameters, where employed. In addition, analytical methods will be utilized to demonstrate that the results of any separate component/module testing are conservative with respect to anticipated performance at the component/module location within the equipment.



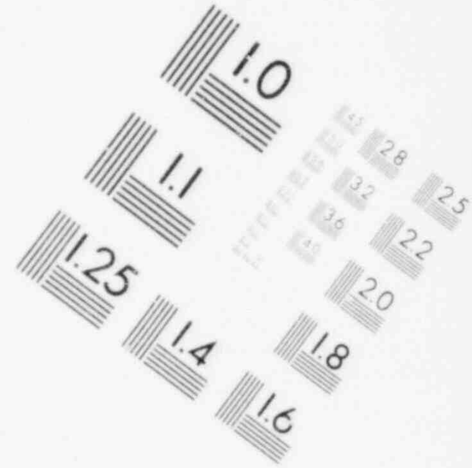
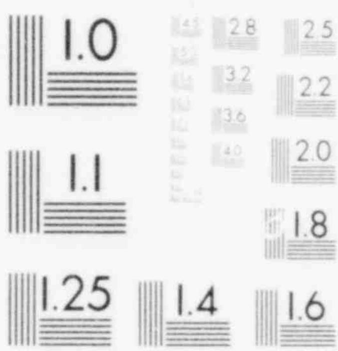
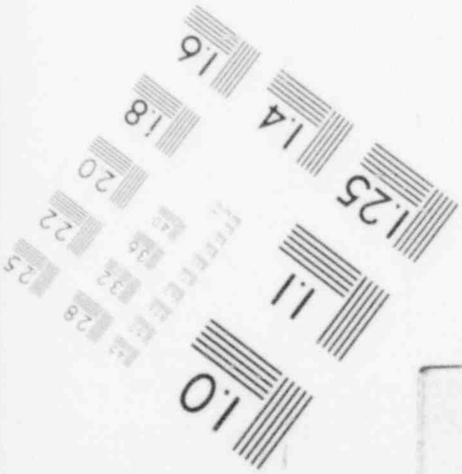


IMAGE EVALUATION
TEST TARGET (MT-3)



6″

MICROCOPY RESOLUTION TEST CHART



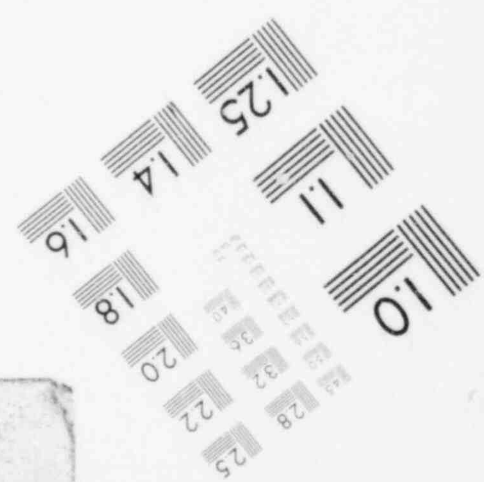


TABLE 7.1

EQUIPMENT FOR WHICH PREVIOUS SEISMIC TESTS DEMONSTRATE CAPABILITY TO IEEE 344-1975

Equipment	EQDP Reference
Nuclear Instrumentation System (NIS)	EQDP-ESE-10
Process Protection Sets	EQDP-ESE-13
Solid State Protection System and Safeguards Test Cabinets (2 Train)	EQDP-ESE-16
Instrument Bus Power Supply (Static Inverter) - 7.5 KVA	EQDP-ESE-18
Instrument Bus Distribution Panel - 7.5 KVA	EQDP-ESE-19

TABLE 7.2

EQUIPMENT NOT REQUIRED TO OPERATE IN A HIGH ENERGY LINE BREAK ENVIRONMENT

Equipment	EQDP Reference
Pressure Transmitters: Qualification Group B	ESE-2
ΔP Transmitters: Qualification Group B	ESE-4
Excore Neutron Detectors	ESE-8 & 9
Nuclear Instrumentation System (NIS)	ESE-10
Source Range Preamplifier	ESE-11 & 36
Main Control Board Switch Modules	ESE-12
Process Protection Sets	ESE-13
Indicators and Recorders	ESE-14 & 15
Solid State Protector System & Safeguards Cabinets	ESE-16 & 17
Instrument Bus Power Supply (Static Inverter)	ESE-18 & 25
Instrument Bus Distribution Panel	ESE-19, 33 & 34
Reactor Trip Switchgear	ESE-20 & 26
4 Section Excore Neutron Detector (Power Range)	ESE-22
Loop Stop Valve Cabinet	ESE-23
RCP Speed Sensor	ESE-24
Main Control Board, Primary Control Console, Secondary Control Console and Safety Center	ESE-25
Nitrogen - 16 Detector	ESE-27
Rod Position Detector	ESE-28
Rod Position Data Cabinet	ESE-29
Integrated Protection Cabinet	ESE-30
Integrated Logic Cabinet	ESE-31
Field Termination Cabinet	ESE-32
PAMS Demultiplexer	ESE-37
Control Board Demultiplexer	ESE-38
Fiber Optic Cable	ESE-39

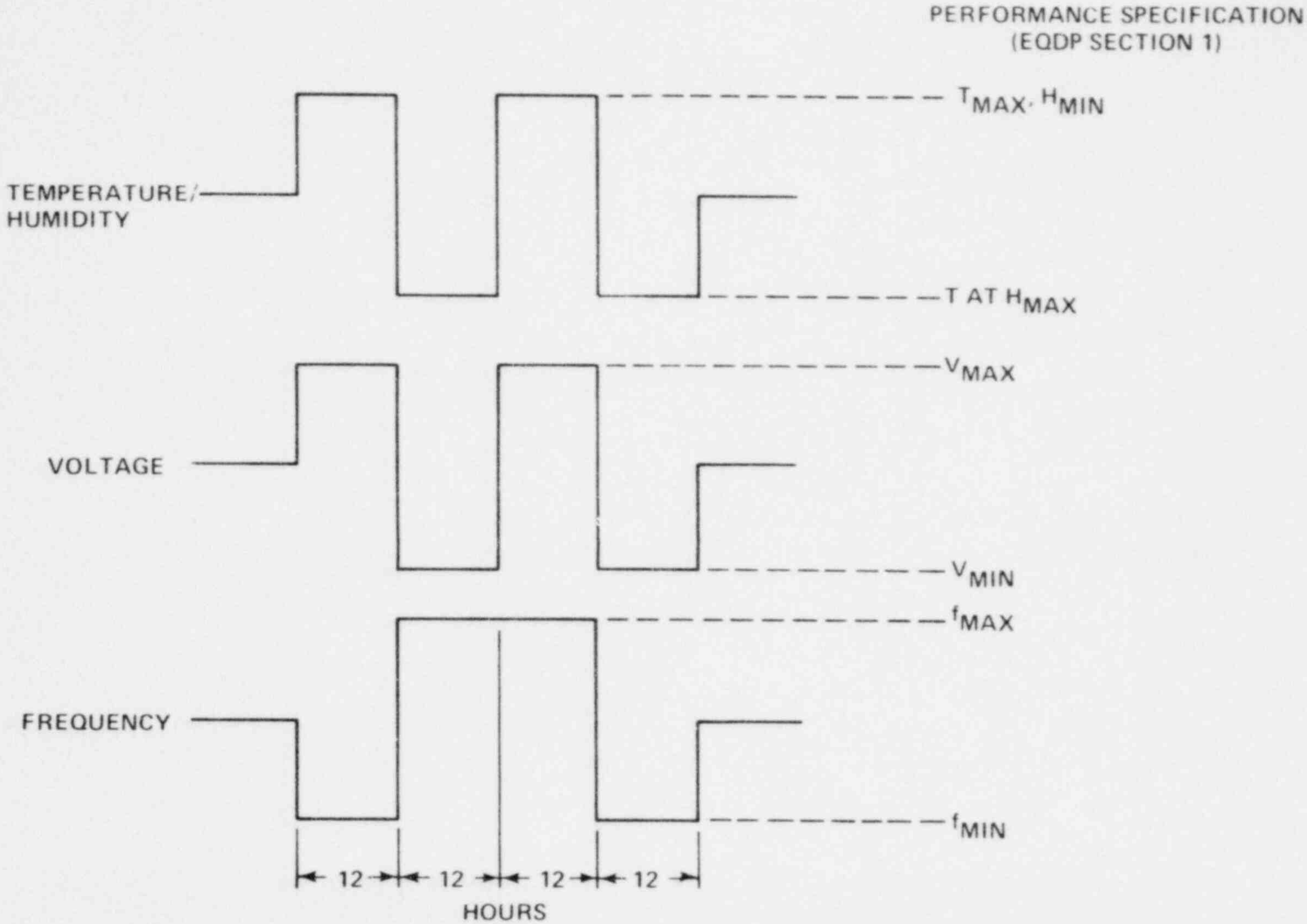


Figure 7-1 Typical Verification Test Profile

14050-15

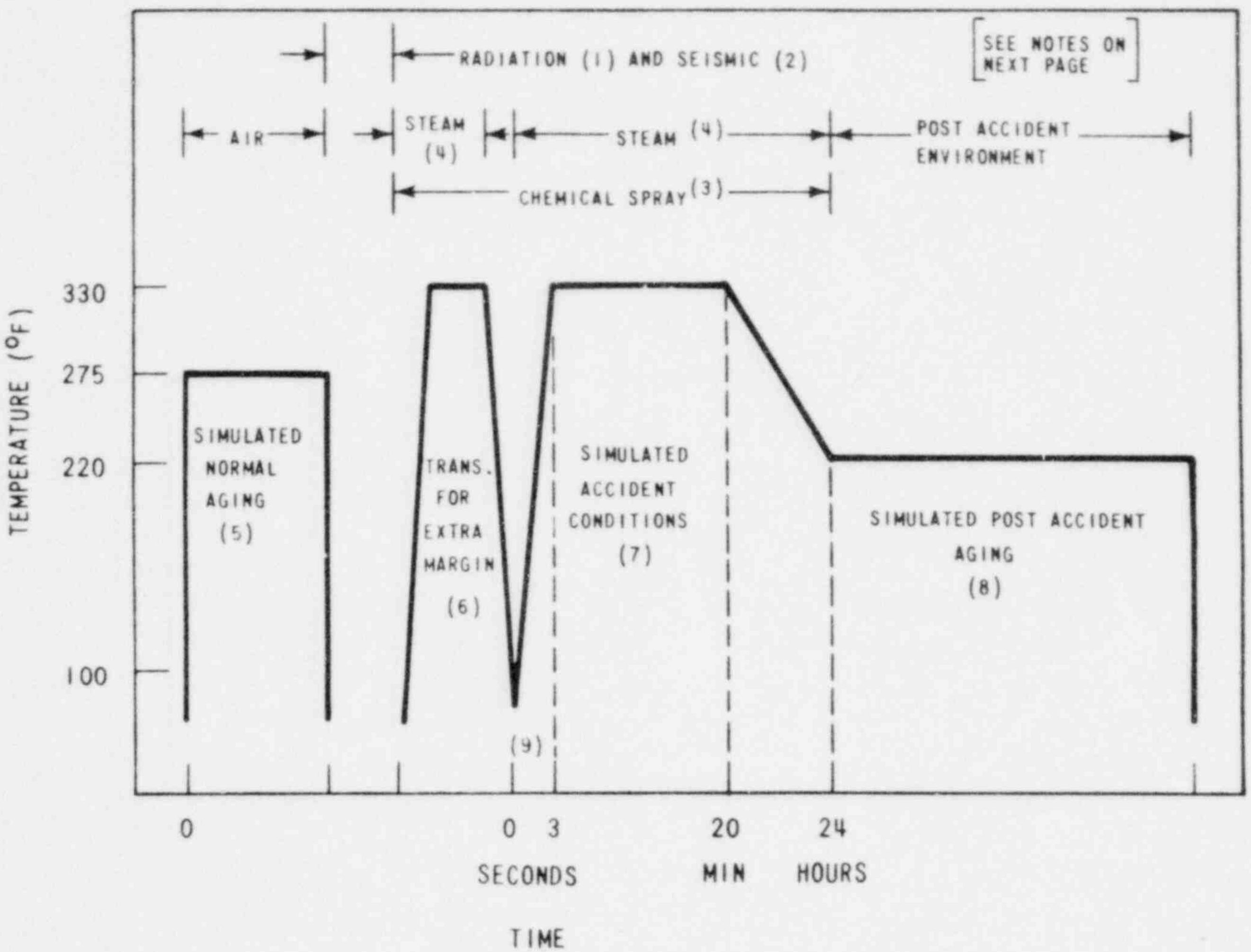


Figure 7-2 Typical Qualification Test Envelope for Equipment Subject to High Energy Line Break Environment

14.050-16

NOTES TO FIGURE 7-2

1. For Radiation Environments, see Sections 6.8.4 and 7.2.6 of this report.

2. For Seismic Methods, see Sections 6.8.4 and 7.2.6 of this report.

3. For the Chemicals applied, see Section 7.2.6 of this report.

4. Simulated Accident conditions normally conducted using saturated steam.

5. Aging is discussed in detail in Section 7.2.5 and Appendix B of this report.

6. Transient for Extra Margin required by IEEE-323-1974. The peak dwell time shall be one minute, minimum.

7. IEEE-323-1974 margins are discussed in Section 7.1.4 and 7.2.6 of this report.

8. Simulated post accident aging time-temperature profile will be defined consistent with the smallest value of activation energy applicable to the thermal aging sensitive components comprising the test equipment or will be a demonstrably conservative activation energy, as described in Appendix B.

9. The rise time achieved in the actual test facility will be the "best effort". Deviations from the specified and/or "best effort" rise time will be justified in the EQDP.

8.0 REFERENCES

Ref. 1. IEEE NPEC SC2 WG 2.6 Environmental Qualification - Draft Environmental Qualification Parameters, 1978.

Ref. 2. Jarecki, S. J., "General Method of Developing Multifrequency Biaxial Test Inputs for Bistables," WCAP-8695 (Non-Proprietary), WCAP-8624 (Proprietary), September 1975.

Ref. 3. Hsieh, T., Barlow, R. T. and Julian, H. V., Environmental Qualification Instrument Transmittor Temperature Transient Analysis WCAP-8936 (Proprietary) WCAP-8937 (Non-Proprietary) February 1977.

Ref. 4. NRC Report - "Short Term Safety Assessment on the Environmental Qualification of Safety Related Electrical Equipment of SEP Operating Reactors," NUREG-0458, May 1978.

Ref. 5. Bordelon, F. M., Murphy, E. T., WCAP-8327, Containment Pressure Analysis Code (COCO) July 1974.

Ref. 6. Letter to Mr. D. B. Vassallo, Chief, Light Water Reactors Project Branch 6, USNRC from Mr. C. Eicheldinger, Manager, Nuclear Safety, Westinghouse Electric Corporation, Dated March 17, 1976 (NS-CE-992).

Ref. 7. Letter to Mr. D. V. Vassallo, Chief, Light Water Reactors Project Branch 6, USNRC from Mr. C. Eicheldinger, Manager, Nuclear Safety, Westinghouse Electric Corporation, Dated July 10, 1975 (NS-CE-692).

Ref. 8. Letter to Mr. D. V. Vassallo, Chief, Light Water Reactors Project Branch 6, USNRC from Mr. C. Eicheldinger, Manager, Nuclear Safety, Westinghouse Electric Corporation, Dated April 7, 1976 (NS-CE-1021).

Ref. 9. Letter to Mr. J. F. Stolz, Chief, Light Water Reactor Project Branch 6, USNRC from Mr. C. Eicheldinger, Manager, Nuclear Safety, Westinghouse Electric Corporation, Dated August 27, 1976 (NS-CE-1183).

Ref. 10. T. Hsieh, et. al., WCAP-8936, "Environmental Qualification Instrument Transmitter Temperature Transient Analysis," February 1977.

Ref. 11. Letter to John F. Stolz, Chief, Light Water Reactors Project, Branch 6, USNRC from C. Eicheldinger, Manager, Nuclear Safety, Westinghouse Electric Corporation, Dated June 14, 1977 (NS-CE-1453).

Appendix B

Westinghouse Aging Evaluation Program

Introduction

1. IEEE-323-1974 requires that aging of Class 1E equipment during normal service be considered as an integral part of the qualification program. The objective is not to address random age induced failures that occur in-service, which are detected by periodic testing and maintenance programs, but to address the concern that some aging mechanisms, when considered in conjunction with the specified Design Basis Events (DBE), may have the potential for common mode failure.

2. Since the endorsement of IEEE-323-1974 by the NRC in November of that year by Reg. Guide 1.89, industry reaction, particularly over the question of aging, has reflected the lack of established methods to comprehensively address this issue with the current state of technology. There has been a reluctance to embark on extensive qualification programs due to the consequent exposure from trying to interpret what is an adequate, state-of-the-art address to aging that would be acceptable to the NRC.

3. A program aimed at establishing the necessary data base to address this issue, in a correct scientific manner in all aspects, would not provide the requisite address to this issue in the short-term and would be outside the financial capabiliti , of any single supplier having a large scope of supply of safety related electrical equipment. Nevertheless, the issue of potential common mode failures, from in-service aging mechanisms, must be addressed.

4. The Westinghouse approach to addressing this issue described below represents a genuine state-of-the-art address to the aging concern and makes maximum use of available data and experience on aging mechanisms. In addition, it takes account of the recommendations, of the various IEEE committees currently involved in developing qualification related standards, as to what constitutes an acceptable, state-of-the-art, address to the aging issue.

Objectives

5. The objectives of the Westinghouse Aging Evaluation Program are:

- To establish, where possible, the effects of the degradation due to aging mechanisms that can occur prior to the occurrence of an accident, when safety related equipment is called upon to function.

- To provide increased assurance that safety related equipment can perform its safety related function under the specified service conditions.

Basic Approach

6. The general approach to addressing aging, as employed by Westinghouse Water Reactor Divisions, allocates equipment to one of three subprograms:

- Subprogram A includes electrical equipment required to perform a safety related function in a high energy line break (HELB) environment. For this equipment an aging simulation will be included as part of the equipment qualification test sequence.

- Subprogram E encompasses structural components and simple equipment for which information is available that demonstrates a lack of pronounced property degradation due to aging mechanisms. The limited effect of aging mechanisms on such materials and equipment permits qualification by evaluation of available test data. (eg., equipment which is primarily of metal construction, etc.)

- Subprogram C includes equipment which is not required to perform a safety related function in a HELB environment. Equipment is included that is required to mitigate HELB's but which, due to its location, is isolated from any adverse external environment resulting from the accident. For equipment in subprogram C the single Design Basis Event (DBE) that is capable of producing an adverse environment at the equipment location is the seismic event. Aging, for subprogram C, will not be included in the equipment qualification test sequence. Aging will be addressed by a separate program that demonstrates that aged components continue to meet manufacturer's performance specifications under applicable seismic DBE conditions and this seismic testing of unaged equipment is not invalidated by any anticipated aging mechanisms. This approach provides several distinct benefits:

- Avoidance of unnecessary retesting of equipment previously seismically tested employing IEEE-344 1975 methodology.

- Seismic and environmental testing of equipment can be completed on schedule for the lead plant without undue delays due to lack of comprehensive knowledge on component aging characteristics.

- Complete seismic retesting of equipment, as a result of future developments in aging technology for individual components or simple design modifications to specific components, is avoided. Component requalification is possible.

- Families of similar components may be qualified by qualification of a representative sample.

- Duplicate aging and testing of identical components, employed in different equipment is avoided.

- Component qualification continues to be applicable for future designed safety related equipment.

- Problems arising due to future unavailability of qualified spare parts can be avoided by qualification of new replacement components. This is especially important since the industry constantly seeks improvements in design and performance of components and avoids the necessity of complete retest and NRC approval.

- Employment of this approach introduces the possibility of optimizing industry wide application of resources, leading to an ever-expanding knowledge of aging effects at the component level (i.e. future data bank of qualified components).

Subprogram C is divided into two phases. The objective of the initial short-term phase of the program is to demonstrate a qualified life of at least 5 years. The second phase of the program will be defined based on the experience acqui . during the initial phase. The objective of the second phase is to extend the demonstrated qualified life to the maximum attainable (not more than 40 years) and to include additional Westinghouse Class 1E equipment to be supplied to later plants. It is the short term program which is specifically addressed in this appendix.

7. Table 1 identifies the Class 1E equipment to be supplied by Westinghouse to the lead plants committed to IEEE 323-1974 and indicates the aging subprogram to which the equipment has been allocated.

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8. Electrical equipment which is required to perform a safety related function in a HELB (i.e., LOCA, feedline break or steamline break) environment is included in subprogram A. This subprogram specifically provides for an aging simulation to be included in the equipment's qualification test sequence.

Scope

9. The equipment scope and aging mechanisms applied under subprogram A are shown in Tables 1 and 2 respectively. The equipment selected is that Class 1E equipment subject to HELB environments either inside or outside containment. The aging mechanisms discussed below are those to which the equipment may be potentially sensitive in its installed location.

Aging Mechanisms

10. The aging mechanisms that could potentially affect electrical equipment in subprogram A are discussed under the following headings:

time in conjunction with:

- operational stresses
  - current, voltage, operating cycles, Joulean heating
- external stresses
  - thermal, vibration, radiation, humidity, seismic

The aging mechanisms considered potentially significant and to be simulated are identified in Table 2 for each item of equipment in subprogram A. Where applied, the aging mechanisms will be simulated as described below.

Time

11. For equipment subject to high energy line break conditions, the most significant in-service aging mechanisms (i.e., radiation and thermal) come into

effect during reactor operation. Consequently,it can be assumed that the "aging clock" starts on plant start-up.

Operational Stresses

Electrical Cycling

12. Electrical supplies to safety related equipment are, in general, highly stable, and aging effects due to supply cycling during running service is not anticipated. Where the equipment is anticipated to experience multiple startup and shutdown cycles, the equipment will be electrically cycled to simulate the number of anticipated startup and shutdown cycles plus 10%.

Mechanical Cycling

13. Aging effects resulting from any anticipated mechanical cycling of the equipment will be simulated by applying, as a minimum, the number of cycles estimated to occur during the target qualified life plus 10%. Mechanical cycling covers such operations as switching, relay actuation, etc.

Joulean Self-heating

14. The aging effects resulting from Joulean self-heating will be recognized by employing the equipment operating temperature as the datum temperature (To) for assessing the accelerated thermal aging parameters to be employed. (Paragraph 15)

External Stresses

Thermal Effects

15. Thermal effects are considered to be one of the most significant aging mechanisms to be addressed. The equipment will be thermally aged to simulate an end-of-qualified-life condition using the Arrhenius Model to establish the appropriate conditioning period at elevated temperature. Where

data is not available to establish the model parameters for the materials employed, a verifiably (Reference 1) conservative value of 0.5 ev will be used for activation energy. For each piece of equipment an appropriate normal and abnormal operating temperature (To) and an associated time history are determined for inclusion in the Arrhenius Model. The equipment temperature is determined by the addition of an appropriate equipment specific ΔT to the external ambient temperature. Reference 1 also provides information concerning the determination of appropriate ambient temperatures and time temperature histories for use in thermal aging evaluation of equipment. Margin is applied to the thermal aging by use of a demonstrably conservative aging model. Post accident thermal aging is included by recognizing the higher post accident ambient temperatures in determining the parameters to be employed for the post-accident accelerated thermal aging simulation.

In-Service Vibration

16. The majority of Westinghouse safety related electrical equipment has a well proven history of in-plant service. Thus, it is unlikely that a significant, undetected, failure mechanism exists due to low level in-plant vibration. In addition, although not strictly equitable, 5 OBE's employed during equipment and component seismic testing gives added assurance that this potential aging mechanism is covered. For pipe-mounted equipment, in-service vibration may be significant and as a consequence an additional vibration aging step will be included in the aging sequence as indicated for certain items of equipment in Table 2.

Radiation

17. Radiation during normal operation will not be considered an aging mechanism for equipment that is subject to in-service integrated doses less than 10^4 rads. Research has established that no aging mechanisms are measurable below 10^4 rads (Reference 2) for materials and components employed in Westinghouse supplied safety related electrical equipment. For radiation doses in excess of 10^4 rads, the equipment will be irradiated using a γ source, to a dose equivalent to the estimated dose to be incurred during normal operation for the

for the target qualified life. The estimated doses to be employed are specified in EQDP Section 1.8.4 and are based on 100% load factor, thus including appropriate margin. It should be additionally noted that in general, for subprogram A equipment, the equivalent accident dose is also applied prior to DBE testing.

Humidity

18. The use of materials significantly affected by humidity will be avoided. For equipment that is subject to High Energy Line Break (HELB) environments, the aging effects due to humidity during normal operation are judged to be insignificant compared to the effects of the high temperature steam accident simulation and therefore no additional humidity aging simulation is required.

Seismic Aging

19. The potential aging effects of low level seismic activity, and some low level in-plant vibration, is addressed by employing 5 OBE's, as recommended by IEEE-344-75, prior to seismic testing of the aged equipment.

Synergism

20. An important consideration in aging is the possible existence of synergistic effects when multiple stress environments are applied simultaneously. Westinghouse will not attempt to simulate synergistic effects. The potential for significant synergistic effects will be addressed by the conservatisms inherent in utilization of the "worst-case" aging sequence (paragraphs 22 and 23), utilization of conservative accelerated aging parameters (paragraphs 11-19), and conservative, design basis event test levels (paragraph 21) all of which provide assurance that any synergistic effects have been enveloped. A continuing review of developments related to synergistic effects will be conducted to determine whether modification of the Westinghouse approach is required.

DBE Testing

21. Design Basis Event testing subsequent to equipment aging is discussed in section 6.8.4 of WCAP-8587 as to guidelines for defining HELB environments and seismic conditions and in EQDP section 2.0 for equipment specific test environments and seismic parameters.

Aging Sequence

22. The aging mechanisms to be applied to equipment subject to HELB environments are determined by definition of the aging environments at the equipment location and a subsequent evaluation of the sensitivity of the equipment to these environments. If the sensitivity of the equipment is not known, aging mechanisms will be simulated by conservative methods as described above. Those aging mechanisms which will be simulated for equipment subject to HELB environments are shown in Table 2.

23. The order in which each of the aging mechanisms is applied is as shown in Table 2. This order is considered to be conservative as no aging mechanism is anticipated to be capable of reducing the impact of the previously applied mechanisms. As an example, thermal aging is applied prior to radiation aging to preclude the annealing out of any radiation induced defects. Similarly, the effects of mechanical aging are considered to be more significant when applied to equipment that has already been preaged to address thermal and radiation phenomena.

Acceptance Criteria

24. The basic acceptance criteria is that the qualification tests shall demonstrate the capability of the aged equipment to perform prespecified safety related functions consistent with meeting the performance specification of Section 1.7 of the applicable EQDP(s) while exposed to the associated environmental conditions defined in EQDP Section 1.8.

Failure Treatment

25. When thermal aging is simulated at an equipment level, a conservative value for the activation energy is assumed for the components comprising the equipment. As a consequence, many components will be grossly over-aged and failure of some of the components can be expected during the aging simulation. Where three test units are being preaged, in the event of such failure(s), one of the following options will be selected.

 - where a particular component fails in one of the three test units, the failure will be considered random and the failed component reolaced by a new component and the test continued.

 - where a particular component fails in more than one of the three test units, either;

   the failed components will be replaced by new identical components and the aging simulation continued. The claimed qualified life of the unit will be consistent with the minimum aging period simulated by at least two of the three units.

 or the failed components will be replaced by identical components specifically aged to the qualified life by assuming for thermal aging a less conservative activation energy specifically determined for the component.

 or the failed components will be replaced by a different type of component which has been aged for a period equal to the test units.

26. Where insufficient test samples prevent such a conclusion being reached, any failures will be investigated to ascertain whether the failure mechanism is of common mode origin. Should a common mode failure mechanism be identified as having caused the failure, a design change will be implemented to eliminate the problem and supplemental or repeat tests completed to demonstrate compliance with the acceptance criteria.

27. Certain types of structural components and simple equipment are known from experience not to be subject to pronounced property degradation due to aging mechanisms. The limited effect of aging mechanisms on such materials and equipment can be justified and supported by an evaluation of available test data.

Scope

28. Equipment in subprogram B for which aging is to be addressed by an evaluation of available test data is listed in Table 1 and the appropriate mechanisms to be considered in Table 2.

Aging Mechanisms

29. The aging mechanisms that have potential impact on the equipment and components in subprogram B are the same categories noted and discussed under subprogram A. Mechanisms which are applicable to items under subprogram B are addressed by consideration of available test data concerning aging mechanisms. This data is compared with the expected operating conditions for the equipment, and a conservative qualified operating life is determined for those aging mechanisms identified as being applicable.

DBE Testing

30. Design Basis Event testing is discussed in section 6.8.4 of WCAP-8587 as to guidelines for DBE test environments and seismic conditions and in EQDP section 2.0 for equipment specific test environments and seismic test parameters. For equipment allocated to subprogram B, DBE testing will be conducted on non-aged equipment since the subprogram will establish the information necessary to demonstrate that there is no in-service aging mechanism capable of degrading the equipment performance under DBE conditions.

Acceptance Criteria

31. For equip... and components for which aging is addressed by evaluation of appropriate mechanisms, the basic acceptance criteria is that the evaluation of test data shall demonstrate the effect of aging is minor and will not affect the capability of the aged equipment to perform prespecified functions consistent with meeting the performance specification of Section 1.7 of the applicable EQDP(s) while exposed to the associated environmental conditions defined in EQDP Section 1.8.

Failure Treatment

32. In the event of failure to demonstrate conformance to acceptance criteria for items applicable under subprogram B, several options are available for resolution of qualification with respect to aging. These options are:

- reduce qualified life,

- replace with components or materials of known acceptable characteristics,

- qualify the item in question by inclusion in subprogram A or subprogram C for testing.

Subprogram C

33. Subprogram C includes Class 1E equipment not required to perform a safety related function in a HELB environment and where insufficient information is available to demonstrate the absence of significant in-service aging mechanisms. For equipment allocated to this subprogram, the single Design Basis Event (DBE) capable of producing an adverse environment at the equipment location is the seismic event. Previously completed seismic testing on unaged equipment will be verified as valid by demonstrating via this subprogram that aged components continue to meet their design specification during a seismic event.

Scope

34. Subprogram C includes equipment which is not required to perform a safety related function in a HELB environment. Equipment is included that is required to mitigate HELB's but which, due to the equipment location, is isolated from any adverse environment resulting from the accident. Equipment allocated to subprogram C is identified in Table 1.

Aging Mechanisms

35. The aging mechanisms considered potentially significant for equipment within the scope of this subprogram are identified in Table 2. The methods of simulating these aging mechanisms are as described in subprogram A.

Synergism

36. For subprogram C, Westinghouse will not attempt to simulate synergistic effects. The conservatisms provided in the short-term program by utilization of the "worst-case" aging sequence (paragraphs 22 and 23), utilization of conservative accelerated aging parameters (paragraphs 11-19), and conservative, design basis event test levels (paragraph 21) provide assurance that any synergistic effects have been enveloped. A continuing review of

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developments related to synergistic effects will be conducted to determine whether any modification of the Westinghouse approach is required for the second phase of subprogram C.

DBE Testing

37. For equipment allocated to subprogram C, the single DBE that is capable of producing an adverse environment at the equipment location is the seismic event. The object of this subprogram is to demonstrate, by seismic testing of aged components, that previously completed seismic testing of unaged equipment is not prejudiced by any in-service aging mechanism. Aged critical components will be seismically tested employing a specially developed required response spectra which envelopes all anticipated locations of the tested components in the equipment. This spectra includes an allowance for potential amplification from the support structure. In general, components will be card mounted with provisions for testing of components live during the seismic event simulation.

Test Samples

38. By employing the decision tree outlined in Figure 1, a complete list of critical components will be established for all equipment allocated to subprogram C (Table 1). For the initial phase of the aging program, the component classification will not be as sophisticated as implied by Figure 1 due to lack of information on the aging characteristics of components. As a result, all non-metallic or non-ceramic components of a piece of Class 1E equipment will be classified as "critical" unless it can be shown that a component's failure will not affect the safety related performance of the equipment. Any such decisions will be justified and documented. Critical components will be sorted into:

Groups - i.e., Resistors

Families - Carbon resistors

Family Members - Different types of carbon resistors

From this total listing of critical components, a sample of components will be defined for subprogram C. The sample will be selected in such a way that it can be shown to be representative of the total list of critical components.

39. Within a particular family of components, the major variable is the vendor. There may be major differences in materials and methods of manufacture for a carbon resistor, for instance, but it is unlikely that a single vendor would manufacture different sizes of carbon resistors with completely different materials and techniques. Consequently, a representative sample of the total list of critical components will be defined to be one that includes no less than 10% of the component members supplied by each vendor to each family of components. An estimate of the size of the representative sample for the equipment allocated to subprogram C is:

$$\text{No. of Groups} \times \frac{\text{No. of Families}}{\text{Group}} \times \frac{\text{No. of Vendors}}{\text{Family}} \times \frac{\text{Members}}{\text{Vendor}} \times \frac{1}{10}$$

$$\simeq 25 \times 4 \times 3 \times (<10) \times \frac{1}{10}$$

$$\simeq 300$$

Assuming an adequate test sample is 9 identical components then $\simeq$2700-components are required for a representative aging test. The minimum acceptable number of samples will be at least 1 per family (i.e., 100 samples). A minimum target of 100 samples (900 components) will therefore be established for the short-term program.

The test sample will be employed as follows:

- 3 component samples at typically 130°C for 2125 hrs. ($\equiv$5 yrs at 60°C for a 0.5 ev activation energy),
- 3 component samples at higher temperature/shorter duration ($\equiv$5 yrs.),
- 3 spares.

The higher temperature will be selected based on limiting material properties. This higher temperature will be used to

- Provide advanced warning of potential problems on the lower temperature samples, thereby giving the option to remove the lower temperature samples early,
- Duplicate qualified life tests by accelerated aging at two temperatures.

Aging Sequence

40. The order in which each of the aging mechanisms is applied is as shown in Table 2. This order has been defined to ensure that no aging mechanism significantly reduces the impact of the previously applied mechanisms. As an example, thermal aging is applied prior to radiation aging to preclude the annealing out of any radiation induced defects. Similarly, the effects of mechanical aging are considered to be more significant when applied to materials that have already been preaged to address thermal and radiation phenomena. Westinghouse will review any information which would suggest that the sequence of applying aging mechanism proposed in Table 2 is non-conservative and will consider whether any modification of the Westinghouse approach is required for the second phase of subprogram C.

Acceptance Criteria

41. Random component failure or unacceptable performance due to aging is detected by routine maintenance and equipment calibration during service. The objective of subprogram C is to demonstrate that a seismic event does not constitute a common mode failure mechanism capable of inducing unacceptable performance characteristics in aged components. Consequently, the single acceptance criteria for the aging portion of the qualification sequence requires that the component not fail to perform its general function, but not that the component meet the original design and procurement specifications. For the seismic event simulation, the component will be considered acceptable if during and after the simulation it does not exhibit any

temporary or permanent step change in performance characteristics. Conversely, any such change will be investigated with respect to tolerable limits of performance characteristics within the equipment. Failure of one of three components being tested will be considered to be a random failure, while failure of more than one component to meet the acceptance criterion will constitute failure to meet qualification requirements.

Failure Treatment

42. In the event of failure to demonstrate conformance to acceptance criteria, several options are available for resolution of qualification with respect to age. The options are:

- reduce qualified life,

- replace the components with those constructed of materials of known acceptable characteristics.

References

1. (Later)

2. (Later)

TABLE 1

INITIAL CLASS 1E EQUIPMENT SCOPE AND SUBPROGRAM ALLOCATION

Aging Method	Equipment	Equipment Qualifiction Data Package
Subprogram A	Valve Motor Operators	EQDP-HE-1 and 4
	Pilot Solenoid Valves	EQDP-HE-2 and 5
	Externally Mounted Limit Switches	EQDP-HE-3 and 6
	Pressure Transmitter (Group A)	EQDP-ESE-1
	Differential Pressure Transmitter (Group B)	EQDP-ESE-2
	Resistance Temperature Detectors	EQDP-ESE-5, 6 and 7
	Neutron Detectors (Power Range)	EQDP-ESE-8 and 22
	Nitrogen-16 Detector	EQDP-ESE-27
Subprogram B	Indicators (Post-Accident Monitoring)	EQDP-ESE-14
	Instrument Bus Distribution Panels	EQDP-ESE-19 and 34
	Pressure Sensor	EQDP-ESE-21
Subprogram C	Pressure Transmitter (Group B)	EQDP-ESE-2
	Differential Pressure Transmitter (Group B)	EQDP-ESE-4
	Nuclear Instrumentation System (NIS)	EQDP-ESE-10
	Main Control Board Switch Modules	EQDP-ESE-12
	Process Protection System	EQDP-ESE-13
	Recorders (Post-Accident Monitoring)	EQDP-ESE-15
	Solid-State Protection System and Safeguards Test Cabinet	EQDP-ESE-16 and 17
	Instrument Bus Power Supply (Static Inverter)	EQDP-ESE-18 and 35
	Reactor Trip Switchgear	EQDP-ESE-20
	Class IE Pump Motors	EQDP-AE-2 and 3

TABLE 2

Equipment	EQDP Ref.	Location	Sub-program	Burn-in	Aging Mechanisms: Thermal	Radiation	Mechanical	Vibration	Electrical	Seismic	DBE: Seismic	HELB
Safety Related Valve, Elec. Motor Operators	EQDP-HE-1	I/C	A		X	X	X	X		X	X	X
	EQDP-HE-4	O/C	A		X	X	X	X		X	X	
Safety Related Pilot Solenoid Valves	EQDP-HE-2	I/C	A		X	X	X	X		X	X	X
	EQDP-HE-5	O/C	A		X	X	X	X		X	X	
Safety Related Externally Mounted Limit Switches	EQDP-HE-3	I/C	A		X	X	X	X		X	X	X
	EQDP-HE-6	O/C	A		X	X	X	X		X	X	
Large Pump Motors (outside containment)	EQDP-AE-2	O/C	C		X	X	X	X	X	X	X	
Canned Pump Motors (outside containment)	EQDP-AE-3	O/C	C		X	X	X	X	X	X	X	
Pressure Transmitters	EQDP-ESE-1	I/C & O/C	A	X	X	X				X	X	X
	EQDP-ESE-2	I/C & O/C	C	X	X					X	X	
Differential Pressure Transmitters	EQDP-ESE-3	I/C & O/C	A	X	X	X				X	X	X
	EQDP-ESE-4	I/C & O/C	C	X	X					X	X	
Resistance Temperature Detectors, Well Mounted	EQDP-ESE-5	I/C	A		X	X		X			X	X
	EQDP-ESE-6	I/C	A		X	X		X			X	X
	EQDP-ESE-7	I/C	A		X	X		X			X	X
Excore Neutron Detectors: Power Range	EQDP-ESE-8	I/C	A		X	X				X	X	X
	EQDP-ESE-22	I/C	A		X	X				X	X	X
Nuclear Instrumentation System (NIS)	EQDP-ESE-10	O/C	C	X	X					X	X	
Main Control Board Switch Modules	EQDP-ESE-12	O/C	C	X	X					X	X	
Process Protection System	EQDP-ESE-13	O/C	C	X	X					X	X	

TABLE 2

Equipment	EQDP Ref.	Location	Sub-program	Aging Mechanisms: Burn-In	Thermal	Radiation	Mechanical	Vibration	Electrical	Seismic	DBE: Seismic	HELB
Indicators, Post-Accident Monitoring	EQDP-ESE-14	O/C	B							X	X	
Recorders, Post-Accident Monitoring	EQDP-ESE-15	O/C	C	X	X					X	X	
Solid-State Protection System and Safeguard Test Cabinet	EQDP-ESE-16	O/C	C	X	X		X			X	X	
	EQDP-ESE-17	O/C	C	X	X		X			X	X	
Instrument Bus Power Supply (Static Inverter)	EQDP-ESE-18	O/C	C	X	X		X			X	X	
	EQDP-ESE-35	O/C	C	X	X		X			X	X	
Instrument Bus Distribution Panel	EQDP-ESE-19	O/C	B							X	X	
	EQDP-ESE-34	O/C	B							X	X	
Reactor Trip Switchgear	EQDP-ESE-20	O/C	C	X	X		X			X	X	
Pressure Sensor	EQDP-ESE-21	I/C	B							X	X	X
Nitrogen-16 Detector	EQDP-ESE-27	I/C	A		X	X		X		X	X	X

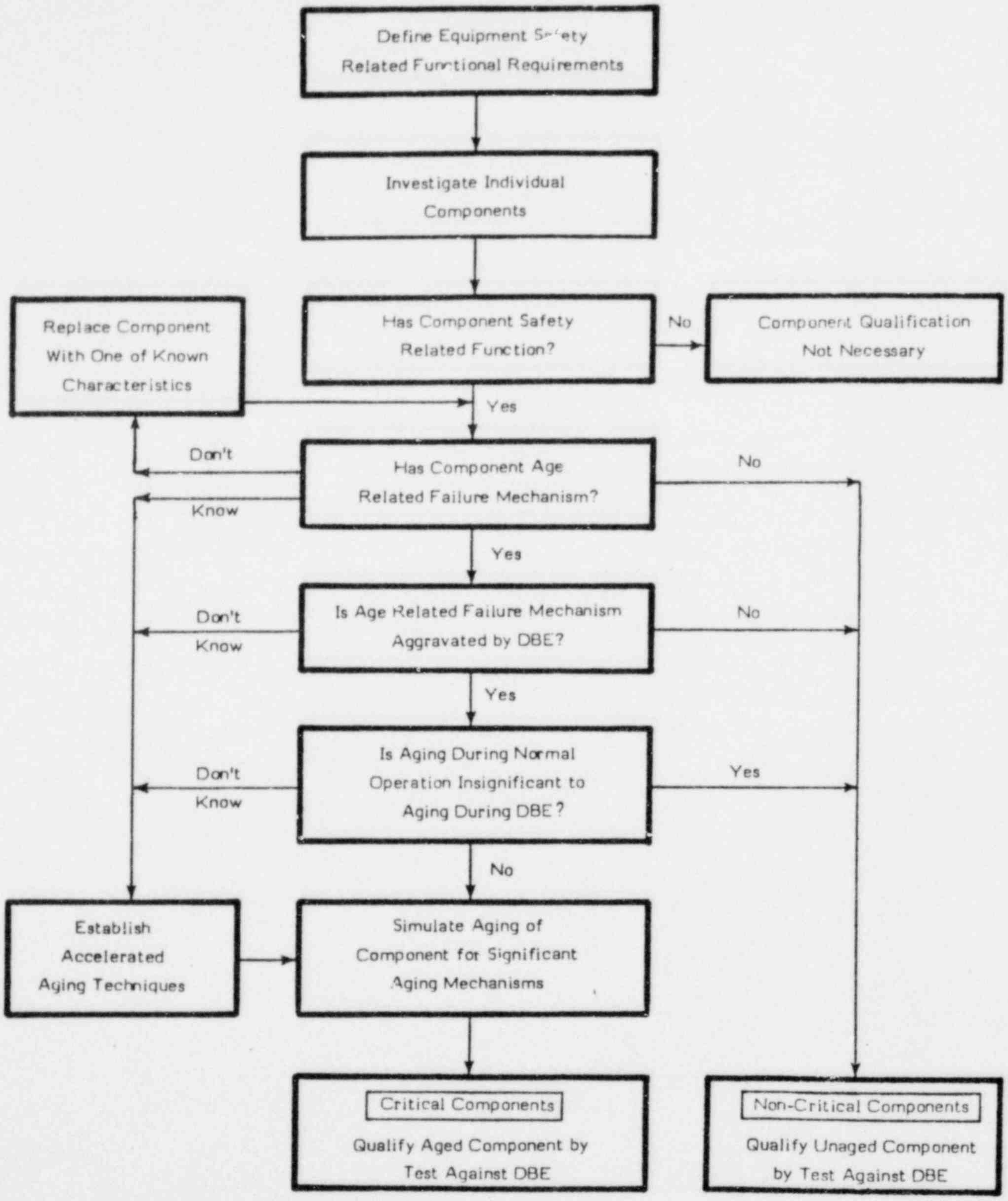

Figure 1. Component Classification