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MIDDLE SOUTH UTILITIES SYSTEM

February 8, 1983

G. D. McLENDON
Senior Vice President

W3P83-0429
3-A20.18
3-A1.01.04
L.09.02

Director of Nuclear Reactor Regulation
Attention: G. Knighton
Licensing Branch No. 3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

SUBJECT: Waterford 3 SES
Docket No. 50-382
Seismic Qualification of Equipment

Reference: NRC Memorandum, T. Y. Chang to Vincent S. Noonan, dated December 13, 1982

Dear Mr. Knighton:

The purpose of this letter is to address generic issues 3 and 4 and specific items 4 and 5 as enumerated in the above referenced memorandum.

Regarding generic issue 3, surveillance and testing programs are being established in lieu of aging the equipment before seismic testing. The inservice testing program was submitted to the Mechanical Engineering Branch in August, 1982, and the PSI/ISI plan is to be submitted to the Materials Engineering Branch in February, 1983.

A review has been conducted of all electrical equipment where operability qualification was performed by analysis alone, and additional justification is hereby provided as response to generic issue 4.

A048

For specific item 4, written confirmation from the valve manufacturer that verification does exist for Engineering Standard ES100 Revision B dated April 8, 1975, has been received and is hereby attached to address 4a. For item 4b the following statement is made.

The deflections calculated in the seismic analysis for order 1-46610, dated April 3, 1976, Tag CH-511 will not interfere with valve closure. All calculated stresses satisfy ASME Code Level B Criteria demonstrating that permanent deformation does not occur. Machining tolerances between the plug and case exceed calculated deflections. The stem is separated from the actuator casing by soft o-rings which will preclude binding.

The design modification of item 5 was reviewed without comment by SQRT. This item has since been identified as SCD #55 and therefore could later be followed up by I&E or the NRC resident inspector.

If you have any questions or comments, please advise.

Yours very truly,

G. D. McLendon

G. D. McLendon

GDMcL:pbc
Attachments

cc: Jim Wilson (NRC), Jerry Jackson (NRC), Jay Singh (EG&G), E. L. Blake
W. M. Stevenson

(w/o attachments)

bcc: L. V. Maurin, R. P. Barkhurst, F. J. Drummond, C. J. Decareaux, R. F. Burski, M. Meyer, K. R. Iyengar, R. W. Prados, S. M. Jones, R. A. Savoie, Central Records, Nuclear Records (4), Licensing Library

Before the

UNITED STATES NUCLEAR REGULATORY COMMISSION

Docket No. 50-382

In the Matter of

LOUISIANA POWER & LIGHT COMPANY

SEISMIC QUALIFICATION

Louisiana Power & Light Company, Applicant in the above captioned proceeding, hereby files additional information on the Seismic Qualification of Equipment.

Respectfully submitted,
LOUISIANA POWER & LIGHT COMPANY

By: G. D. McLendon
for L. V. Maurin
Vice President
Nuclear Operations

DATE: Feb. 8, 1983

Control Associates, Inc.
422-426 Highland Avenue
P.O. Box 908
Cheshire, Connecticut 06410
Phone 203/272-1611

FISHER

Control Associates

January 31, 1983

Combustion Engineering, Inc.
1000 Prospect Hill Road
Windsor, Connecticut 06095

Attention: Mr. Vince Tokarz

Reference: Louisiana Power & Light
CEI P.O. 9102040-9270
Serial No. 5040523
Fisher 1-46610

Gentlemen:

We wish to confirm that the reference to "seismic 3" is referring to the seismic verification No. ES100 Rev. B and ES107. Attached for your information is a confirming telex received from Fisher Controls, Marshalltown, Iowa. If you require further information, please do not hesitate to contact us.

Very truly yours,

E. C. Hart ms

Edward C. Hart
FISHER CONTROLS INTERNATIONAL
CONTROL ASSOCIATES, INC., Rep.

ECH:ms

encl

A Sales Representative of Fisher Controls

CONTROL CHSH

RCA JAN 27 2103
CONTROL CHSH

225306 MNSTO UR
ZCZC MVZ392

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:JF (01-000-109.80-000)
A/JF547/JA27/1146/1957/1/RF816/QZQ(01-000-109.80-000) 7104552654

CONTROL ASSOCIATES
ATTN ED HART
1-27-83
CHESHIRE CONN

REF CE - ARIZONANUCLEAR
L P AND L SN 5040523

SEISMIC 3 IS SYNONYMOUS TO ES 100 REV B AND ES107.

THEREFORE THE SEISMIC VERIFICATION MATERIAL CE HAS

IS APPROPRIATE.

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MTOWN IOWA MSG 92 GEN OFCS
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MVZ392

NOTE- C-E HAS SEISMIC 3 VERIFICATION IN FILE

GENERIC CONCERN NO. 4

Seismic qualification of complex electric equipment by analysis alone to ensure operability is highly questionable, and IEEE 344-1975 cautions against this. The failure mode of such equipment may not be adequately addressed by purely analytical methods. For example, it is common practice to qualify some large electric motors seismically by analytical means; however, the insulation by wiring in the motor may become brittle after a certain duration of service due to the aging of the insulation. Thus in reality, the motor may not be able to perform its designed safety function during and after an earthquake.

The applicant should perform a review of all electrical equipment where operability qualification was performed by analysis and provide additional justification for the validity of the qualification by providing supporting test information on similar items and/or specific reasons why operability can be assured by analyses alone.

RESPONSE:

IE electrical equipment has been purchased for the most part to the requirements of IEEE-323-71 and 344-71. Some equipment has been purchased to later editions of these standards. All harsh environment equipment, as defined by LP&L's "Response to NUREG-0588", Revision 2, dated 11/82 has been reviewed to the requirements of NUREG-0588. Individual central file record packages have been developed for each equipment type. These packages contain all the necessary backup documentation required to assure that the equipment is qualified to operate for its qualified life at its service conditions.

In general, equipment located inside the containment is actually type tested in the LOCA environments. Supplementary Analysis and review is necessary to demonstrate that MSLB conditions are enveloped by LOCA qualification. This use of analysis is concurred within the Staff's position on comment resolution number 49 in NUREG-0588, Rev 1.

The staff's concern as outlined in the above questions seems to focus on aging of materials which could ultimately affect their ability to perform their safety function during a DBE. In order to discuss this subject, we must separate harsh from mild environment.

HARSH ENVIRONMENT AGING

LP&L's program has addressed pre-aging for harsh environment type testing. This approach is in full compliance with NRC positions. Each harsh environment safety-related component is evaluated with full consideration for potential aging induced degradation. The effect of thermal aging may be determined using the Arrhenius radiation methodology, which assumes that the lifetime of the material is related to the temperature dependent reaction rates occuring in the materials. This method has been extended to situations where the temperature may vary with time and where accelerated testing at a higher temperature is used to simulate the effects of aging for a longer period of time at a lower temperature. Metallic materials are generally excluded from aging and are classifed as non-age sensitive.

HARSH ENVIRONMENT AGING (Cont'd)

Age sensitive classified components are aged to the "end-of-life" condition (or plant life condition) prior to further testing. The Arrhenius methodology used by LP&L is detailed in Attachment 1 to this letter. It should also be noted that the use of typical accelerated aging techniques such as the Arrhen method, is extremely conservative.

This method requires the determination of a readily determined "endpoint" prior to DBA stress. For the materials of major concern (i.e., electrical insulators) the endpoint is determined by lab test methods not generally representative of the equipment installation. For example, the typical air-oven testing of electrical cable insulation material in lieu of completed cable assembly (i.e., the insulation typically isolated from air by the inner conductor or outer jacket) is extremely conservative as the change in physical properties (e.g., tensile strenght or elongation) is significantly increased in an oxygen rich environment. Furthermore, the as installed cable (as well as all motors and other electrical coils) operating temperature is due to the self-heating (I^2R) of the current carrying conductor with the inner insulation surface limited to the total allowable temperature of the specific insulation while the outer surface is expected to be 10-15C cooler. In addition, the actual current which the cabling (or motor winding) carries is a function of the electrical load which is seldom at the nameplate rating (e.g., a pump maximum brake horsepower may be 74.8 hbp while the nameplate rating of the motor drive is 125 hp) resulting in a significant reduction in operating temperature as the operating temperature is a function of the square for the operating current.

Based on the type test data plus Arrhenius methodology, we have evaluated the weak-link material for all harsh environment equipment to assure that it will continue to function throughout its qualified life. Pre-aging of materials, as part of the sequential testing required by IEEE-323-74 has been addressed in each central file equipment package. Deviations to the testing sequence have been justified, as required.

CONCLUSION:

Operability justification for all harsh environment equipment was based on type testing plus supplementary analysis. Based on this evaluation, confidence has been established that there will be no material failure/degradation which will affect the safety function of the equipment. It is recognized, and so documented, that certain materials will have to be replaced at regular intervals in accordance with a replacement schedule to maintain the qualified life of the equipment. Appropriate margin has been taken into account in all cases as required by NUREG-0588. Documentation of all Class IE equipment in a harsh environment is located in the EQ central file at the jobsite. It is further noted that these files were recently audited (1/4-6/83) with a successful result and no outstanding comments were identified as regards to the preceding problem.

MILD ENVIRONMENT AGING

Available information and evidence does not justify that there will be any significant enhancement to the safety of nuclear power plants by including pre-aging as part of the testing program for qualification of safety related equipment subject only to mild environments. This industry position has been generated and forwarded to the staff through AIF position papers of July 2, 1981 and January 4, 1982, both of which are attached (Attachments 2 and 3).

In addition to these two position papers, we offer the following to substantiate this position. Experimental studies (refer to IEEE "Study of the Effect of Aging on the Operation of Switching Devices", 1980) were used to determine whether equipment aging affects the vulnerability of electrical switching devices to malfunctions caused by vibrational stresses in the range of seismic frequencies and acceleration amplitudes.

For most devices tested, the fragility levels was approximately the same before and after testing. Overall, the changes were not significantly different from the fragility levels observed for duplicate specimans under identical test conditions. The results of these tests support the industry position. Further backup to support our position is contained in Attachment 4, which is an excerpt from Appendix O of the EQ Guidebook.

Based on the discussions for harsh and mild environment aging we do not feel that there is a problem as regards degradation of material due to aging considerations preventing a component from performing its safety function during and after an earthquake.

Generic Concern Number 4 specifically references qualification of large motors and the possibility of degradation of insulation material as a cause of inoperability of the motor during a seismic event. Attachment 5 to this letter is Appendix M to LP&L's EQ Guidebook which discusses environmental testing of motors, including a detailed disucssion of aging considerations.

CONCLUSIONS

LP&L realizes that qualification of equipment by analysis alone cannot assure operability. As discussed above, for harsh environment equipment, qualification is based on type testing with supplementary analysis as required to document the equipment's qualification to IEEE-344 and IEEE-323. A rigorous evaluation has been conducted to assure that equipment meets the requirements of IEEE-344 and IEEE-323 as modified by NUREG-0588. Special emphasis in these evaluations is placed on operability and aging. The various programs used by LP&L have been attached to this letter and have been reviewed by the Equipment Qualification Branch during the EQ audit of January 4-6, 1983. Analysis combined with type testing confirm that age susceptible materials will not be affected by aging through their plant life or they will be replaced in accordance with a published replacement schedule.

CONCLUSIONS (Cont'd)

For mild environment equipment, we feel that pre-aging prior to seismic qualification is not necessary and this is substantiated by industry positions as documented in this response. The effects of aging on mild environment equipment will not significantly affect the operability.

Attachment 1

APPENDIX H

UTILIZATION OF ARRHENIUS AGING MODEL

APPENDIX H

This is a multipart appendix providing a description of the various uses of the Arrhenius Model.

PART 1 - THEORY

1.1 THEORY OF ARRHENIUS MODEL

The Arrhenius model is presented below:

1) The Arrhenius model is usually applied to thermal aging. The basic equation is as follows:

$$L = Be^{A/KT} \tag{1}$$

where: L = Time to reach a specified end point

B = Constant (usually determined experimentally)

A = Activation energy (eV)

K = Boltzman constant ($.8617 \times 10^{-4}$ eV/°K)

T = Absolute temperature (°K)

2) Activation energies for most organic materials and components range approximately between .5 and 1.5eV. Small values of activation energy are associated with:

a) rapid reaction rate
b) rapid aging
c) long accelerated aging time

In case of uncertainty, the conservative approach is to assume a small value of activation energy (i.e., L is small when A is small).

1.2 ALTERNATE FORM OF BASIC ARRHENIUS EQUATION

An alternate form of equation (1) is

$$\frac{dq}{dt} = B'e^{-A/KT} \tag{2}$$

where $\frac{dq}{dt}$ = reaction rate

B' = constant

By integraton and rearranging, equation (2) can be rewritten as:

$$t_1 = t_2 \exp\left[\frac{A}{K}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)\right]$$

1.3 EXAMPLE

This formula may be utilized for the accelerated aging time determination for cable insulation as shown by the following example:

Material - Tefzel cable

t_1 = Time at aging temperature, hrs

t_2 = Time at service temperature, hrs (40 yrs = 350,400 hrs)

A = Activation energy = .87eV

K = Boltzman's constant (8.617×10^{-5} ev/°K)

T_1 = Aging temperature °K (135°C = 408°K)

T_2 = Service temperature °K (35°C = 308°K)

$$t_1 = 350{,}400 \exp \frac{.87}{.00008617}\left[\left(\frac{1}{408} - \frac{1}{308}\right)\right]$$

$$= 113.6 \text{ hrs}$$

The cable will therefore be thermally aged at 135°C for 113.6 hours to simulate the aging that would occur in the Tefzel insulation material. Such aging would represent a 40 year aging quantity.

PART 2 - COMPUTER PROGRAM

It is obvious from the equation described in Part 1 that the Arrhenius calculations are quite laborious when done by hand.

Consequently, Ebasco has developed a proprietary computer program, Program 2644, which defines and assesses equivalency of thermal aging. This computer program was used during the environmental qualification review of equipment. A program description is a part of the Central File and is available for NRC audit.

PART 3 - DEVELOPMENT OF PARAMETRIC ANALYSIS OF THERMAL AGING EVALUATIONS UTILIZING ARRHENIUS METHODOLOGY

The methodology employed for thermal aging evaluation proceeds from the specified environmental requirements for the component under consideration, as shown on the QDEF's and based on testing data, and/or Arrhenius analysis. Analyses utilize the "weak-link" approach of identifying the most susceptible components of a particular item of equipment, chosen from a component breakdown list, and then determining their behavior under the environmental conditions.

In order to identify which components are most susceptible, we first consult Table C-1 of Appendix C of IEB 79-01B. This is in compliance with NRC directives for operating plants in IEB 79-01B. Then, we refer to other references in the literature on thermal aging, such as the EPRI report on environmental qualification ("A Review of Equipment Aging Theory and Technology", EPRI RP890-1). This procedure is consistent with the statement made in Appendix C to IEB 79-01B that the Table is a <u>partial</u> list of materials, which may be found in a number of power plants.

The basic input for the weak-link analysis is a comprehensive data bank comprising EPRI referenced data, EBASCO referenced data, and Table C-1, Appendix C of the DOR guidelines. Table C-1 was used as a preliminary screening criterion only. Materials/components not considered potentially susceptible to thermal aging, according to Table C-1, for the 40 year service term were excluded from further consideration and deemed acceptable from the thermal aging standpoint subsequent to confirmation from at least one other data source. Material/components considered potentially susceptible to thermal aging were further investigated utilizing EPRI and EBASCO referenced data. The data consisted of the following: Citations delineating the materials/components tested to thermal aging lifetime failure as a function of temperature, derivable activation energy and log normal slope intercept values, and the referenced documents from which the test data issued. The number of material/component items indexed were no fewer than 220.

As additional guidance, and as a checking device to supplement the thermal lag analysis for St Lucie 1, a parametric study was engaged. The parametric study was invested in a computer program which considered 13 different accident environment temperature profiles for DBA LOCA and DBA MSLB pertinent to St Lucie Unit No. 1 as a function of required equipment operability duration. The parametric study encompassed the Arrhenius activation energy range and log normal slope intercept range derivable from the references. Activation energies were varied in intervals of .10 ev from 0.2 to 0.5 and .01 ev from 0.5 to 1.5 ev; log normal slope intercept values were varied in intervals of 0.5 from 0.5 to 25. An actual parametric study for WSES-3 was not performed as there has been no case where thermal lag analysis or use of Program 2644 has not enveloped the qualification needs of the equipment. The rationale for the parametric analysis was presented to NRC in the St. Lucie Unit No. 1 SER Response via FP&L letter L-81-442 dated October 8, 1981. Attachment 1 to this Appendix includes the applicable excerpt from the SER Response.

The parametric analysis provided the insight which led to the derivable conclusion that the fraction of thermal aging lifetime used by the accident temperature profile relative to the combined normal operations and accident temperature profiles ranged from 1% to 10% in the borderline acceptance region of 0.5 to 0.8 ev activation energy for both the long-term as well as short-term postulated accidents both inside as well as outside containment. Thus in effect the severity of the thermal aging environmental stress factor arising out of a postulated accident is subsumed within the severity of 40 year normal operating conditions. A tabulation of sample derivable results is given below:

		Fraction of Thermal Aging Life Used by Accident Modus			
Accident Temp Considered	Schedule	.5ev	.6ev	.7ev	.8ev
Short-term MSLB	0-1 min @ 400F 1 min-75 min @ 240F >75 min @ ambient of 100F	.0004	.001	.003	.011
Long-term MSLB	0-8 hrs @ 340F 8 hrs-24 hrs @ 110F >24 hrs @ ambient of 100F	.049	.057	.066	.080
Long-term LOCA	0-2 hr @ 270F 2 hr-22 hr @ 240F 22 hr-30 day @ 150F 30 day-1 year @ 110F >1 year @ ambient of 100F	.05	.058	.067	.078

Please note that we have indeed had all susceptible electrical safety equipment tested and otherwise demonstrated to be LOCA and MSLB qualified in the containment when such equipment is required to function during and after a DBA.

ATTACHMENT 1

Parametric Analysis Of Thermal Aging

Evaluations Utilizing Arrhenius Methodology

A parametric analysis was developed and utilized to assist in Thermal aging evaluations. The analysis utilized Arrhenius methodology. The scope of the parametric analysis was such that it enveloped the gamut of Arrhenius methodology values derivable from the references to this attachment. The parametric analysis encompassed 13 environmental temperature profiles specified for St Lucie Unit No. 1 as given in Specimen 1 and generated thermal aging lifetime depletion values* for each of the profiles as a function of activation energy and lognormal slope intercept. A computer program was used to generate the output. A sample of the output is given by Specimen 2.

Application of Arrhenius methodology utilizing the references in this Attachment required evaluation of activation energy, and the lognormal slope and intercept values from test data in order to derive thermal aging lifetimes. The latter lifetime evaluations were requisite for deriving the thermal aging lifetime depletion values. A discussion follows.

Given the lognormal distribution

$$\text{Log}_{10} L^* = u(x) = \overset{*}{a} + \overset{*}{B}x$$

where x is the reciprocal of absolute temperature T, u(x) is the logarithmic mean, and L^* is the median lifetime in hours at temperature T.

we have

$$B^* = \frac{T'T}{T'-T} \log (t^*/t^{*\prime})$$

$$T' > T$$

$$a^* = \log (t^{*\prime}) - (B^*/T')$$

$$Ø = kB^*/.4343$$

where T' and T are test data temperatures with corresponding median value testing lifetimes (in hours) of $t^{*\prime}$ and t^*, B^* is the median slope value, a is the median intercept value for the lognormal distribution, and K=Boltzman constant = 8.617E-5 ev/°K. As B^* and a are determinable from test data we are led to solutions in median lifetimes L^*_i as a function of temperature T_i and we have

$$L^*_i \text{ (years)} = \frac{\text{Antilog} \quad \left(- \log \underset{\text{value}}{\text{intercept}}\right) + \left(\frac{\text{Slope Value}}{T_i}\right)}{8760}$$

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* Assume that the thermal aging lifetime is normalized to one, then a thermal aging lifetime depletion value of less than one indicates thermal aging qualification, whereas a depletion factor greater than one indicates thermal aging failure.

where T_i represents interpolative temperatures. T_i was assigned values corresponding to temperatures of importance cited in accident temperatures profiles or normal operating temperature zone maps. Some of these temperatures are given in Specimen 1.

Having established the median lifetimes relative to the temperature values for all the Arrhenius data pertaining to the references in this Attachment, it is possible to establish a simple test to determine analytically whether a material/component which is required to endure an environmental temperature profile combining a specified DBA and a normal operations temperature over 40 years will be qualified for thermal aging. The test is based on the criterion:

$$\sum_i \frac{t_{T_i}}{t^*_i} \leq 1$$

where $t^*_i = t^*_1, t^*_2, t^*_3, \ldots, t^*_n$ corresponds to

Lifetimes $L_1^*, L_2^*, \ldots, L_n^*$

which were evaluated for the referenced $T_1, T_2, T_3, \ldots, T_n$, and

$t_{T_i} = t_{T_1}, t_{T_2}, t_{T_3}, \ldots, t_{T_{13}}$ corresponds to the cumulative postulated durations at temperatures $T_1, T_2, T_3, \ldots, T_n$. The technique can be thought of as matching temperatures and summing corresponding median lifetime ratios.

If the temperatures do not match exactly, conservatism would dictate only that larger reference temperature values be selected to compare with anticipated temperatures and that the use of smaller reference temperatures be disallowed.

For example if the Environmental Temperature profile and the derivative thermal aging lifetimes for a given reference data block (citation) were as depicted below:

	ENVIRONMENTAL TEMPERATURE SCHEDULE	TEMPERATURE	THERMAL AGING LIFETIME
1)	Normal operations	270°F	6536 hrs
	40 years @ 110°F	240°F	1742 hrs
2)	Accident	160°F	4.51 years
	0 - 24 hrs 270°F	130°F	170.16 years
	2 - 24 hrs 240°F	110°F	459.37 years
	1 - 31 days 130°F		

For Activation Energy 0.8 ev Log Normal Slopes Intercept 6.13

The qualification test in essence would be the criterion test:

$$\text{Is } \sum_{i} \frac{t_{T_i}}{t^*_i} \leq 1?$$

Where the test is passed if the value is less than or equal to unity.

$$\text{or Is } \left(\frac{40 \text{ year}}{459.37 \text{ year}} + \frac{2 \text{ hours}}{6536 \text{ hours}} + \frac{20 \text{ hrs}}{1742 \text{ hours}} + \frac{720 \text{ hrs}}{4.51 \times 8760} + \frac{334\ (24) \text{ hrs}}{170.16 \text{ year} \times 8760 \text{ hrs}} \right) \leq 1?$$

If the answer is yes, the test is passed and the material/component associated with the values as given by the citation is qualified. If the answer is no, the test is failed and the material/component does not qualify on this basis. Evaluating, we get 0.13 hence test is passed and material/component qualifies. Of course if the statistical approach were used the response would not be simply yes or no but rather a probability table for different confidence intervals relative to passing or failing the test. Specimen 2 computer output exemplifies a sample of the thermal aging lifetime depletion value output.

SPECIMEN 1

ENVIRONMENTAL TEMPERATURE PROFILES AS A FUNCTION OF POSTULATED LOCA AND MSLB AND REQUIRED EQUIPMENT OPERABILITY TIME FOR ACCIDENT MITIGATED OR POST ACCIDENT MONITORS

CASE	TYPE OF ACCIDENT	REQUIRED E/OPERABILITY TIME	TEMPERATURE (^{o}F)								
			370	340	270	240	150	130	120	110	94
1	LOCA	1 year	-	-	2 h.	22 h.	30 d.	334 d.	-	40 y.	-
2	LOCA	1 year	-	-	2 h.	22 h.	30 d.	334 d.	40 y.	-	-
3	LOCA	38 day	-	-	2 h.	22 h.	30 d.	-	-	40 y.	-
4	LOCA	30 day	-	-	2 h.	22 h.	30 d.	-	40 y.	-	-
5	LOCA	1 day	-	-	2 h.	22 h.	-	-	-	40 y.	-
6	LOCA	1 day	-	-	2 h.	22 h.	-	-	40 y.	-	-
7	MSLB	15 mins.	15 m.	-	-	-	-	-	-	40 y.	-
8	MSLB	15 mins.	15 m.	-	-	-	-	-	40 y.	-	-
9	MSLB	15 mins.	15 m.	-	-	-	-	40 y.	-	-	-
10	MSLB	15 mins.	15 m.	-	-	-	-	-	-	-	40 y
11	MSLB	1 y or 30 d.	-	8 h.	-	4 d.	-	-	-	-	40 y
12	MSLB	1 y or 30 d.	-	8 h.	-	4 d.	-	-	-	40 y.	-
13	MSLB	1 day	-	8 h.	-	-	-	-	-	40 y.	-

SPECIMEN 2

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MEAN VALUES OF RATIO TEST FOR THERMAL AGING; ACTIVATION ENERGY= 0.80 ELECTRON VOLTS

SLOPE INTRCPT  CASE  1 CASE  2 CASE  3 CASE  4 CASE  5 CASE  6 CASE  7 CASE  8 CASE  9 CASE 10 CASE 11 CASE 12 CASE 13

   0.50        2.30E-07 3.68E-07 2.17E-07 3.55E-07 2.14E-07 3.52E-07 2.12E-07 3.50E-07 5.69E-07 9.18E-08 1.25E-07 2.45E-07 2.32E-07
   1.00        7.28E-07 1.16E-06 6.87E-07 1.12E-06 6.78E-07 1.11E-06 6.70E-07 1.11E-06 1.80E-06 2.90E-07 3.90E-07 7.76E-07 7.34E-07
   1.50        2.30E-06 3.68E-06 2.17E-06 3.55E-06 2.14E-06 3.52E-06 2.12E-06 3.50E-06 5.69E-06 9.18E-07 1.25E-06 2.45E-06 2.32E-06
   2.00        7.28E-06 1.16E-05 6.87E-06 1.12E-05 6.78E-06 1.11E-05 6.70E-06 1.11E-05 1.80E-05 2.90E-06 3.90E-06 7.76E-06 7.34E-06
   2.50        2.30E-05 3.68E-05 2.17E-05 3.55E-05 2.14E-05 3.52E-05 2.12E-05 3.50E-05 5.69E-05 9.18E-06 1.25E-05 2.45E-05 2.32E-05
   3.00        7.28E-05 1.16E-04 6.87E-05 1.12E-04 6.78E-05 1.11E-04 6.70E-05 1.11E-04 1.80E-04 2.90E-05 3.90E-05 7.76E-05 7.34E-05
   3.50        2.30E-04 3.68E-04 2.17E-04 3.55E-04 2.14E-04 3.52E-04 2.12E-04 3.50E-04 5.69E-04 9.18E-05 1.25E-04 2.45E-04 2.32E-04
   4.00        7.28E-04 1.16E-03 6.87E-04 1.12E-03 6.78E-04 1.11E-03 6.70E-04 1.11E-03 1.80E-03 2.90E-04 3.90E-04 7.76E-04 7.34E-04
   4.50        2.30E-03 3.68E-03 2.17E-03 3.55E-03 2.14E-03 3.52E-03 2.12E-03 3.50E-03 5.69E-03 9.18E-04 1.25E-03 2.45E-03 2.32E-03
   5.00        7.28E-03 1.16E-02 6.87E-03 1.12E-02 6.78E-03 1.11E-02 6.70E-03 1.11E-02 1.80E-02 2.90E-03 3.90E-03 7.76E-03 7.34E-03

   5.50        2.30E-02 3.68E-02 2.17E-02 3.55E-02 2.14E-02 3.52E-02 2.12E-02 3.50E-02 5.69E-02 9.18E-03 1.25E-02 2.45E-02 2.32E-02
   6.00        7.28E-02 1.16E-01 6.87E-02 1.12E-01 6.78E-02 1.11E-01 6.70E-02 1.11E-01 1.80E-01 2.90E-02 3.90E-02 7.76E-02 7.34E-02
   6.50        2.30E-01 3.68E-01 2.17E-01 3.55E-01 2.14E-01 3.52E-01 2.12E-01 3.50E-01 5.69E-01 9.18E-02 1.25E-01 2.45E-01 2.32E-01
   7.00        7.28E-01 1.16E+00 6.87E-01 1.12E+00 6.78E-01 1.11E+00 6.70E-01 1.11E+00 1.80E+00 2.90E-01 3.90E-01 7.76E-01 7.34E-01
   7.50        2.30E+00 3.68E+00 2.17E+00 3.55E+00 2.14E+00 3.52E+00 2.12E+00 3.50E+00 5.69E+00 9.18E-01 1.25E+00 2.45E+00 2.32E+00
   8.00        7.28E+00 1.16E+01 6.87E+00 1.12E+01 6.78E+00 1.11E+01 6.70E+00 1.11E+01 1.80E+01 2.90E+00 3.90E+00 7.76E+00 7.34E+00
   8.50        2.30E+01 3.68E+01 2.17E+01 3.55E+01 2.14E+01 3.52E+01 2.12E+01 3.50E+01 5.69E+01 9.18E+00 1.25E+01 2.45E+01 2.32E+01
   9.00        7.28E+01 1.16E+02 6.87E+01 1.12E+02 6.78E+01 1.11E+02 6.70E+01 1.11E+02 1.80E+02 2.90E+01 3.90E+01 7.76E+01 7.34E+01
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  21.50        2.30E+14 3.68E+14 2.17E+14 3.55E+14 2.14E+14 3.52E+14 2.12E+14 3.50E+14 5.69E+14 9.18E+13 1.25E+14 2.45E+14 2.32E+14
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Attachment to
LW3-167-83

Attachment 2

Atomic Industrial Forum, Inc.
7101 Wisconsin Avenue
Washington, D C 20014
Telephone (301) 654-9260
TWX 7108249602 ATOMIC FOR DC

January 4, 1981

Mr. Harold Denton
Director, Office of Nuclear
Reactor Regulation
U.S. Nulcear Regulatory
Commission
Washington, D.C. 20555

Dear Mr. Denton:

Enclosed for your attention and consideration are the following industry position papers regarding environmental qualification of safety-related electrical equipment:

(1) One-hour minimum operating time margin requirement

(2) Pre-aging concerns for seismic qualification

These papers were developed with input from a broad spectrum of the industry including the EPRI/Utility Advisory Group on Equipment Qualification. Also, the Nuclear Safety Analysis Center provided support for the workshops at which the initial draft of the papers were developed.

The enclosed papers are among a series of position papers we are developing on some twelve technical issues regarding environmental qualification of equipment. The first two were forwarded to your office on July 2, 1981.

Sincerely,

Richard M. Eckert

Richard M. Eckert
Chairman, Committee on
Power Plant Design
Construction & Operation

RE:kr
Enclosure

A NUCLEAR INDUSTRY POSITION
REGARDING THE ONE-HOUR MINIMUM
OPERATING TIME MARGIN REQUIREMENT

Introduction

The NRC has issued a proposed revision to Regulatory Guide 1.89 titled, "Environmental Qualification of Electric Equipment Important to Safety for Light-Water-Cooled Nuclear Power Plants". This is companion to the proposed rule to change 10 CFR Part 50. The proposed revision incorporates a one-hour minimum time margin requirement in addition to the existing time period for required operability of equipment exposed to harsh environmental conditions. Section 5B of the proposed revision is as follows:

> "Some equipment may be required by the design to only perform its safety function within a short time period into the event (i.e., less than 10 hours) and once its function is complete, subsequent failures are shown not to be detrimental to plant safety. Other equipment may not be required to perform a safety function but must not fail within a short time period into the event, and subsequent failures are also shown not to be detrimental to plant safety.
>
> Equipment in these categories should remain functional in the accident environment for a period of at least 1 hour in excess of the time assumed in the accident analysis. For all other equipment (e.g., post-accident monitoring, recombiners, etc.), the 10 percent time margin identified in Section 6.3.1.5 of IEEE Std., 323-1974 should be used."

The NRC also addressed this area in Supplement 2 to I & E Bulletin 79-01B "Environmental Qualification of Class 1E Equipment", Answer 12 and in NUREG-0588 "Interim Staff Position on Environmental Qualification of Safety Related Electrical Equipment", Section 3(4). These interim positions stated the one-hour margin as a requirement.

Evidently, the NRC is concerned that a conservative margin be provided to account for unanalyzed events possibly not addressed in the qualification program. For example, peak environmental conditions during a small-line-break accident would occur at a later time than during a large-line-break accident. NRC emphasized this at the July 7-10, 1981 Bethesda meeting, and subsequently solidified the position in the Resolution of Comment No. 76 of NUREG-0588 Rev. 1.

Another apparent basis for the NRC requirement is to eliminate the possibility that failure, after the equipment performs safety functions, would lead to erroneous indications of plant status to the operator.

We agree with the intent of these concerns. However, we believe that these concerns are best resolved as stated in the following nuclear industry position.

Position

An adequately conservative and technically justifiable approach to establishing maximum operating time for electrical equipment required to perform its safety function consists of:

(1) Determination of appropriate design basis accident scenarios and corresponding environment histories.

(2) Safety System analysis to determine the maximum time required for operation and to assure that subsequent failure of the equipment is not detrimental to plant safety. (e.g., the failure does not mislead the operator).

The conservatism (margin) built in to existing qualification practice and standards is adequate. Imposition of an additional, arbitrary time margin is unwarranted and would lead to significant cost impact with insignificant improvement of plant safety.

The following discussion amplifies this position.

DISCUSSION

Establishment of Operating Time Requirements

The operating time for each component of a safety system is based on the safety system operational requirements developed during the specific accident analysis required in the safety evaluation. This establishes the design basis from which component performance and qualification requirements are generated. Appropriate margins are factored into the design to ensure the safety system will functionally perform in the required time interval. The industry's analysis and the NRC's review insure that system design features, including component response time, set point, and accuracy, are established properly. They also verify that the system will perform safety function(s) when required.

System design requirements and reviews verify component failure as non-detrimental to safety system performance. Special designs are implemented (i.e., trip and lock in) to assure safety function actuation reset will not occur due to sensor failure. Reviews are also performed to determine the effect of equipment failure subsequent to role performance in the safety system. Equipment required to maintain operational capability is qualified for the time period and the environmental conditions imposed by the system design.

The NRC reviews system design features, including component response time, set point, and accuracy, and issues a statement of adequacy in the form of a Safety Evaluation Report (SER). The SER addresses performance safety function(s) when required.

Role of Qualification in Assuring Safety Function Actuation

The NRC requires action on the part of utilities to demonstrate and document that all safety-related electrical equipment, whether inside or outside containment, is capable of functioning as required during accident conditions. Functioning capacity must take place following previous exposure to normal operating conditions for the design lifetime of the plant. This is accomplished through a program that includes, but is not limited to, design, qualification, production quality control, installation, maintenance, and periodic testing. Environmental parameter margins are specified in qualification programs to account for reasonable uncertainties in demonstrating satisfactory performance and for normal variations in commercial production. The margin in time suggested in IEEE Standard 323-74 (which applies to plants in NUREG 0588 Catagory I) is "10 percent of the period of time the equipment is required to be operational following the design basis event". The committee preparing a revision of this standard expressed its disagreement with the one-hour minimum requirement (item 76A of the NUREG 0588 comments).

Conservatism in Environmental Parameter Criteria

Inherent conservatism is factored into development of the accident environmental parameters as a result of assumptions used in calculating accident environments. For example, derivation of the radiation levels inside containment assumes instantaneous release of radionuclides from the core. It can be shown that instantaneous release is physically impossible and that gross release occurs several minutes subsequent to LOCA. Also source terms are calculated for worst case DBA, and therefore, exceed releases for the more probable lesser accident.

The equivalent time margin inherent in assuming an instantaneous release of radiation is overly conservative. This is especially true for equipment having short term operation requirements and located in upper levels of containment. These radiation levels do not exist within the short time required for performance of the safety function.

In addition, due to assumptions made in the accident environment analyses, pressure and temperature profiles are conservative. Analyses performed in accordance with the models and correlations specified in 10 CFR 50 Appendix K are inherently conservative and result in conditions which are substantially more severe than have been observed in LOFT experiments. Also, 100% mixing is assumed for PWR's whereas the degree of mixing is known to be a time dependent phemonenon.

Much Class 1E equipment consists of instrumentation that is designed to sense increases in environmental parameters and trip actuation of safety systems. In general, such instrumentation is set to low increments above the normal operating condition. When subjected to severe environments as in a large-break LOCA, these sensors trigger very quickly after event initiation. Qualification to the subsequent harsh environment for an extended period, such as one hour, is technically not justified.

Under small-break conditions it is conceivable, but unlikely, that these instruments would not be triggered until as much as an hour after event initiation. But by definition the pre-actuation environment remains below the small set-point values. Therefore, long term qualification to the harsher environments is not justified.

The same argument applies to some degree for all equipment. If analysis shows that small-break conditions lead to long pre-actuation durations, the equipment should be qualified for these durations, but in conjunction with the less-than-maximum environment corresponding to such small breaks.

Other Considerations

If a one-hour time margin is added to the analyzed and already conservative period of operability, additional or more severe environmental parameters would result in the qualification process if the maximum credible accident profile is assumed. As an example, not only would environmental parameters such as pressure, temperature, and radiation dose increase to overly conservative values, but also the effects of chemical (or water) spray or submergence would have to be needlessly addressed for devices that have already performed their safety functions and subsequent failure is not shown detrimental to plant safety.

There is also a disparity between the one-hour qualification time requirement and guidance provided to the operator in emergency procedures. Safety analyses generally assume, as a measure of conservatism, that the operator does not take any action for 10, 20 or 30 minutes. In fact, there is a high degree of confidence that the operator would react in substantially shorter times. Therefore, the one-hour operating time requirement for some equipment is inconsistent both with safety analysis assumptions and expected operator performance. Operator action provides defense in depth for components qualified for less than one hour as well as those for more than one hour.

Conclusion

The arbitrary requirement of a one-hour qualification time margin for safety-related equipment is unnecessarily conservative and would result in a significant cost impact with no demonstrated improvement to safety. Inherent margins in other qualification parameters as discussed above, coupled with the recommended time margin in IEEE 323-1974, are sufficient to assure proper performance of short duration equipment. In addition, analysis ensures that subsequent failure will not compromise safety system performance or mislead operators.

The industry position is, therefore, that the one-hour minimum operating time margin not be included as part of the proposed revision to Regulatory Guide 1.89. Instead we recommend that the NRC continue to provide review and evaluation of licensing submittals, which establish maximum operating time on the basis of proper system design and accident scenario analysis, in accordance with the technically justifiable arguments presented in this paper.

A NUCLEAR INDUSTRY POSITION REGARDING CONCERNS FOR SEISMIC QUALIFICATION OF SAFETY RELATED ELECTRICAL EQUIPMENT SUBJECTED ONLY TO MILD ENVIRONMENTS

Introduction

The industry position paper addressing the Environmental Qualification of Safety Related Electrical Equipment Subjected Only To Mild Environments dated July 2, 1981, did not specifically include a detailed consideration of the requirements for seismic testing as part of that document. This paper supplements the mild environment position paper to include seismic testing considerations within its scope.

Particularly of concern when formulating seismic testing programs is the validity of requiring the inclusion of preaging in order to demonstrate the adequacy of the equipment to perform its safety related function.

Position

Available evidence does not indicate that there wll be any significant enhancement to the safety of nuclear power plants by including pre-aging as part of a seismic testing program for qualification of safety-related equipment subject only to mild environments. It is recommended that the NRC not include such requirements in their ongoing rulemaking and regulatory activities.

Discussion

At a meeting with the NRC staff on August 12, 1981, information was presented by Arnold Roby, Chairman of the AIF Subcommittee on Equipment Qualification, supporting the position that any requirement for preaging of equipment would have no meaningful consequence on the results of a seismic test program performed on unaged equipment.

The spectra of information supplied to the NRC staff (list of reference documents enclosed) and on which this position was based included:

1. Manufacturers Test Reports: Tests performed specifically to identify and quantify differences in the results of seismic test programs have been performed on both aged and unaged equipment to determine their fragility levels. The test results were not supportive of a conclusion that aging effects play a consequential role in the ability of the equipment to function, even at the upper limits of seismic operability.

2. Testing Laboratory Reports: Tests performed at the component level illustrate that the aging/seismic coupling is not significant in terms of the components ability to function under seismic stress conditions. The components tested were chosen to be representative of those used in equipment installed in nuclear power plants.

3. Historic Information: Reports evaluating the operation of naturally aged equipment when subjected to actual seismic events have been reviewed. They conclude that the electrical equipment performed its function even where seismic design considerations were exceeded. In many instances the equipment evaluated was approaching the end of service life condition.

4. Industry Standards: Seismic performance requirements contained in industry standards for electrical equipment in non nuclear stations are based on many years of experience. These Standards also are applicable in nuclear stations since the equipment environmental conditions and seismic stresses are the same for non nuclear and nuclear station equipment in non-harsh environments. Preaging, as part of a seismic test program, is not included in these Standards either as a requirement or recommendation.

5. Manufactureres Type and Rating Tests: These tests demonstrate the margins inherent in the equipment for reliable operation over design life. These tests not only assure design conservatisms, but document the equipment's ability to reach an end of design life without degradation of structural, mechanical, or electrical integrity to such an extent where the equipment's capability to perform its safety functions during seismic conditions is seriously impaired.

6. Plant Surveillance and Testing Programs; These programs are designed to identify and correct abnormal degradation effects well before a level of concern is reached related to performance under seismic conditions. These programs will both identify deterioration at an early stage and enable corrective action to be taken.

Collectively, this information presents compelling evidence that any requirement for preaging equipment prior to seismic vibration testing is not justified. Further supporting this conclusion there is a complete lack of information demonstrating any unacceptable operation of naturally aged equipment when it has been subjected to actual seismic conditions. Although a potential can exist for aging effects to reduce the margin available for equipment operation, the sum total of available information demonstrates that these effects would be inconsequential to the aged equipment's ability to function during and after a seismic event.

In formulating a seismic test program the objective for including preaging is to establish confidence that throughout the service life and under normal service conditions, the equipment will function to meet its safety goals when subjected to a predetermined level of seismic vibration. Significant information is presently available demonstrating that this confidence level currently exists without the necessity for costly and time consuming efforts by the licensee to specifically include preaging each time a seismic test is performed. In this regard, preaging requirements represent a major portion of the costs and time to complete a seismic qualification program.

Conclusion

The statements and programs contained in the AIF position paper on the environmental qualification of equipment in mild environment, are applicable also to seismic qualification concerns. The programs detailed in that paper not only provide a high degree of assurance that aging degradation will not go undetected, but that it will be recognized early and corrected well before a level of concern is reached. Current information provides substantive evidence that requiring preaging prior to seismic test programs is not technically supportable and is not a major consideration in assuring seismic acceptability of equipment.

Recognizing also that preaging requirements represent a large proportion of the costs and time associated with testing programs, we conclude that additional industry resources should not be expended for the inclusion of preaging as part of seismic test programs.

Reference Documents Supplied to NRC.

1. A Study of the Effect of Aging on the Operation of Switching Devices - Carfagno & Heberlein.
2. Correlation of Age - Sensitivity & Seismic Qualification - J. F. Gleason.
3. Correlation Between Aging & Seismic Qualification for Nuclear Plant Electrical Components - Phase 1 Wyle Laboratories Report.
4. Class 1E Medium AC Motors - Qualification Document - Westinghouse Electric Corporation. (Proprietary information, not for general dissemination).
5. Recommended Practices for Seismic Design of Substations - IEEE Power Engineering Society.
6. Proposed Standard - Seismic Qualification of Class 1E Metal Enclosed Power Switchgear Assemblies - IEEE Switchgear Committee.
7. Equipment Response at the El Centro Steam Plant during the October 15, 1979, Imperial Valley Earthquake - Lawrence Livermore Laboratory.
8. Effects of November 8, 1980, Earthquake on Humbolt Bay Power Plant and Eureka, California Area - U.S. Nuclear Regulatory Commission.

Attachment 3

Attachment to
LW3-167-83

Atomic Industrial Forum, Inc.
7101 Wisconsin Avenue
Washington, D.C. 20014
Telephone: (301) 654-9260
Cable: Atomforum Washingtondc

July 2, 1981

Mr. Harold R. Denton
Director, Office of Nuclear
Reactor Regulations
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Denton:

Enclosed for your attention and consideration are the following two industry position papers regarding environmental qualification of safety-related electrical equipment:

(1) Equipment subjected only to mild environments, and

(2) Replacement parts for equipment located in harsh environments.

These papers were developed with input from a broad spectrum of the industry including the EPRI/Utility Advisory Group on Equipment Qualification.

Your March 17, 1981 letter to Carl Walske, President of the Atomic Industrial Forum, stated that the DOR Guidelines and NUREG-0588 have a large amount of flexibility written into them, and that this is being taken into account during the review. It is with regard t this flexibility and our concerns with changing requirements that we have developed the enclosed position papers.

Also we are developing position papers on some 10 other technical issues regarding environmental qualification of equipment. These will be forwarded to the NRC Staff as they are developed to assist in resolving these issues.

Sincerely,

Stephen H. Howell

Stephen H. Howell, Chairman
Committee on Power Plant Design,
Construction and Operation

SHH:ksr
Enclosures

A NUCLEAR INDUSTRY POSITION REGARDING ENVIRONMENTAL QUALIFICATION OF SAFETY-RELATED ELECTRICAL EQUIPMENT SUBJECTED ONLY TO MILD ENVIRONMENTS

I. INTRODUCTION

A Nuclear Regulatory Commission Memorandum and Order (CLI-80-21) dated May 23, 1980 requires that "by no later than June 30, 1982, all safety-related electrical equipment in all operating plants shall be qualified to the" DOR Guidelines(1) or NUREG-0588(2).

The purpose of this paper is to define a nuclear industry position regarding qualification of safety-related electrical equipment subject only to mild environments.

II. DEFINITIONS

Safety-Related Electrical Equipment - Electrical equipment required to achieve and maintain emergency reactor shutdown, containment isolation, reactor core cooling, containment and reactor heat removal, and prevention of significant release of radioactive material to the environment following a design basis event.

Mild Environments - Environments that may exceed the normal expected environment but that do not expose equipment in any given area to immediate or prolonged high-stress conditions during or following a design basis event.

Harsh Environments - Environments that may change significantly from the normal expected environment in a sudden or prolonged manner due to the direct effects of a design basis event (i.e., Loss of Coolant Accident (LOCA) or High Energy Line Break (HELB) Accident).

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(1) Division of Operating Reactors - "Guidelines for Evaluating Environmental Qualification of Class IE Electrical Equipment" (Enclosure to IE Bulletin 79-01B and SEP Letters)

(2) NUREG-0588 - "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment" (December 1979)

III. DISCUSSION

Mild environment areas are general plant areas outside containment which are normally maintained at room conditions and which are not subjected to harsh service conditions resulting from design basis events (i.e., Section 4.3.3 of the DOR Guidelines). The only abnormal conditions expected in these areas are those resulting from a complete loss of Heating, Ventilating and Air Conditioning (HVAC) systems. As stated in the DOR Guidelines, safety-related electrical equipment "located in these areas does not experience significant stress due to a change in service conditions during a design basis event." This statement can be supported since the maximum temperatures, pressures, and humidity in these areas are not expected to change significantly, if at all, during design basis events. The DOR Guidelines also state, "Therefore, no special consideration need be given to the environmental qualification of Class IE equipment in these areas provided the aging requirements discussed in Section 7.0 below are satisfied and the areas are maintained at room conditions by redundant air conditioning or ventilation systems served by the onsite emergency power sources." The approach used to address the aging of this equipment will be discussed later.

In addressing environmental qualification in mild environments, it is appropriate and consistent with DOR Guidelines to define two major classes of mild environment areas. These two classes of mild environment areas are defined below:

1. Areas which are maintained at room conditions by redundant HVAC systems powered by the onsite emergency electrical power system; and
2. Areas not served by redundant HVAC trains powered by the onsite emergency electrical power systems.

The HVAC systems serving all Class 1 areas are designed to the single-failure criterion and powered from onsite emergency power systems. Safety-related electrical equipment located in Class 1 areas is, therefore, not subject to a significant change in its normal environment resulting from any design basis event coincident with both a loss of offsite power and a single random failure in the HVAC system. In Class 1 areas, failures of safety-related electrical equipment resulting from a change in the environment do not need to be postulated.

Safety-related electrical equipment located in Class 2 areas is potentially subject to gradual increases in area temperatures and humidity due to a loss of HVAC systems, but no significant change in pressure or radiation dose rates is expected. The DOR Guidelines state this equipment should "be qualified for the environmental extremes which could result from a failure of the systems as determined from a plant-specific analysis." Qualification requires that the Class 1E equipment demonstrates successful performance of specified safety functions under the application of plant service conditions. For most operating plants, documented plant-specific analyses are not available but a potential loss of HVAC systems was accounted for in the plant design. The following generic statements provide adequate assurance of equipment operability:

1. The mild environments resulting from loss of HVAC equipment are typically slow transients with resulting steady-state conditions which are not harsh by definition. Because the equipment operates well below the maximum stress level capability in its normal environment, it is unlikely that low-level, short-duration temperature excursions caused by loss of HVAC will result in the maximum stress level capability being exceeded. In addition, due to the slow nature of this temperature transient, time is available for operator action to correct the environmental problem by re-establishing or improvising ventilation. Since several means are available to the operator to correct the problem, the duration of the transient is confidently expected to be short. Operating experience has demonstrated that failures of equipment initiated by the mild environments are rare;

2. Equipment similar to that used in safety-related electrical applications in mild environments has been in use in nuclear power plants for over 300 reactor-years and in fossil power plants for several thousand plant-years. This equipment has been exposed on numerous occasions to abnormal environments resulting from loss of HVAC systems. From all available documentation of the types of failures encountered with this equipment, no evidence has been found of common-mode failures of electrical equipment resulting from mild environments. Licensee Event Reports (LERs) do not indicate that common-mode failure of safety-related equipment resulting from mild environments is a problem(1).

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(1) Taylor, J.R., Common Mode and Coupled Failure, Danish Atomic Energy Company, Risoe-M-1826, October 1975.

3. Equipment in mild environments is accessible for normal periodic maintenance, inspection, and repair or replacement which is based on sound engineering practice, recommendations of the equipment supplier, and the results of surveillance programs. This allows the preservation of the high reliability of this equipment since normal surveillance and maintenance can continue during and following a design basis event and repair or replacement is possible should an unlikely failure occur;

4. Conservative design practices are utilized in both equipment and system design for safety-related applications. This conservatism provides further assurance that the equipment can continue to operate under the low stresses of mild environments. The DOR Guidelines state that "this equipment was designed and installed using standard engineering practices and industry codes and standards (e.g., ANSI, NEMA, National Electric Code)." Supporting this, NUREG/CR-0988, which reviews the many qualification standards, also states that "Nuclear power reactors are designed, constructed, and operated to extremely high standards. Plant design features emphasize quality, redundancy, inspectability, and testability of components to assure maximum tolerance to system malfunctions." This conservatism has demonstrated its effectiveness in the excellent operating history of electrical systems at various nuclear plants and at fossil plants under more extreme conditions.

The above statements clearly describe the existing methods by which operating plants adequately address environmental qualifications in Class 2 mild environment areas. These methods already meet the requirements of 10 CFR 50, Appendix A, General Design Criterion 4, as well as the requirements of the DOR Guidelines, Section 4.3.3. Therefore, no additional evaluations or documentation are necessary to assure that this equipment will perform its safety function, even assuming a loss of HVAC systems.

Section 7.0 of the DOR Guidelines regarding aging states that, "Implicit in the staff position in Regulatory Guide 1.89 with regard to backfitting IEEE Std. 323-1974 is the staff's conclusion that the incremental improvement in safety from arbitrarily requiring that a specific qualified life be demonstrated for all Class IE equipment is not sufficient to justify the expense for plants already constructed and operating." The industry agrees with this statement. Establishment of a qualified life for equipment subject only to mild environments, given the present state-of-the-art in aging theory and the lack of evidence that degradation of equipment due to aging is a significant common-mode failure mechanism, is unwarranted. The DOR Guidelines continue that "This position does not, however, exclude equipment using materials that have been identified as being susceptible to significant degradation due to thermal and radiation aging. Component maintenance or replacement schedules should include considerations of the specific aging characteristics of the component materials. Ongoing programs should exist at the plant to review surveillance and maintenance records to assure that equipment which is exhibiting age-related degradation will be identified and replaced as necessary."

The above requirements to identify and mitigate potential equipment failures caused by aging degradation in mild environments are already being addressed with the following programs:

1. An equipment surveillance activity which typically includes periodic inspections, analysis of equipment and component failures, and a review of the results of preventive maintenance and periodic testing programs;

2. A periodic testing program to verify operability of safety-related equipment within its performance specification requirements as required by the plant Technical Specifications; and

3. A periodic maintenance, inspection, and/or replacement program based on sound engineering practice and recommendations of the equipment manufacturer and which is updated as required by the results of the surveillance program. For example, when certain equipment exhibits an age-related degradation or limited lifetime (e.g., vacuum tubes, radiation detectors, electrolytic capacitors, motor bearings), the equipment is placed on routine replacement schedules.

In total, the above programs are more than adequate to address the aging requirements of the DOR Guidelines, Section 7.0, for electrical equipment located in both Class 1 and Class 2 mild environment areas. Ongoing studies by EPRI are underway which we feel will demonstate a lack of correlation between aging and seismic requirements. Therefore, no additional evaluation or documentation are required to address either the aging or the environmental qualification of safety-related electrical equipment located in mild environment areas.

IV. CONCLUSION

Operating plants already comply with 10 CFR 50, Appendix A, General Design Criterion 4 and are in full compliance with Section 4.3.3 of the DOR Guidelines for environmental qualification in mild environments. The bases for these conclusions are as follows:

1. As concluded by the DOR Guidelines, equipment located in mild environments "does not experience significant stress due to a change in service conditions during a design basis event";
2. Operability of similar equipment in mild environments even with a loss of HVAC systems, has been demonstrated by many years of experience in the utility industry;
3. Safety-related electrical equipment has been conservatively designed, fabricated, and instralled consistent with standard engineering practices and industry codes and standards;
4. Mild environment equipment is accessible for periodic maintenance, inspection, and repair or replacement during and following a design basis event; and
5. Equipment failures due to aging degradation are currently being addressed by surveillance, testing, and periodic maintenance programs already in existence.

From the foregoing it is clear that existing industry positions and programs are consistent with the level of safety required regarding environmental qualification of safety-related electrical equipment subject only to mild environments.

It is recommended that the mild environment issue be fully resolved as concluded above and that no additional industry resources be expended in this area.

2407W-1

Attachment 4

APPENDIX O

AGE CONSIDERATIONS FOR
SEISMIC DESIGN
AND
SURVEILLANCE/MAINTENANCE
IN
MILD ENVIRONMENTS

FOREWORD

This Appendix treats two related aspects of equipment aging. For clarity the presentation is subdivided accordingly. Part 1 of this Appendix discusses the aspects of Age Considerations for Equipment Seismic Design. Part 2 of this Appendix covers the feasibility of Surveillance Maintenance as Basis for Equipment Qualification.

PART 1

AGE CONSIDERATIONS FOR EQUIPMENT SEISMIC DESIGN

1.0 INTRODUCTION

Special concern exists regarding the need for equipment preaging prior to seismic test. Much of this concern arises due to the often conflicting guidance provided by IEEE-323-1974, DOR Guidelines, NUREG-0588, and IEEE-344-1975. The purpose of this Appendix is to demonstrate the nonvalidity of the requirement to include preaging. As a rule, when formulating seismic testing programs, in order to prove the adequacy of the equipment to perform its safety-related design function.

2.0 POSITION

Available information and evidence does not justify that there will be any significant enhancement to the safety of nuclear power plants by including preaging as part of the testing program for qualification of safety-related equipment subject only to mild environments. Neither do experimental studies conducted (Refer to IEEE "Study of the Effect of Aging on the Operation of Switching Devices," 1980) to determine whether equipment aging affects the vulnerability of electric switching devices to malfunction caused by vibrational stresses in the range of seismic frequencies and acceleration amplitudes. For most devices tested, the fragility level was approximately the same before and after testing, in some cases the fragility level increased while in others it decreased. Overall the changes were not significantly different from the fragility levels variations observed for duplicate specimens under identical test conditions. The results of this test support the position that seismic qualification need not be conducted with aged specimens.

Based on above considerations and other equipment aged versus non-aged testing such as the Position Paper "Justification for Seismic Testing Un-Aged Sub-Vendor Qualified Items," tests results provided from such Sub-Vendors as: Amp Special Industries, Anaconda Ericson Inc, Brand Rex Co, Electroswitch Corp and General Electric Co, it is our position that the preaging requirement to seismic test (IEEE-323-74, Subsection 6.3.5) be waived in the Qualification Program of Safety-Related Equipment subjected only to Mild Environments and that only IEEE-344-75 requirements be considered for seismic testing in this Class 1E equipment.

3.0 DISCUSSION

3.1 Based on information submitted by the Industry, and in particular the data presented by the Atomic Industrial Forum, and in a meeting held with the NRC on August 12, 1981 we concluded that any requirement for preaging of equipment would have no meaningful consequence on the results of a seismic test program performed on unaged equipment.

This conclusion was documented with information supplied to NRC from the following sources:

i. Manufacturers Test Reports

Tests performed on aged and unaged equipment show results not supportive of a conclusion that aging effects play a consequential role in the ability of the equipment to function, even in the upper limits of seismic operability.

ii. Test Laboratory Reports

Tests performed in components illustrate that the aging - seismic combination is not significant in terms of component ability to function under seismic stress conditions.

iii. Historical Data

Reports evaluating equipment operation of aged equipment subjected to actual seismic events conclude that the electrical equipment performed its functions even where seismic design considerations were exceeded and when some of the devices were approaching end-of-life condition.

iv. Industry Standards

Performance requirements for nonnuclear stations for seismic considerations are based on standards which are also applicable to nuclear stations because equipment environmental conditions and seismic stresses are similar for nonnuclear and nuclear non harsh conditions. Pre-aging is not included in the seismic test neither is recommended.

v. Manufacturers Type and Rating Tests

These tests document the equipment's ability to reach an end of design life without degradation of structural, mechanical, or electrical integrity not affecting the equipment's capability to perform its safety functions during seismic conditions.

vi. Plant Surveillance and Testing Programs

These aspects of equipment aging are discussed in the latter part of this Appendix.

3.2 The IEEE members S P Carfagno, Franklin Research Center, and G Erich Herberlein, Jr, Gould Inc., conducted an experimental study in 1980 on twenty-four (24) different specimens consisting of duplicated pairs, except for starters, circuit breaker and current-limiting fuses, to determine pre-aging effects on the vulnerability of electric switching devices to malfunction caused by vibratory stress in the range of seismic frequencies and acceleration amplitudes.

The devices tested were: Circuit Breakers, Relays, Time-Delay Relays, Contactors, Starters, Current-Limiting Fuses and Fuse Blocks.

The experimental program consisted of:

a. Functional Test
b. Vibration Test
c. Functional Test
d. Gamma Radiation
e. Functional Test
f. Accelerated Thermal Aging (At High Relative Humidity)
g. Functional Test
h. Electrical/Mechanical Life Cycling
i. Functional Test
j. Accelerated Thermal Aging (Coils Only)
k. Functional Test
l. OBE Vibration
m. Repeat of Vibration Test
n. Functional Test

Description of these tests can be found in IEEE Paper F-80-259-2, IEEE Power Generation Committee, IEEE Power Engineering Society, February 3-8, 1980.

Results of the tests show that specimens 5B, 6B and 21B were removed from program after irradiation. These specimens correspond to devices Time-Delay Relay (5B, 6B) and Circuit Breaker (21B) because they failed to function after irradiation. All the other devices passed the environmental test and were afterwards submitted to the seismic test. In most cases, there was no difference between the fragility levels before and after aging; this includes the cases in which the fragility level exceeded the test limit.

Table 1 shows the specimen identification by number and function description. Table 2 shows the Cycles Accumulated During Electrical/Mechanical Life Tests.

The test results demonstrate that there is no significant difference between fragility levels before and after accelerated aging, including cases in which the fragility level exceeded the test limit.

The specimens passed inspections and functional tests conducted in accordance with the experimental program where minor exceptions occurred after gamma irradiation. Details of the exceptions are discussed in the IEEE Paper, Page 4 affecting mostly plastic material of some components. Since two time-delay relays (specimens 7B and 8B) did not function properly after irradiation, they were replaced by specimens 27B and 28B, added to the program, which functioned satisfactorily afterwards. All specimens passed the final vibration tests and all passed successfully the initial vibration test (Specimens 27B and 28B were not submitted to the initial vibration test due to lack of availability of test facility when the specimens were added to the program).

An analysis of the component seismic vulnerability was made to determine whether aging had produced a significant change in the fragility level (measure of the ability of the devices to withstand vibrations in the seismic range). An attempt was made to ascertain whether the changes observed were sufficiently large to be unlikely to have occurred by chance. A curve was plotted showing the significant reductions in fragility level after aging compared to the level before aging (aging effect on seismic capability), chance variations (small reductions in fragility level) and the normal distribution curve.

A thorough analysis of the Fragility Level Curve by the probability law was conducted. These anlayses again support the hypothesis that there is no statistically significant aging effect. Summary of the results is tabulated in Table 3.

From the test and study conducted, in which devices were submitted to vibration test consisted of shaking each device in the direction that was most likely to cause spurious opening or closing of contacts, at discrete frequencies between 1.0 and 32.0 Hertz at interval of 1/3 octave and maximum acceleration amplitudes increasing from 0.4g at 1 Hz to 6g at 12.7 Hz, it was concluded that aging does not have a significant effect on the seismic vulnerability of most of the types of contact devices tested.

3.3 Summarizing the documents, tests and analysis referred to in above Paragraphs 3.1 and 3.2 of this discussion confirm the statement of our position, Paragraph 2.0 that the pre-aging does not affect substantially the seismic capability of equipment when in mild environments such as Motor Control Center Rooms, Switchgear Rooms, Main Control Rooms, etc, therefore the pre-aging requirement for seismic testing in Class 1E equipment should not be included in the seismic reports.

It is no coincidence that the above testing demonstrates the insignificance of accelerated aging before seismic testing. Virtually all of the components used within mild environments are identical in design to their commercial grade components. In most cases the only parameter increased for the nuclear grade component is the price, the lead time and the volumes of documentation supplied by test labs attempting to reinvent the decades of experience of the international electrical industry.

The conclusion of the ITE Gould/Franklin Research test program demonstrating that equipment aging does not effect seismic withstand ability serves as testimony to the quality of industry in its design and manufacture of equipment. Industry, both in the U.S. and worldwide, has addressed the subject of equipment aging for the past 30 years and has designed their equipment accordingly.

Industry representations have developed many concensus standards to cover the area of equipment aging.

In particular, two ANSI standards apply to a vast majority of the equipment of concern. The first is the Standard for Industrial Control Equipment ANSI/UL-508 and the second is the Standard for Polymeric Materials, Long-Term Evaluations ANSI/UL-746B. Both these ANSI standards were adopted from the standards of Underwriters Laboratories. A review of ANSI/UL-746B standard identifies among its basis materials standards published by the IEEE. These include IEEE-1 and IEEE-101, the same standards which form the basis of Arrhenius methodology for NUREG-0588.

The point above is that the utilities already use industry standards developed over decades which reasonably addresses aging. Unfortunately, a mystique has been carried around the word "nuclear," requiring a reinvention of techniques adopted not only within the U.S. but worldwide (IEC 216, "Guide for the Determination of Thermal Endurance Properties of Electrical Insulating Materials," IEC 493, "Guide for the Statistical Analysis of Aging Test Data," etc).

The entire issue regarding the aging of mild environment equipment before OBE and DBE goes away when analysis can point back to the industry standards. Moreover, the NASA, and MIL, Standards are more stringent. These reflect vibration and require severe acceleration values for extended time periods much greater than 30 seconds at under 5g's (the typical nuclear plant numbers).

Another aspect of equipment aging addresses solid state component. As indicated within IEEE-650 solid state devices are generally considered not to possess age related failure mechanisms. This position is supported by reliability models such as the bathtub curve and the Unified Field Theory. The latter approach identifies a constantly decreasing failure rate with time when the equipment is under a continuous stress (i.e., aging, voltage, etc).

Use of the standard bathtub curve with its infant failure region of decreasing failure rate, the flat region of constant failure rate, and the hypothetical region of increasing failure rate demonstrates that equipment operating in the constant failure rate region does not significantly age, all failures being considered random. The recent evidence, Figure 0-1 more than supports the theory that aging to the deteriorated "end-of-life point" is not applicable for solid state components. The most failure prone time is the beginning of life, consequently supporting the industry practice of solid state component "burn-in."

There is however an immediate problem with these philosophies. Both models account only for a continuous level of equipment stress. The situation in a harsh environmental area of a nuclear plant is different. Here, the equipment appears to see a step function increase in the level of equipment stress (especially that equipment used only for and during accident mitigation). This apparent situation decreases confidence level regarding immunity to common-mode failures. Use of engineering analysis tools such as thermal inertia calculations, review of actual Arrhenius curves, etc can still be used to demonstrate acceptability. Moreover, component derating can be used to regain the reliability numbers during all adverse conditions.

PART 2

THE FEASIBILITY OF EQUIPMENT QUALIFICATION BY SURVEILLANCE MAINTENANCE

This is Part 2 of Appendix O which describes the Applicant's approach to determining the cost-effective feasibility of applying surveillance/maintenance as the basis for mild environment equipment qualification. At the time of issuance of this appendix there is no Class 1E equipment dependent on surveillance/maintenance to establish qualification.

1. Introduction

NUREG-0588, paragraph 1.5(2) requires that, "Equipment located in general plant areas outside containment where equipment is not subjected to a design basis accident environment should be qualified to the normal and abnormal range of environmental conditions postulated to occur at the equipment location." Every nuclear plant receiving an operating license subsequent to May 23, 1980 (per NUREG-0588 Revision 1, Memorandum and Order CLI-80-21 and IEB 79-01B Supplement 2 Question/Answer 3) is required to meet NUREG-0588.

Earlier plants (those in operation prior to May 23, 1980) were to meet IEB 79-01B (Supplements 1-3) which did provide a specific limitation in scope of the formal submittal to the NRC for harsh environment located equipment, (refer to IEB 79-01B Supplement 1, Question/Answer 1). However, even these plants required "qualification" (IEB 79-01B enclosure 4, paragraphs 4.3.3 and 7), where significant aging degradation has been identified.

No official regulation (proposed 10CFR50.49) or regulatory guide (proposed RG 1.89, revision 1) exists on the issue of mild environment equipment. Literally thousands of pages of draft staff positions, ACRS/NRC meeting transcripts, etc. exist - but no official guidance to the industry.

What does exist is NUREG-0800 (Rev 2 - July 1981) Section 3.11 which is the NRC Standard Review Plan (SRP). Contained within that plan is the following:

Mild Environment

The environmental qualification of all electrical and mechanical equipment located in the mild environment is acceptable if the following procedure is followed:

> "The documentation required to demonstrate qualification of equipment in a mild environment are the "Design/Purchase" specifications. The specifications shall contain a description of the functional requirements for its specific environmental zone during normal and abnormal environmental conditions. A well supported maintenance/surveillance program in conjunction with a good preventive maintenance program will suffice to assure that equipment that meets the design/purchase specifications is qualified for the designed life."

> "Furthermore, the maintenance/surveillance program data and records shall be reviewed periodically (not more than 18 months) to ensure that the design qualified life has not suffered thermal and cyclic degradation resulting from the accumulated stresses triggered by the abnormal environmental conditions and the normal wear due to its service condition. Engineering judgment shall be used to modify the replacement program and/or replace the equipment as deemed necessary."

2. Definition

Replacement/Maintenance Internal

The replacement/maintenance interval is determined as the maximum cost effective period of time during which there is a high level of confidence that installed equipment can perform its necessary function up to, during and following a design basis event.

3. Evaluation of NRC SRP Position on Mild Environment Equipment and Its Potential Negative Impact

The key phrases in the NRC SRP position are "well supported maintenance/surveillance", "a good preventive maintenance program", and "maintenance/surveillance program data and records shall be reviewed periodically (not more than 18 months)."

These phrases and unofficial NRC discussions reflect very intensive surveillance/maintenance activities, perhaps at every refueling outage. Implementation of these activities necessitates a definition of meaningful degradation, determination of a surveillance/maintenance procedure to measure that degradation, initiation and maintenance of traceable surveillance/maintenance records for trending, and other very labor intensive and burdensome tasks.

The magnitude of the intensive effort must consider.

Labor Productivity

a) Travel Time
b) Waiting for tools and parts
c) Unavailability of components

Workload and Workwindow

a) Magnitude of craft personnel
b) Time available to do work (e.g. refueling)

Leadership/Training

a) Quality of supervision and training

Availability of QC/QA Support

a) Magnitude of QA/QC personnel available to support work on Class IE items

Planning/Scheduling

a) Significant magnitude of planning/scheduling to support intensive efforts without impacting plant availability - Is it possible?

Engineering Support

a) Evaluation of trending

Purchasing/Inventory Support

a) Level of inventory for seals, gaskets; service engineering to support maintenance.

Nuclear Records Management

a) Significant historical record keeping to verify maintenance performed, maintenance results and other pertinent information. The collected information can be handled manually on historical record cards or preferably by computer.

Surveillance/Maintenance Operating Review

a) Procedures (efforts) to identify deficiencies and problem areas

b) Factor (a) above into continuing program

To bring this into context review Guidebook Subsection 8.3.4 and Appendix E. We can easily demonstrate that most commercial grade items such as simple relays, precision switches (e.g. Microswitches) have a cycle life far in excess of the majority of plant requirements or alternatively we can check every relay contact for wear at every refueling. Likewise cables and motors can be qualified for the 40 year life, or alternatively the insulation resistance can be measured and dielectric tests can be conducted at each refueling or at a maximum of eighteen month intervals. For solid state components we can demonstrate that aging is insignificant and need not be considered prior to seismic testing (as described in part 1 of this appendix), or we can attempt to establish (if practical), meaningful surveillance/maintenance tests for solid state components.

The impact on resources to establish "well supported" surveillance/maintenance both by the utility during plant life and by the design team appears to be more costly than qualifying equipment for mild environments.

For example, simply extending the surveillance/maintenance interval from a 2-4 year range to a 6-8 year range on 40-50 valve/damper operators results in a plant cost savings of some $350 - 400,000.00 on an engineering evaluated (present worth) basis. It is clear that excessive dependence on frequent surveillance/maintenance will run in the many millions of dollars.

4. Qualification Methods for Mild Environments

Significant data exists and/or can be completed to demonstrate that a significant percentage of equipment is qualified. Much of this analysis is based on the application of Military and Industry Standards. Appendix E contains much data which can be used to qualify equipment by analysis supported by "partial test data".

5. Industry

Frankly, some industry members want to close the mild environment issue in the short term and are presently willing to commit the industry to intensive surveillance/maintenance planning to "renew the fight at a later day". Other members want to face and resolve the entire issue now and recognize the qualification inherent in the standards now used for commercial grade items described in Appendix E.

6. Qualification Feasibility By Surveillance/Maintenance Decision Logic Tree

The attached logic tree (Figure O-2) may aid in determining if surveillance and maintenance, as a basis for mild environment equipment qualification is feasible and logical. Use of this logic tree quickly and directly leads to a "real world" determination if and when qualification based on surveillance/maintenance in lieu of qualification is prudent. 1

TABLE 1

IDENTIFICATION OF TEST SPECIMENS

Note: All specimens consisted of duplicate pairs, except specimens 19B through 22B.

Specimen No.	Description
1B	Circuit Breaker
2B	Circuit Breaker
3B	Relay
4B	Relay
5B*	Time-Delay Relay
6B*	Time-Delay Relay
7B	Time-Delay Relay
8B	Time-Delay Relay
9B	Relay
10B	Relay
11B	Contactor
12B	Contactor
13B	Starter
14B	Starter
15B	Circuit Breaker
16B	Circuit Breaker
17B	Circuit Breaker
18B	Circuit Breaker
19B	Starter
20B	Starter
21B	Circuit Breaker
22B	Current-Limiting Fuses/Fuse Block Trip Indicator
27B	Time-Delay Relay
28B	Time-Delay Relay

*Failed functions test after irradiation

TABLE 2

CYCLES ACCUMULATED DURING ELECTRICAL/MECHANICAL LIFE TESTS

Specimen No.	No. of Cycles	Conditions
1B	6000	30 amp
	4000	No load
2B	6000	30 amp
	4000	No load
3B	2.0×10^6	5 amp
4B	2.0×10^6	5 amp
5B	Removed from program after irradiation	
6B	Removed from program after irradiation	
7B	1.0×10^6	Relay load
8B	1.0×10^6	Relay load
9B	2.0×10^6	5 amp
10B	2.0×10^6	5 amp
11B	2.5×10^6	30 amp
12B	2.5×10^6	30 amp
13B*	2.5×10^6	Note 1
14B*	2.5×10^6	Note 1
15B	6000	30 amp
	4000	No load
16B	6000	30 amp
	4000	No load
17B	6000	125 amp
	4000	No load
18B	6000	125 amp
	4000	No load
19B*	1.0×10^6	Note 2
20B*	1.0×10^6	Note 1
21B	Removed from program after irradiation	
22B	No operations required	-
27B	1.0×10^6	Relay load
28B	1.0×10^6	Relay load

*These devices were cycled without electrical loading. However, the contacts were replaced with contacts removed from identical devices previously subjected to electrical load cycles as follows:

Note 1. Make 84 A& 45% P.F., break 14 A& 90% P.F. and 480 V.
2.5×10^6 cycles at rate of 900/h

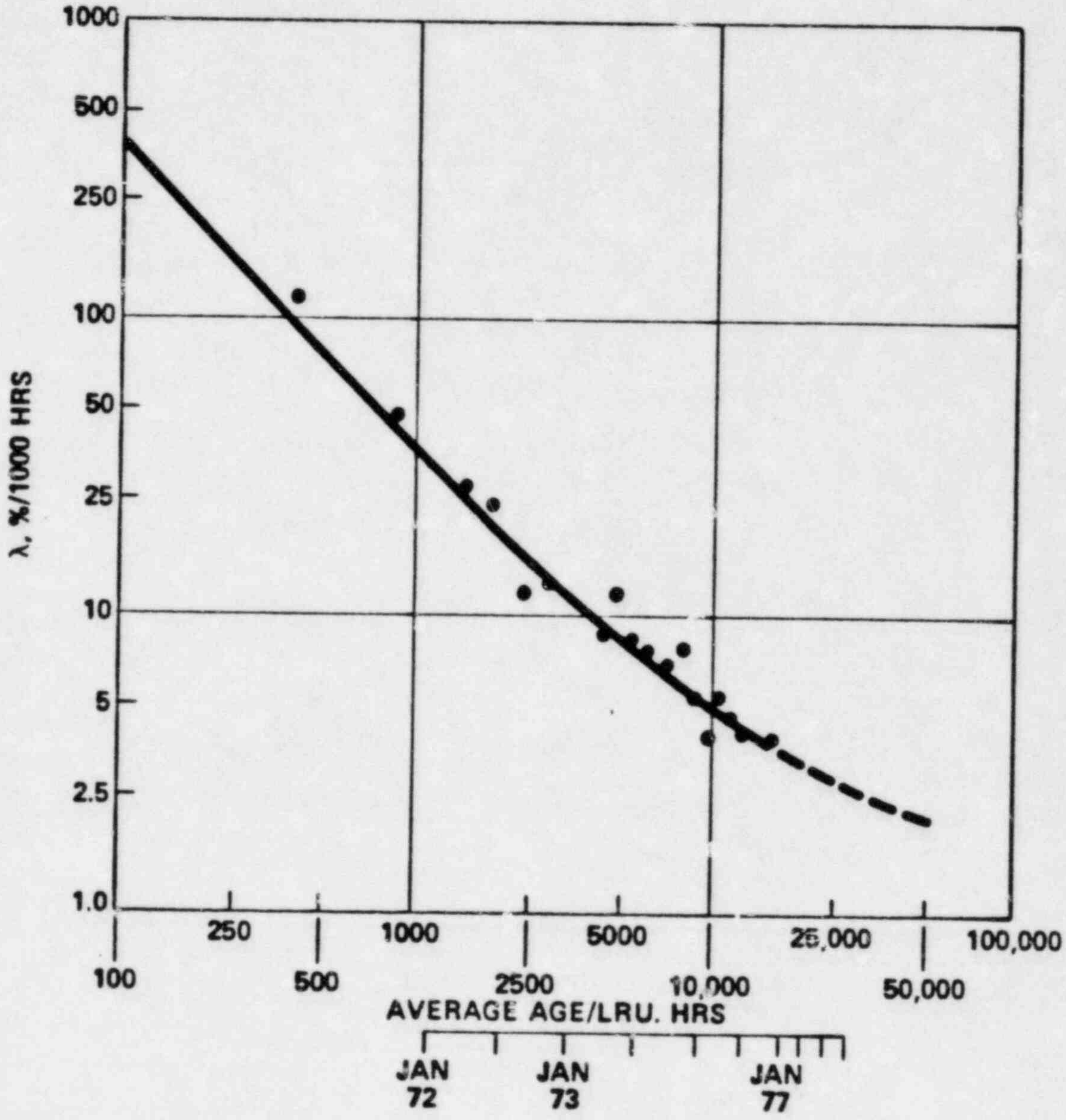
Note 2. Make 300 A& 45% P.F., break 50 A& 98% P.F. and 480V.
2.5×10^6 cycles at rate of 450/h

Special Note - A quantitative review and analysis of contact cycle life based upon electrical ratings is discussed within Appendix E of this Guidebook.

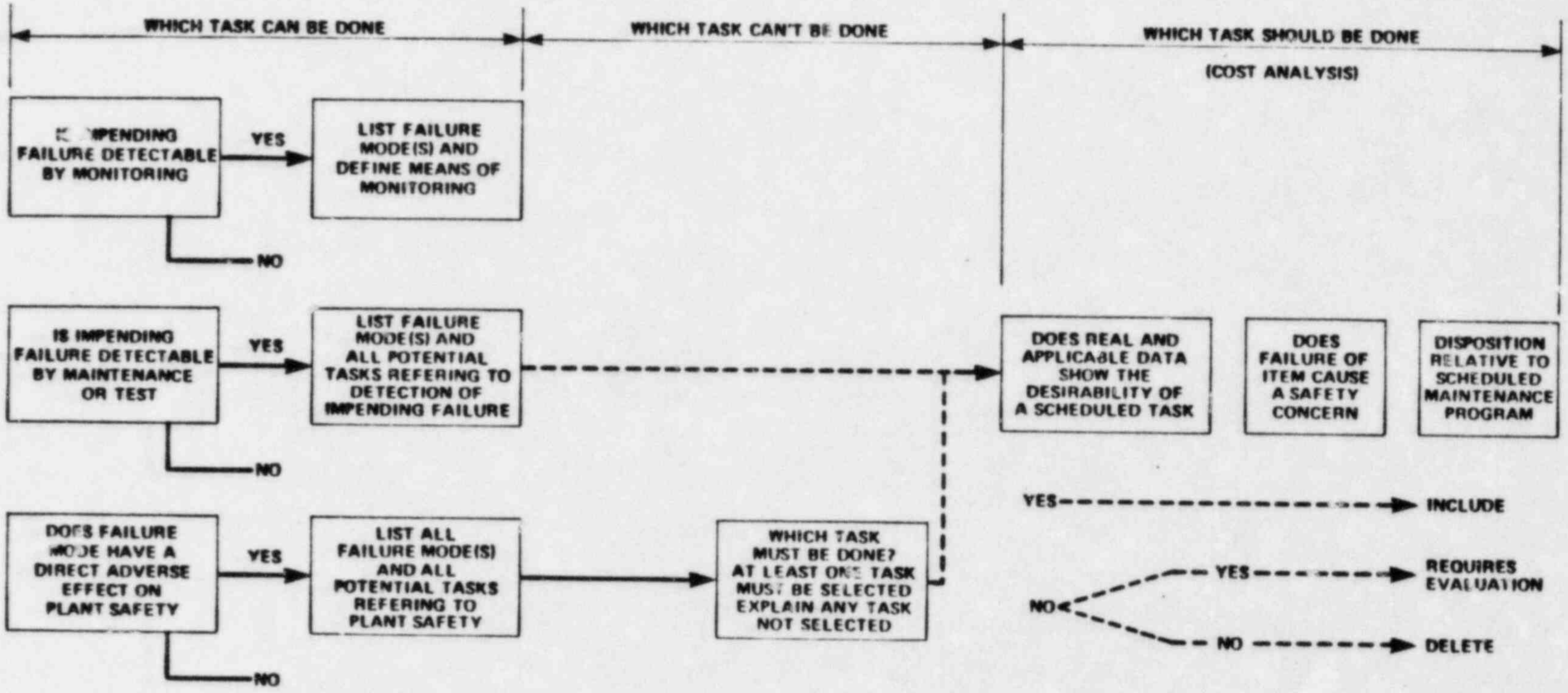
TABLE 3

SUMMARY OF OBSERVED CHANGES IN FRAGILITY LEVEL

	Specimens 9B & 10B						Specimens 11B & 12B						Specimens 13B & 14B						Specimen 19B			Specimen 20B		
		Decrease		Increase				Decrease		Increase				Decrease		Increase								
(f) Hertz	None	Signif	Not Signif	None	Sign	Not Sign	None	Signif	Not Signif	None	Signif	Not Signif	None	Signif	Not Signif	None	Signif	Not Signif	None	Decrea	Increa	None	Decrea	Increa
1.0	x						x						x						x			x		
1.3	x						x						x						x			x		
1.5	x						x						x						x			x		
2.0	x						x						x						x			x		
2.5	x						x						x						x			x		
3.2			x				x						x						x			x		
4.0	x						x						x						x			x		
5.0					x		x						x						x			x		
5.3			x						x						x					x			x	
8.0						x	x						x							x			x	
10.1						x		x						x						x			x	
12.7			x						x						x						x		x	
16.0			x					x						x						x			x	
20.1			x							x						x				x			x	
25.4		x						x						x						x			x	
32.0		x							x						x					x			x	



LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	ELECTRONICS FAILURE RATE VERSUS AVERAGE AGE IN HOURS	Figure O-1



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LOUISIANA POWER & LIGHT CO.
Waterford Steam Electric Station

QUALIFICATION FEASIBILITY BY SURVEILLANCE MAINTENANCE DECISION LOGIC TREE

FIGURE O-2

Attachment 5

2375w-6

APPENDIX M

GENERIC OVERVIEW OF "SEPARATE" EFFECTS TESTING VS "TYPE" OR "PROTOTYPE" TESTING OF MOTORS

APPENDIX M

GENERIC OVERVIEW OF "SEPARATE" EFFECTS TESTING VS "TYPE" OR "PROTOTYPE" TESTING OF MOTORS

1.0 INTRODUCTION

Several questions were raised by the NRC regarding the appropriateness of "Separate Effects" vs "Prototype" or "Type Testing" in motor qualification during site audits for a recent NUREG-0588 Category I plant. On one motor, a specific question requests the justification of separate effects (not sequentially testing for thermal aging, radiation, seismic). This appendix provides the overview and background for that justification on a generic basis.

It must be noted that this appendix is significantly related to the concepts of equipment rating (derating), aging, and commercial grade items. Consequently, a complete understanding of the issues requires a review of EQ Report Section 8.3 as well as Appendices E and H.

2.0 "SEPARATE EFFECTS" VS "PROTOTYPE" OR "TYPE TESTING" FOR OUTSIDE CONTAINMENT MOTORS

The definition of type tests in IEEE 323-1974 is as follows:

> Tests made on one or more sample equipment to verify adequacy of design and the manufacturing process.

NUREG-0588 Section 2, "Qualification Methods" paragraph 2.1(2) allows analysis in lieu of test data when testing is impractical due to size limitations and partial type test data is provided to support analysis and conclusions.

The specific NRC question was first raised during the review of a High Pressure Safety Injection Pump Motor outside containment. This motor is 400 hp, 4000 volt rated and is rather massive in size which is outside the limits of practicality of type testing. Although credit for this reason could be taken solely not to type test, other reasons are more important such as consistency with the requirements of IEEE class 1E motor qualification standard, IEEE 334-1974, Paragraph 5.

The definition of type testing illustrates that such testing is to be based on "sample" equipment. Such samples are indeed the basis for the motor qualification for commercial as well as Class 1E qualification. Qualification is accomplished by testing age-conditioned models and/or functional subassemblies at simulated operational conditions and providing the necessary auditable link between their performance and that of the actual equipment. Within the various motor qualification standards (IEEE 117, 275) these models are known as "formettes or motorettes."

Parts of the motors which are or have age-related failure mechanisms are represented by statistically significant number of identical models (formettes or motorettes). The models are subjected to accelerated aging in accordance with IEEE-117, 275. Mandatory electrical tests follow each aging cycle until all specimens fail. The failure rates are then evaluated in accordance with IEEE 101. This process is repeated at several different thermal acceleration rates. Each aging cycle consists of the temperature exposure for a specified number of days followed by 1 hour of vibration and 2 days of 100 percent relative humidity exposure. Electrical tests are performed on the specimens still in the humidity chamber. Figure M-1 illustrates the hierarchy (family) of qualification standards.

This outside containment motor qualification is by standard based on separate effects, historical testing data and commercial standards such as IEEE 275 as referenced in IEEE 334. Appendix A to the IEEE 334 standard includes a typical "Flow Chart for Qualification of Class 1E Motors". The flow chart depicts an inside-containment qualification process using type testing and an outside-containment process which is exactly in accordance with the approach taken on typical Class IE motors. The program adopted is consistent with a concern for unsupported analysis.

An effective EQ program utilizes the term analysis, engineering extrapolation or some other synonym to define an engineered and documented approach based on sound, logical, auditable, reasonable logic traceable to auditable scientific/engineering sources. To restrict the use of analysis in combination with partial test data does not enhance the qualification goals and moreover only confuses the issue.

For example, the life value of age-sensitive material may be based on material activation energies, traceability to recognized age index (e.g. UL 746 Arrhenius Methodology and temperature index), service environments, and operability requirements. Appendix E provides significant data demonstrating the adequacy of industry standards. The NRC has endorsed the use of stress analysis methodology as employed in IEEE Std 650-1979 (as indicated in NRC Supplement 2 to IEB 79-01B Question/Answer 7). Per 5.1.2.1 of this standard, a stress analysis of equipment shall be performed to assure that no electrical component is stressed to a point where its aging is accelerated beyond that expected in normal operation. Appendices to IEEE 650-1979 outline analysis procedures, stress ratios for various types of components, failure mechanisms, etc. For example, Appendix D states that the predominant failure mode of electromechanical devices such as relays, switches, contactors, etc. is cycle-induced fatigue. Electromechanical devices have typically been endurance tested up to hundreds of thousands of operations. In a typical plant installation, these devices will be subject to only a few hundred operations over their expected qualified life. The actual operating duty is therefore only a small fraction of the tested life of the device and thus provides a very high design margin. Additional discussion of conservatism in contact life is described in Appendix E.

The NRC has endorsed the use of the analysis methodology of NUREG-0588 Appendix B for MSLB transients. (A discussion of this is included in EQ Report Appendix A).

It is important to discuss the very significant degree of conservatism used in the accelerated aging techniques which form the basis for much of the qualification effort. The EQ Report Subsection 8.3.2 demonstrates significant margin in the typical air-oven testing and end-point criteria selected to determine the basis for thermal life.

For example, reference is made to Westinghouse testing (reference 13 in the EQ Guidebook) performed since the early 1950's which "represents an accumulation of almost 10,000,000 hours (over 1000 years) of thermal aging time on coils" wherein the conservative IEEE 275 Arrhenius thermal life curve implies a 2 - 5 year life actual Westinghouse life data exceeds 20 - 50 years.

Sequential testing (per IEEE 323-1974 Section 6.3.2) is addressed in NUREG 0588 Section 2 paragraph 2.3 and the NRC Comment Resolution No. 66 in NUREG 0588, Revision 1 which indicates that "staff agrees with the statement in the standard that if a data base is available from other tests on identical or essentially similar equipment then there is no need to repeat a test to establish a redundant set of performance characteristics at a normal environment". This comment resolution recognizes that "justified exception" to the sequence may be found acceptable.

Sequential aging aspects are related to the concern for synergism raised in NUREG-0588 Section 4 paragraph 4 (3) wherein it is stated that "Synergistic Effects should be considered...". LP&L has performed a comprehensive review of the issue documented in Appendix J of the EQ Report. The sequential or simultaneous application of the normal or below threshold degradation parameters (radiation) will make no significant difference to qualification results.

A review of IEEE 323-1974 paragraph 6.3.2 (4) includes a statement that, "If the required radiation level can be shown to produce less effect than that which would cause loss of equipment's Class 1E function, radiation need not be included as part of aging". The radiation values experienced, even including the post LOCA environment for motors, outside containment is significantly less than the threshold value of the motor materials as indicated in the various test reports. Consequently even including them in consideration let alone sequentially, separately, or synergistically is conservative.

As clarified in IEEE-323-1975, "Supplement to the Foreword of IEEE 323-1974," the intent of aging was misconstrued. The actual statement regarding intent is:

> "It was not the intent that aging must be applied to all class 1E equipment, but rather that aging must be considered in the same manner as environmental parameters."

Later IEEE standards (e.g., IEEE 627 referenced in NUREG-0800, Section 3.11) as well as the NRC guidance given to industry in July 1981 quoted in Section 8.4 of this EQ Report indicates that aging must be significant to the DBE of concern to be required. As the seismic withstand capability of the motor is a function of the mechanical components (shaft, frame, motor bolts, motor feet) which do not thermally age the industry does not necessarily pre-age a motor to demonstrate seismic capability. Rather it typically utilizes the analytical methods allowed in IEEE 334-1975.

The IEEE 334-1974 standard "For Type Tests of Continuous Duty Class 1E Motors For Nuclear Power Generating Stations" paragraph 9, "Aging Simulation" ends with the following requirement.

> "Following the thermal aging, the stator or insulation system model should be vibrated for one hour 1 1/2 times the acceleration of gravity

> as described in IEEE Std. 117-1974, IEEE Std. 275-1966 (Reaff 1972), or IEEE 429-1972".

As previously described this "nuclear plant requirement" is in fact industry standard for each motor in accordance with the IEEE. ANSI/UL 1446 requires the same standard vibration demonstration.

Consequently, the sequential vs separate effects aspects are adequately addressed.

3. CONCLUSION

The use of the standard industry methods found in the documentation packages are found in IEEE 275 and 117. Such industry methods are based on decades of testing which is tempered by experience to assure the reasonableness of results. Highlights of this qualification method include preparation of "formettes" or "motorettes" tested to destruction (typically ten or more for assurance of statistical adequacy) to generate industry acceptable Arrhenius data. Included in the testing is thermal shock both in heat-up and cool down cycles, typically ten cycles of testing on each model, mechanical stress exposure of 1 hour at 1.5G, moisture exposure to 95 - 100% humidity for 48 hour cycles, voltage exposures. Such a program forms the basis for all known generic motor qualifications such as Reliances NUC-9, and Westinghouses MM-9112. | 1

For all the above reasons it is concluded that the proper use of separate, sequential or synergistic effects are all factored in the WSES-3 program.

TABLE M-1

FLOW CHART FOR QUALIFICATION OF MOTORS

IEEE STD 323 - 1974 Qualifying Standard

Continuous Duty
Motors IEEE Std 334 -
Type Test*

- Definitions
  IEEE Std 380
- Radiation
  ASTM D-1953-71 Classification
  ASTM D-1672-66 Test Methods
- Seismic
  IEEE Std 344
- Thermal Aging
  IEEE Std 117 Random Wound AC
  IEEE Std 275 Form Wound AC
  IEEE Std 304 Direct Current Machines
  IEEE Std 434 High-Voltage Machines
- Methods
  IEEE Std 4 Techniques for Dielectric Tests
  IEEE Std 43 Testing Insulation Resistance
  IEEE Std 99 Preparation of Test Procedures
  IEEE Std 101 Guide for Statistical Analysis
  IEEE Std 286 Power Factor Tip-Up
  IEEE Std 522 Turn-to-Turn Testing
- Voltage Endurance (Motors Only)
  IEEE Std 434 High-Voltage Machines

*Actually most Class 1E Motors are
primarily in standby mode.

Table M-1

Relationship of Applicable Standards