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AUTH.NAME AUTHOR AFFILIATION
UTLEY,E.E. Carolina Power & Light Co.
RECIP.NAME RECIPIENT AFFILIATION
VARGA,S.A. Operating Reactors Branch 1

SUBJECT: Forwards list of qualified electrical equipment important to safety & response to SERs.Final environ qualification scheduled to be completed by 850331. S66 RDT

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CP&L

Carolina Power & Light Company

P. O. Box 1551 • Raleigh, N. C. 27602

MAY 20 1983

SERIAL: LAP-83-185

E. E. UTLEY
Executive Vice President
Power Supply and Engineering & Construction

Director of Nuclear Reactor Regulation
Attention: Mr. Steven A. Varga, Chief
Operating Reactors Branch No. 1
Division of Licensing
United States Nuclear Regulatory Commission
Washington, DC 20555

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
DOCKET NO. 50-261
LICENSE NO. DPR-23
ENVIRONMENTAL QUALIFICATION OF SAFETY RELATED ELECTRICAL EQUIPMENT

Dear Mr. Varga:

In accordance with the requirements of 10CFR50.49, Carolina Power & Light Company (CP&L) hereby submits for the H. B. Robinson Steam Electric Plant Unit No. 2 (HBR2) a list of qualified electrical equipment important to safety. This list will be periodically reviewed and updated as modifications and other required design changes are completed within the plant. A schedule for completing proposed corrective actions for non-qualified equipment is also included. Final environmental qualification of currently identified non-qualified equipment is scheduled to be completed by March 31, 1985. The compliance of CP&L's previous submittals on environmental qualification of electrical equipment with paragraphs (a) and (b) of 10 CFR 50.49 will be addressed in CP&L's response to your clarification letter dated April 28, 1983.

Carolina Power & Light Company has received and reviewed your Safety Evaluation Reports (SER) for environmental qualification of safety related electrical equipment for HBR2 dated January 5, 1983 and March 29, 1983. The schedule for the ninety day response required by your January 5, 1983 letter was superceded by the requirements of 10 CFR 50.49, and therefore, CP&L's response to both SERs is also attached. As stated within the SER response, certain documentation pertaining to electrical penetrations is being resubmitted for your review.

A048
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If you have any further questions on this subject, please contact our staff.

Yours very truly,

E. E. Utley

ONH/kjr (6881ONH)
Attachments

cc: Mr. J. P. O'Reilly (NRC-RII)
Mr. G. Requa (NRC)
Mr. Steve Weise (NRC-HBR)

RESUBMITTAL OF DOCUMENTATION FOR

TER ITEM NO. 24

ELECTRICAL PENETRATION ASSEMBLIES

---

1. Westinghouse letter dated November 29, 1977 from R. J. Muth to R. B. Starkey, Jr.
2. Crouse-Hinds Specification Description
3. Qualification Test Report on In-Containment Cables dated December 23, 1981 by Wyle Laboratories

---

MAY 1983

NLBlair / TB Clem... 2

Westinghouse
Electric Corporation

Box 4908
1299 Northside Drive NW
Atlanta Georgia 30302
CPL-77-550

November 29, 1977

Mr. R. B. Starkey, Jr, Plant Manager
Carolina Power & Light Company
H. B. Robinson SEG Plant
P. O. Box 790
Hartsville, South Carolina 29550

Attention: S. Zimmerman

Dear Mr. Starkey:

CAROLINA POWER & LIGHT COMPANY
H. B. ROBINSON UNIT 2
INFORMATION ON CONTAINMENT
ELECTRICAL PENETRATIONS TESTS

Reference: 1) Telephone conversation S. Zimmerman and R. Longdon on November 28, 1977
2) Telephone conversation S. Zimmerman and R. Muth on November 29, 1977

This letter documents the information requested and the answers given during the referenced telephone conversations.

CP&L requested information on any tests that were run to assure that H. B. Robinson type penetrations met LOCA conditions.

The Crouse-Hinds or Westinghouse type electrical penetrations were both designed by Westinghouse. Some were manufactured by Crouse-Hinds in the past but now are manufactured by Westinghouse.

Westinghouse manufacturing has run the following test on two production run units:

Test on First Penetration

5 KVA and 8 KVA at 340°F with saturated steam - 105 pounds for six (6) hours duration.

Test on Second Penetration

At instrument voltage using no. 1, no. 10, and no. 16 conductors. Temperature 340°F at 56 to 60 pounds for six (6) hours duration,

CPL-77-550

then a ramp down from 320°F to 250°F for 18 hour duration was performed.

RESULTS - Both units passed.

Crouse-Hinds did some testing but only information available was a test performed at 320° F and 90 psig.

Since both the Crouse-Hinds and Westinghouse penetrations were designed by Westinghouse the test results from Westinghouse test are deemed applicable to Crouse-Hinds manufactured penetrations. It should be noted that NRC requested the same information from the Westinghouse manufacturing plant and the above information on Westinghouse tests was given to the NRC.

Very truly yours,

RJ Muth

R. J. Muth
Customer Service Engineer
Southern Service Region
Nuclear Service Division

cc: B. J. Furr
H. R. Banks
R. M. Coats
D. B. Waters
J. F. Halifax

RPC Circuit Breaking Power Connectors

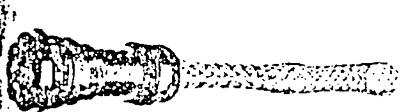
RPE Control Circuit and Power Connectors

Accessories Pg. 5P-12
Dimensions Pg. 5P-10 & 11

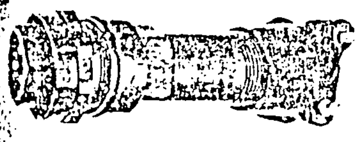
Crouse-Hinds

Options (continued):

- Crimp type contacts—available on all assemblies with solder well contacts. To order, add letter "T" to Cat. No., immediately following polarity letter
Examples: RPC217-127-301N-ARE23 and RPC217-127-302A-ARE23 except with crimp contacts would be ordered as RPC217-127-301NT-ARE123 and RPC217-127-302AT-ARE123 respectively.
- Alternate cable strain relief methods for plugs and connectors:
Stainless steel wire mesh cord grip. To order, add letter "K" to first section of Cat. No.
Example: RPC117-150—PO1N with wire mesh grip would be ordered as RPCK117-150—PO1N



Mechanical cord grip of copper-free aluminum, natural finish. To order, add letter "M" to first section of Cat. No.
Example: RPC117-150—PO1N with mechanical cord grip would be ordered as RPCM117-150—PO1N



Electrical Rating Ranges:

- Voltage—250, 480 and 600vac
- See listings for specific ratings

Ampere Ratings:

- Ratings given in the table at right are applicable to RPC circuit breaking power connectors and RPE control connectors, as indicated
- RPC connectors are capable of making or breaking circuits at the full rated load indicated in the table on the listing pages
- Contact assemblies of RPE connectors have the current carrying capabilities shown in the table, as defined by applicable military specifications (MS) and NEC requirements, for circuits not made or broken under load. It should be noted that these non-interrupting ampere ratings exceed the NEC rating of the corresponding wire size

Contact Size AWG	RPC Circuit Breaking Connectors NEC Rating	RPE Connectors Non-Interrupting Ampere Rating MS(AN)	NEC
#16		22	16
#12	20A	41	30
#10	30A	57	40
#4	60A	135	90
1/0	100A	250	160
4/0	200A	335	225

Compliances:

• Properties	Characteristics
Industrial use	excludes dust, lint, fibers and flyings, oil seepage and coolant seepage—meets J. I. C. Standard
Driptight	excludes falling moisture or dirt—materials unaffected by condensation
Weather resistant (weatherproof)	performs normally in outdoor areas
Watertight	excludes water by hose spray or stream
Dust tight	excludes dust, but performs normally if dust is accidentally enclosed during disconnect
Submersible	performs normally when submerged in water
Chemical resistance	highly resistant to alkalis, strong caustics, acids, petroleum base and organic solvents
Pressure	300 psi external—200 psi internal

• Compliance with Military Specifications

Environment	Performance Data
Corrosion resistance	salt spray 300 days. Exceeds MIL-C-5015D and MIL-E-4970A
Temperature	−80°F to 275°F, meeting requirements of MIL-C-5015D
Air leakage	exceeds Class E specification MIL-C-5015D
Dust resistance	exceeds requirements of MIL-E-5272C and MIL-E-4970A
Shock resistance	50G exceeds MIL-C-5015D
Vibration	exceeds 20G, method II, MIL-C-5015D and MIL-E-5272C
Humidity & moisture	exceeds Class E specification MIL-C-5015D

• UL Standard: 498

United States
Nuclear Regulatory Commission
Docket No. 50-261
License No. DPR-23

ENVIRONMENTAL QUALIFICATION OF ELECTRICAL EQUIPMENT

H. B. ROBINSON E. G. PLANT UNIT 2

Response to Amended NRC Regulation on Environmental Qualification of Electrical Equipment Important to Safety 10CFR50.49 (February 22, 1983)

Response to NRC Safety Evaluation Report for Environmental Qualification of Safety Related Electrical Equipment for H. B. Robinson Steam Electric Plant Unit No. 2 (January 5, 1983)

CAROLINA POWER & LIGHT COMPANY
RALEIGH, NORTH CAROLINA

MAY 1983

TABLE OF CONTENTS

1.0 GENERAL

1.1 Introduction

This Carolina Power & Light Company (CP&L) submittal responds to NRC documents entitled, Final Rule, Environmental Qualification of Electric Equipment Important to Safety, 10 CFR 50.49, effective February 22, 1983; and Safety Evaluation Report for Environmental Qualification of Safety-Related Electrical Equipment for H. B. Robinson Steam Electric Plant, Unit No. 2, dated January 5, 1983. It is divided into two (2) separate sections, each of which is dedicated to the NRC documents described above. Since there are some similar requirements (i.e., schedules to complete qualification compliance), cross-references between sections are included for brevity purposes.

Review of the Safety Evaluation Report (SER), its attendant Franklin Research Center (FRC) Technical Evaluation Report (TER), and subsequent evaluations of the deficiencies stated in the TER, has resulted in recategorizing equipment listed within Categories IB and IIA to the IA (qualified) category. Therefore, the response to rule subsection (g) requiring identification of equipment already qualified includes the evaluated qualified equipment, as well as equipment already stated qualified within Category IA of the TER.

To aid in the review of evaluated equipment, an updated set of SCEW sheets has been included with a complete reference list of qualification support documentation. The technical portions of the evaluation reports added to the reference list have been combined and included as an addendum to this submittal. These form the basis for resolution of stated deficiencies listed within Categories IB and IIA of the FRC TER.

Category IV, Documentation Not Made Available, of the FRC TER lists Item 24, electrical penetrations. Copies of the FRC-requested documents had been previously transmitted to the FRC, but were not included in their review. Therefore, and additional set of the requested documents in included with this submittal. Based on this documentation and our evaluation, we consider the electrical penetrations to be qualified and include them within our list of qualified equipment (Section 2.1).

Our response to the rule includes consideration of Paragraph (b) of 10 CFR 50.49, Electric Equipment Important to Safety, to the level as described in our Revision 3 response to NRC Bulletin 79-01B (90-Day Report), Environmental Qualification of Electrical Equipment, dated February 1, 1981, Section 5.0, Report Quality Assurance. Paragraph (b)2 will be under additional study and updated as the equipment list is modified per the requirements stated within Section 2.4 of this response. Paragraph (b)3 is addressed in our H. B. Robinson Unit 2 submittal to NRC dated April 15, 1983, in the section entitled, Regulatory Guide 1.97, Instrumentation for Light Water Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident.

1.2 Description of Report Contents

Section 2.0 of this report is divided into four (4) further sections. Section 2.1, List of Qualified Equipment, and Section 2.2, Schedule for Achievement of Compliance to Equipment Qualification per 10 CFR 50.49, fulfill the requirements of paragraph (g) of the amended rule.

The qualified equipment list is presented in Section 2.1 using the Plant I.D. numbers, which can be related to the master list of electrical equipment previously submitted under IE Bulletin 79-01B. The generic name and the manufacturer/model listing is also included to correlate to the item listing as found in the FRC TER, Section 4, Technical Evaluation.

The schedule is presented in Section 2.2 using the NRC categories found in the FRC TER and referred to in the NRC SER issued January 5, 1983. Categories IB, IIA and IIB are addressed. The combined Sections, 2.1 and 2.2, cover all electrical equipment currently located in a harsh environment at H. B. Robinson Unit No. 2.

To aid in reevaluation assessment, revised SCEW sheets are presented in Section 2.3. These are updated to include the current documentation reference numbers assigned to the studies/analyses performed to establish the related qualification.

To complete this section, a combined master list of equipment important to safety is included as Section 2.4. This list combines equipment/hardware located in harsh and non-harsh environments. The table, by the use of notes, differentiates between those components which require no qualification per their location, components currently qualified, and those components undergoing further evaluation.

Section 3.0 is dedicated to the NRC SER and the included FRC TER. The major qualification deficiencies presented within the NRC SER Conclusions are addressed in Section 3.1.1. Responses to the additional resolution requirements listed within the SER Conclusions are found in Section 3.1.2.

For audit purposes, the reevaluations performed to account for item deficiencies have been individualized in reports per generic name. Identification numbers and titles of these reports are listed in the Table of Contents under Section 4.0, Addendum. The technical portions of each have been included within the Addendum to aid in assessing the qualification process used in our reevaluations.

2.0 RESPONSE TO AMENDED NRC REGULATION ON ENVIRONMENTAL QUALIFICATON OF ELECTRIC EQUIPMENT IMPORTANT TO SAFETY (10 CFR 50.49)

2.1 List of Qualified Equipment

In accordance with Paragraph (g) of 10 CFR 50.49, a list of the electric equipment important to safety which are already qualified is presented in this section. This list represents the items known or evaluated as qualified and is subject to update as additional information is received or evaluations are generated.

These items cover NRC Category IA stated within the FRC TER and items found in NRC Categories IB, IIA, and IIC which have been reevaluated and declared qualified per the material found in Section 4.0, Addendum.

LIST OF QUALIFIED EQUIPMENT

Plant I.D. No.	Generic Name	Manufacturer/Model
V-869	Valve, Motor Operator	Limitorque SMB-00
B-1, B-2, B-5, B-9, C-1, C-2, C-3, C-4, C-6, C-8, C-9, D-1, D-2, D-3, D-5, D-8, D-9	Electrical Penetration	Crouse-Hinds
RHR-A & B	Motor, Residual Heat Removal Pump	Westinghouse 506UPZ
V-860A & B	Valve, Motor Operator	Limitorque SMB-0
V-861A & B	Valve, Motor Operator	Limitorque SMB-0
V-863A & B	Valve, Motor Operator	Limitorque SMB-00
TE-412B & D	Temperature Element	Rosemount 176KF
TE-422B & D	Temperature Element	Rosemount 176KF
TE-432B & D	Temperature Element	Rosemount 176KF
HVH-1, 2, 3, 4	Motor, Fan	Westinghouse 685.5-S
CVC-200A, B, C	Valve, Solenoid	ASCO 206-381-2U
CVC-381	Valve, Motor Operator	Limitorque SMB-00
V12-7 & 9	Valve, Solenoid	ASCO NP8316E65E
V12-11 & 13	Valve, Solenoid	ASCO NP8316E35E
2/C, 3/C, 4/C Shielded #16	Instrumentation Cable	Continental Wire & Cable
Heat Shrink Tubing	Cable Splice	Raychem
	Terminal Lug	AMP 53548-1
	Valve, Solenoid	ASCO LB8320A185
3/C #12	Power Cable	Kerite
Silicon Rubber	Connection Protection	3M-Scotch #70

2.2 Schedule for Achievement of Compliance to Equipment Qualification per 10 CFR 50.49

In accordance with paragraph (g) of 10 CFR 50.49, a schedule is provided below for the qualification of equipment to the provisions of the rule or for the replacement of the remaining electric equipment not identified as qualified.

Review of the list of electric equipment important to safety, Section 2.4, indicates four (4) equipments which need to be considered for replacement scheduling or additional qualification by analysis. These items are addressed by their generic names per Table 4-1 of the FRC TER rather than the instrument numbers assigned in the Section 2.4 list. They cover the NRC categories IB, IIA, and IIB. In all four cases, CP&L expects to have qualified equipment installed by March 31, 1985. However, if problems arise, CP&L will notify NRC per the guidance provided in 10 CFR 50.49 for any required extensions.

NRC Category IB, Items 20 and 21

The Endevco 2273AM20 (Item 20) and Unholtz-Dickie 22CA-2TR (Item 21) are part of the Babcock & Wilcox Valve Monitoring System. This system is presently undergoing qualification testing due for completion in mid-June, 1983, with a test report due for evaluation purposes by mid-July. As this test program is on-going, no recommendations for changeout or judgement on qualification can be made at this time. Upon test completion, CP&L will determine the action required and report to the NRC. This action is scheduled to be completed by March 31, 1985.

NRC Category IIA, Items 5, 6, 9, 10, and 11

Limitorque SMB valve actuators are undergoing continued qualification testing. Programs include the testing of a replacement motor to upgrade in-containment/harsh environment actuators (Item 5) and a new model SB Limitorque to replace the SMB/motor brake combination (Item 6). When completed, the resultant test reports will be reviewed to determine if replacement is required or if further investigation for substitute equipment is necessary. This action is scheduled to be completed by March 31, 1985.

Fisher and Porter Transmitters (Items 9, 10, and 11) have been replaced with Rosemount 1153A transmitters which currently meet the qualification requirements for their location. These replacements are part of an on-going transmitter replacement program initiated prior to the start of the IE Bulletin 79-01B program, but subsequent to the issuance of the Revision 3 response to NRC IE Bulletin 79-01B (90-day Report) dated February 1, 1981.

NRC Category IIB, Items 12, 13, 14, 15, 16, and 17

Rosemount transmitter model 1153A (Items 12, 13, 14, and 15) is in extensive use inside and outside containment at H. B. Robinson Unit 2. For those applications outside of its current qualification

level, a replacement model (Rosemount 1153D) is being investigated. Carolina Power & Light Company is part of a Utilities Group which is underwriting a qualification program to IEEE 323-1974 standards. These tests are currently completed and a test report is to be issued by mid-June 1983. After review of this report, CP&L will determine what additional replacement action or transmitter modification will be required to comply with 10 CFR 50.49 requirements. This action is scheduled to be completed by March 31, 1985.

A model similar to GEMS XM-52495 (Item 16) and XM-36495 (Item 17) level transmitters has completed qualification testing to IEEE 323-1974. The test report is due to be released by June 1, 1983. Upon review, CP&L will determine if transmitter changeout, modification, or if similarity analysis will be required for qualification. This action is scheduled to be completed by March 31, 1985.

Justification for Continued Operation (JCO) reports have been previously submitted for all Category IIB items and have been approved by NRC per SER letter issued March 29, 1983 titled Environmental Qualification of Electrical Equipment, Justification for Continued Operation for Unqualified Equipment at H. B. Robinson Steam Electric Plant, Unit No. 2.

2.3 Revised SCEW Sheets

A complete revised set of SCEW sheets previously submitted with our Revision 3 of the NRC IE Bulletin 79-01B (90-Day Report), dated February 1, 1981, are included. Equipment qualification is established by the inclusion of additional studies and references as stated on these SCEW sheets.

Due to an ongoing replacement program at H.B. Robinson of selected instrumentation transmitters, previously listed Fischer and Porter transmitters have been replaced with Rosemount models. These previously listed SCEW sheets are marked as superseded in order to maintain page number sequence.

All other section numbers and figure identification relate to the 79-01B submittals.

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (4)		
System: SAFETY INJECTION Plant ID No. FT-940 (1)	Operating Time	30 DAYS	2 HRS.	38	17	SIMULTANEOUS TEST	NONE
Component: FLOW TRANSMITTER	Temperature (°F)	AMBIENT	287	38	17	SIMULTANEOUS TEST	NONE
Manufacturer: FISHER & PORTER	Pressure (PSIA)	ATMOS.	75	38	17	SIMULTANEOUS TEST	NONE
Model Number: 10B2496PBBABBB	Relative Humidity (%)	AMBIENT	100	38	17	SIMULTANEOUS TEST	NONE
Function: SAFETY INJECTION	Chemical Spray	NOT REQUIRED	-		-	-	
Accuracy: Spec: ± 1/2% Demon:	Radiation	1.1×10^6	2×10^8	(3)	17	SEQUENTIAL TEST (5)	NONE
Service: HEADER FLOW (Hot Leg) Location: REACTOR AUXILIARY BLDG.	Aging						
Flood Level Elev: (2) Above Flood Level: Yes No	Submergence	NOT REQUIRED	-	-	-	-	

R2

SUPERSEDED

(1) Transmitter not exposed to DBE - Long-term mitigation radiation exposure only
(2) Not involved in containment flood postulation
(3) See Section 1.3.2

(4) See Section 3.2.2 for evaluation.
(5) Test performed after LOCA simulated environmental exposure R2

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (4)		
System: SAFETY INJECTION Plant ID No. FT-943 (1)	Operating Time	30 DAYS	2 HRS.	38	17	SIMULTANEOUS TEST	NONE
Component: FLOW TRANSMITTER	Temperature (°F)	AMBIENT	287	38	17	SIMULTANEOUS TEST	NONE
Manufacturer: FISHER & PORTER	Pressure (PSIA)	ATMOS.	75	38	17	SIMULTANEOUS TEST	NONE
Model Number: 10B2496PBBABBB	Relative Humidity (%)	AMBIENT	100	38	17	SIMULTANEOUS TEST	NONE
Function: SAFETY INJECTION Accuracy: Spec: Demon:	Chemical Spray	NOT REQUIRED	-		-	-	
Service: HEADER FLOW (Cold Leg)	Radiation	1.1×10^6	2×10^8	(3)	17	SEQUENTIAL TEST (5)	NONE
Location: REACTOR AUXILIARY BUILDING	Aging						
Flood Level Elev: (2) Above Flood Level: Yes No	Submergence	NOT REQUIRED	-	-	-	-	

SUPERSEDED

(1) Transmitter not exposed to DBE - Long-term mitigation radiation exposure only
(2) Not involved in containment flood postulation
(3) See Section 1.3.2
(4) See Section 3.2.2 for evaluation.
(5) Test performed after LOCA simulated environmental exposure

R2

DELE

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (4)		
System: SAFETY INJECTION Plant ID No. PT-934 (1)	Operating Time	30 DAYS	2 HRS.	38	17	SIMULTANEOUS TEST	NONE
Component: PRESSURE TRANSMITTER	Temperature (°F)	AMBIENT	287	38	17	SIMULTANEOUS TEST	NONE
Manufacturer: FISHER & PORTER	Pressure (PSIA)	ATMOS.	75	38	17	SIMULTANEOUS TEST	NONE
Model Number: 50EP1041BCXA	Relative Humidity (%)	AMBIENT	100	38	17	SIMULTANEOUS TEST	NONE
Function: BORON INJECTION Accuracy: Spec: Demon:	Chemical Spray	NOT REQUIRED	–	–	–	–	–
Service: TANK HEADER PRESSURE	Radiation	1.1×10^6	2×10^8	(3)	17	SEQUENTIAL TEST (5)	NONE
Location: REACTOR AUXILIARY BLDG.	Aging						
Flood Level Elev: (2) Above Flood Level: Yes No	Submergence	NOT REQUIRED	–	–	–	–	–

SUPERSEDED

R2

(1) Transmitter not exposed to DBE - Long-term mitigation radiation exposure only
(2) Not involved in containment flood postulation
(3) See Section 1.3.2
(4) See Section 3.2.2 for evaluation.
(5) Test performed after LOCA simulated environmental expusure

R2

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

SUPERSEDED

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (4)		
System: SAFETY INJECTION Plant ID No. PT-940 (1)	Operating Time	30 DAYS	2 HRS.	38	17	SIMULTANEOUS TEST	NONE
Component: PRESSURE TRANSMITTER	Temperature (°F)	AMBIENT	287	38	17	SIMULTANEOUS TEST	NONE
Manufacturer: FISHER & PORTER	Pressure (PSIA)	ATMOS	75	38	17	SIMULTANEOUS TEST	NONE
Model Number: 50EP1041	Relative Humidity (%)	AMBIENT	100	38	17	SIMULTANEOUS TEST	NONE
Function: SAFETY INJECTION Accuracy: Spec: Demon:	Chemical Spray	NOT REQUIRED	–	–	–	–	–
Service: HEADER PRESSURE (Hot Leg)	Radiation	1.1×10^6	2×10^8	(3)	17	SEQUENTIAL TEST (5)	NONE
Location: REACTOR AUXILIARY BUILDING	Aging						
Flood Level Elev: (2) Above Flood Level: Yes No	Submergence	NOT REQUIRED	–	–	–	–	–

(1) Transmitter not exposed to DBE - Long-term mitigation radiation exposure only
(2) Not involved in containment flood postulation
(3) See Section 1.3.2
(4) See Section 3.2.2 for evaluation.
(5) Test performed after LOCA simulated environmental exposure

R2

DELETE

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (4)		
System: SAFETY INJECTION (1) Plant ID No. PT-943	Operating Time	30 DAYS	2 HRS.	38	17	SIMULTANEOUS TEST	NONE
Component: PRESSURE TRANSMITTER	Temperature (°F)	AMBIENT	287	38	17	SIMULTANEOUS TEST	NONE
Manufacturer: FISHER & PORTER Model Number: 50EP1041BCXA	Pressure (PSIA)	ATMOS.	75	38	17	SIMULTANEOUS TEST	NONE
	Relative Humidity (%)	AMBIENT	100	38	17	SIMULTANEOUS TEST	NONE
Function: SAFETY INJECTION Accuracy: Spec: Demon:	Chemical Spray	NOT REQUIRED	-		-		
Service: HEADER PRESSURE (Cold Leg) Location: REACTOR AUXILIARY BUILDING	Radiation	1.1×10^6	2×10^8	(3)	17	SEQUENTIAL TEST (5)	NONE
	Aging						
Flood Level Elev: (2) Above Flood Level: Yes No	Submergence	NOT REQUIRED	-	-	-	-	

SUPERSEDED

(1) Transmitter not exposed to DBE - Long-term mitigation radiation exposure only
(2) Not involved in containment flood postulation
(3) See Section 1.3.2
(4) See Section 3.2.2 for evaluation.
(5) Test performed after LOCA simulated environmental exposure

R2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (5)		
System: SAFETY INJECTION Plant ID No. V-866A (1) Component: MOTOR OPERATOR	Operating Time	1 HR	7 DAYS	38	14	SIMULTANEOUS TEST	NONE
	Temperature (°F)	(2)	308	35, 38	14, 17	SIMULTANEOUS TEST	NONE
Manufacturer: LIMITORQUE	Pressure (PSIA)	(3)	75	35	14, 17	SIMULTANEOUS TEST	NONE
Model Number: SMB-00	Relative Humidity (%)	100	100	35	14, 17	SIMULTANEOUS TEST	NONE
Function: HOT LEG INJECTION Accuracy: Spec: Demon:	Chemical Spray	H_3BO_3 NaOH	H_3BO_3 NaOH		14	SIMULTANEOUS TEST	NONE
Service: MOTOR OPERATED VALVE-SIS	Radiation	1.0×10^6	2×10^8	(4)	17	SEQUENTIAL TEST (6)	NONE
Location: CONTAINMENT 241	Aging		40 YRS		17	SEQUENTIAL TEST (6)	NONE
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence	NOT REQUIRED					

R2

R2

R2

NOTES:
(1) Same data this sheet applies to V-866B.
(2) See accident profile - Temperature - Figure 3.1-1 - Reference 59
(3) See accident profile - Pressure - Figure 3.1-2 - Reference 59
(4) See Section 1.3.2 of Reference 59
(5) See Section 3.2.3 of Reference 59 for evaluation
(6) Test performed prior to LOCA simulated environmental exposure

R2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (3)		
System: SAFETY INJECTION Plant ID No. V869	Operating Time	(1)	30 DAYS	30	57, 58	SIMULTANEOUS TEST/ ANALYSIS	NONE
Component: MOTOR OPERATOR	Temperature (°F)	AMBIENT	250	35	57, 58	SIMULTANEOUS TEST	NONE
Manufacturer: LIMITORQUE	Pressure (PSIA)	ATMOS.	25	35	57, 58	SIMULTANEOUS TEST	NONE
Model Number: SMB-00	Relative Humidity (%)	AMBIENT	100	35	57, 58	SIMULTANEOUS TEST	NONE
Function: HOT LEG INJECTION BORON INJECTION Accuracy: Spec: Demon:	Chemical Spray	NOT REQUIRED	H_3BO_3 NaOH		57, 58	SIMULTANEOUS TEST	NONE
Service: MOTOR OPERATED VALVE	Radiation	1.1×10^6	2.0×10^7	(2)	57, 58	SEQUENTIAL TEST (5)	NONE
Location: REACTOR AUXILIARY BLDG.	Aging	-	40 YRS.		57, 58	SEQUENTIAL TEST/ANALYSIS	NONE
Flood Level Elev: (4) Above Flood Level: Yes No	Submergence	NOT APPLICABLE					

R2 (margin marks beside Chemical Spray, Radiation and Aging rows)

(1) To be used intermittantly during mitigation of LOCA
(2) See Section 1.3.2 of Reference 59.
(3) See Section 3.2.3 of Reference 59 for evaluation.
(4) Not involved in containment flood postulation
(5) Test performed prior to LOCA simulated environmental exposure | R2

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (4)		
System: SAFETY INJECTION Plant ID No. LS-1925A Component: LEVEL SWITCH	Operating Time	CONTINUOUS	NONE	-	-	-	(5)
	Temperature (°F)	(2)	NONE	-	-	-	(5)
Manufacturer: MADISON	Pressure (PSIA)	(3)	NONE	-	-	-	(5)
Model Number: 5602	Relative Humidity (%)	100	NONE	-	-	-	(5)
Function: CONTAINMENT SUMP WATER LEVEL MEASUREMENT Accuracy: Spec: 1/2" increment Demon:	Chemical Spray	H_3BO_3 NaOH	NONE	-	-	-	(5)
Service: DETECT WATER LEVEL CHANGES	Radiation	1.4×10^7	NONE	-	-	-	(5)
Location: CONTAINMENT 228'	Aging		NONE	-	-	-	(5)
Flood Level Elev: 231.2' Above Flood Level: Yes No X	Submergence		NONE				

R2

(1) Same data this sheet applies to LS-1925B
(2) See accident profile - Temperature - Figure 3.1-1 - Reference 59.
(3) See accident profie - Pressure - Figure 3.1-2 - Reference 59.
(4) See Section 3.2.7 of Reference 59 for evaluation.
(5) Function to be superceded by two channels of analog measurement equipment. No qualification testing required.

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (5)		
System: AUXILIARY COOLING	Operating Time	5 MIN	7 DAYS	40	14	SIMULTANEOUS TEST	NONE
Plant ID No. V-744A (1)	Temperature (°F)	(2)	308	35, 38	14, 17	SIMULTANEOUS TEST	NONE
Component: MOTOR OPERATOR							
Manufacturer: LIMITORQUE	Pressure (PSIA)	(3)	75	35	14, 17	SIMULTANEOUS TEST	NONE
Model Number: SMB-3	Relative Humidity (%)	100	100	35	14, 17	SIMULTANEOUS TEST	NONE
Function: REACTOR CORE DELUGE	Chemical Spray	H_3BO_3 $NaOH$	H_3BO_3 $NaOH$		14	SIMULTANEOUS TEST	NONE
Accuracy: Spec: Demon:	Radiation	9.5×10^5	2×10^8	(4)	17	SEQUENTIAL TEST (6)	NONE
Service: MOTOR-OPERATED VALVE-SIS							
Location: CONTAINMENT 245'	Aging		40 YRS		17	SEQUENTIAL TEST (6)	NONE
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence						

R2

NOTES:
(1) Same data this sheet applies to V-744B.
(2) See accident profile - Temperature - Figure 3.1-1 - Reference 59
(3) See accident profile - Pressure - Figure 3.1-2 - Reference 59
(4) See Section 1.3.2 of Reference 59
(5) See Section 3.2.3 of Reference 59 for evaluation
(6) Test performed prior to LOCA simulated environmental exposure

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (4)		
System: AUXILIARY COOLING Plant ID No. V860A	Operating Time	(2)	30 DAYS	30	57, 58	SIMULTANEOUS TEST/ ANALYSIS	NONE
Component: MOTOR OPERATOR	Temperature (^oF)	AMBIENT	250	35	57, 58	SIMULTANEOUS TEST	NONE
Manufacturer: LIMITORQUE	Pressure (PSIA)	ATMOS.	25	35	57, 58	SIMULTANEOUS TEST	NONE
Model Number: SMB-1	Relative Humidity (%)	AMBIENT	100	35	57, 58	SIMULTANEOUS TEST	NONE
Function: CV SUMP TO RHR SUCTION Accuracy: Spec: Demon:	Chemical Spray	NOT REQUIRED	H_3BO_3 NaOH		57, 58	SIMULTANEOUS TEST	NONE
Service: MOTOR OPERATED VALVE	Radiation	1.1×10^6	2.0×10^7	(3)	57, 58	SEQUENTIAL TEST (6)	NONE
Location: REACTOR AUXILIARY BLDG.	Aging	–	40 YRS.		57, 58	SEQUENTIAL TEST/ANALYSIS	NONE
Flood Level Elev: (5) Above Flood Level: Yes No	Submergence	NOT APPLICABLE	–				

R2

R2

(1) Same data this sheet applies to V860B
(2) To be used intermittantly during mitigation of LOCA.
(3) See Section 1.3.2. of Reference 59.
(4) See Section 3.2.3 of Reference 59 for evaluation.
(5) Not involved in containment flood postulation
(6) Test performed prior to LOCA simulated environmental exposure R2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (4)		
System: AUXILIARY COOLING Plant ID No. V861A (1)	Operating Time	(2)	30 DAYS	30	57,58	SIMULTANEOUS TEST/ ANALYSIS	NONE
Component: MOTOR OPERATOR	Temperature (°F)	AMBIENT	250	35	57, 58	SIMULTANEOUS TEST	NONE
Manufacturer: LIMITORQUE	Pressure (PSIA)	ATMOS.	25	35	57, 58	SIMULTANEOUS TEST	NONE
Model Number: SMB-1	Relative Humidity (%)	AMBIENT	100	35	57, 58	SIMULTANEOUS TEST	NONE
Function: CV SUMP TO RHR SUCTION Accuracy: Spec: Demon:	Chemical Spray	NOT REQUIRED	H_3BO_3 NaOH		57, 58	SIMULTANEOUS TEST	NONE
Service: MOTOR OPERATED VALVE	Radiation	1.1×10^6	2.0×10^8	(3)	57, 58	SEQUENTIAL TEST (6)	NONE
Location: REACTOR AUXILIARY BLDG.	Aging	-	40 YRS.		57, 58	SEQUENTIAL TEST/ANALYSIS	NONE
Flood Level Elev: (5) Above Flood Level: Yes No	Submergence	NOT APPLICABLE					

R2

R2

(1) Same data this sheet applies to V861B
(2) To be used intermittantly during mitigation of LOCA.
(3) See Section 1.3.2 of Reference 59.
(4) See Section 3.2.3 of Reference 59 for evaluation.
(5) Not involved in containment flood postulation
(6) Test performed prior to LOCA simulated environmental exposure

R2

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (4)		
System: AUXILIARY COOLING Plant ID No. V863A	Operating Time	(2)	30 DAYS	30	57, 58	SIMULTANEOUS TEST/ ANALYSIS	NONE
Component: MOTOR OPERATOR	Temperature (°F)	AMBIENT	250	35	57, 58	SIMULTANEOUS TEST	NONE
Manufacturer: LIMITORQUE	Pressure (PSIA)	ATMOS.	25	35	57, 58	SIMULTANEOUS TEST	NONE
Model Number: SMB-00	Relative Humidity (%)	AMBIENT	100	35	57, 58	SIMULTANEOUS TEST	NONE
Function: RHR DISCHARGE TO SI SPRAY SYSTEM Accuracy: Spec: Demon:	Chemical Spray	NOT REQUIRED	H_3BO_3 NaOH		57, 58	SIMULTANEOUS TEST	NONE
Service: MOTOR OPERATED VALVE	Radiation	1.1×10^6	2.0×10^7	(3)	57, 58	SEQUENTIAL TEST (6)	NONE
Location: REACTOR AUXILIARY BLDG.	Aging	–	40 YRS.		57, 58	SEQUENTIAL TEST/ANALYSIS	NONE
Flood Level Elev: (5) Above Flood Level: Yes No	Submergence	NOT APPLICABLE					

(1) Same data this sheet applies to V863B
(2) To be used intermittantly during mitigation of LOCA.
(3) See Section 1.3.2 of Reference 59.
(4) See Section 3.2.3 of Reference 59 for evaluation.
(5) Not involved in containment flood postulation
(6) Test performed prior to LOCA simulated environmental exposure

R2
R2
R2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (5)		
System: AUXILIARY COOLING Plant ID No. RHR-A (1)	Operating Time	CONTINUOUS	CONTINUOUS	34, 35			(2)
Component: MOTOR, PUMP	Temperature (°F)	85 (AVG) AMBIENT	90° C RISE	35, 19			(2)
Manufacturer: WESTINGHOUSE	Pressure (PSIA)	15	15	35, 19			(2)
Model Number: 506UPZ Function: CIRCULATE SUMP WATER & BORATED REFUELING WATER TO REACTOR COOLANT SYSTEM-POST LOCA	Relative Humidity (%)	AMBIENT	AMBIENT	35, 19			(2)
	Chemical Spray	NOT REQUIRED	NOT REQUIRED				
Accuracy: Spec: Demon:	Radiation	1.1×10^6	2.0×10^8	19 (3)	18,67	SEQUENTIAL TEST/ ANALYSIS	NONE
Service: RESIDUAL HEAT REMOVAL PUMP - SIS Location: AUXILIARY BUILDING	Aging		40 yrs.		18,67	SEQUENTIAL TEST/ ANALYSIS	NONE
Flood Level Elev: N/A Above Flood Level: Yes No	Submergence	NOT APPLICABLE					

NOTES:
(1) Same data this sheet applies to RHR-B.
(2) Motor not exposed to DBE, no qualification testing needed.
(3) See Section 1.3.2 of Reference 59
(4) See Section 3.2.8 of Reference 59 for evaluation

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: REACTOR PROTECTION Plant ID No. TE-412B (1)	Operating Time	1 HR.	2 WKS.	21	48,68	SIMULTANEOUS TEST	NONE (5)
Component: TEMPERATURE ELEMENT	Temperature (°F)	(2)	320	21	48,68	SIMULTANEOUS TEST	NONE (5)
Manufacturer: ROSEMOUNT	Pressure (PSIA)	(3)	81	21	48,68	SIMULTANEOUS TEST	NONE (5)
Model Number: 176KF	Relative Humidity (%)	100	100	21	48,68	SIMULTANEOUS TEST	NONE (5)
Function: MAIN STEAM LINE BREAK MONITOR Accuracy: Spec: Demon:	Chemical Spray	-	H_3BO_3 NaOH		48,68	SIMULTANEOUS TEST	NONE (5)
Service: T_{AV}-REACTOR COOLANT LOOP #1 SIS GENERATION	Radiation	1.5×10^7	1.0×10^8	(4)	48,68	SEQUENTIAL TEST (6)	NONE (5)
Location: CONTAINMENT 243'	Aging		40 YRS. + 2 WKS.		48,68	SEQUENTIAL TEST (6)	NONE
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence	NOT APPLICABLE					

R2

R2

NOTES:

(1) Same data this sheet applies to TE-412D
(2) See accident profile - Temperature - Figure 3.1-1 - Reference 59
(3) See accident profile - Pressure - Figure 3.1-2 - Reference 59
(4) See Section 1.3.2 of Reference 59
(5) Not required for DBE - used only for outside containment Main Steam line Break protection
(6) Test performed prior to LOCA simulated environmental exposure

R2

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: REACTOR PROTECTION Plant ID No. TE-422B (1)	Operating Time	1 HR.	2 WKS.	21	48,68	SIMULTANEOUS TEST	NONE (5)
Component: TEMPERATURE ELEMENT	Temperature (°F)	(2)	320	21	48,68	SIMULTANEOUS TEST	NONE (5)
Manufacturer: ROSEMOUNT	Pressure (PSIA)	(3)	81	21	48,68	SIMULTANEOUS TEST	NONE (5)
Model Number: 176 KF	Relative Humidity (%)	100	100	21	48,68	SIMULTANEOUS TEST	NONE (5)
Function: MAIN STEAM LINE BREAK MONITOR	Chemical Spray	–	H_3BO_3 NaOH		48,68	SIMULTANEOUS TEST	NONE (5)
Accuracy: Spec: Demon: Service: T_{AV}-REACTOR COOLANT LOOP #2 SIS GENERATION	Radiation	1.5×10^7	1.0×10^8	(4)	48,68	SEQUENTIAL TEST (6)	NONE (5)
Location: CONTAINMENT 243'	Aging		40 YRS. + 2 WK. POST ACCIDENT		48,68	SEQUENTIAL TEST (6)	NONE
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence	NOT APPLICABLE					

R2

NOTES:

(1) Same data this sheet applied to TE-422D
(2) See accident profile - Temperature - Figure 3.1-1 - Reference 59
(3) See accident profile - Pressure - Figure 3.1-2 - Reference 59
(4) See Section 1.3.2 of Reference 59
(5) Not required for DBE - only used for outside containment Main Steam Line Break protection
(6) Test performed prior to LOCA simulated environmental exposure R2

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: REACTOR PROTECTION	Operating Time	1 HR.	2 WKS.	21	48,68	SIMULTANEOUS TEST	NONE (5)
Plant ID No. TE-432B (1)	Temperature (°F)	(2)	320	21	48,68	SIMULTANEOUS TEST	NONE (5)
Component: TEMPERATURE ELEMENT	Pressure (PSIA)	(3)	81	21	48,68	SIMULTANEOUS TEST	NONE (5)
Manufacturer: ROSEMOUNT	Relative Humidity (%)	100	100	21	48,68	SIMULTANEOUS TEST	NONE (5)
Model Number: 176KF	Chemical Spray	–	H_3BO_3 NaOH		48,68	SIMULTANEOUS TEST	NONE (5)
Function: MAIN STEAMLINE BREAK MONITOR	Radiation	1.5×10^7	1.0×10^8	(4)	48,68	SEQUENTIAL TEST (6)	NONE (5)
Accuracy: Spec: Demon:	Aging		40 YRS. + 2 WKS.		48,68	SEQUENTIAL TEST (6)	
Service: T_{VA}-REACTOR COOLANT LOOP #3 – SIS. GENERATION							
Location: CONTAINMENT 243'							
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence	NOT APPLICABLE					

R2

NOTES:

(1) Same data this sheet applies to TE-432D
(2) See accident profile – Temperature – Figure 3.1-1 – Reference 59
(3) See accident profile – Pressure – Figure 3.1-2 – Reference 59
(4) See Section 1.3.2 of Reference 59
(5) Not required for DBE – only used for outside containment main steam line break protection
(6) Test performed prior to LOCA simulated environmental exposure

R2

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (5)		
System: HVAC Plant ID No. HVH-1 (1) Component: MOTOR, FAN	Operating Time	3 hrs.	24 hrs. +	36	16,67	Simultaneous Test	None
	Temperature (°F)	(2)	315	36	16,67	Simultaneous Test	None
Manufacturer: WESTINGHOUSE Model Number: 685.5-S	Pressure (PSIA)	(3)	75-95	36	16,67	Simultaneous Test	None
	Relative Humidity (%)	100	100	36	16,67	Simultaneous Test	None
Function: TRANSFER HEAT FROM CONTAINMENT TO SERVICE WATER Accuracy: Spec: Demon:	Chemical Spray	H_3BO_3 NaOh	H_3BO_3 NaOh	34	16,67	Simultaneous Test	None
Service: CONTAINMENT FAN COOLER	Radiation	3.4×10^6	1.41×10^8	(4)	15,67	Sequential Test (6)	None
Location: CONTAINMENT 275'	Aging		40 yrs.	-	15,67	Sequential Test (6)	None
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence	NOT APPLICABLE					

R2

NOTES:

(1) Same data this sheet applies to HVH-2, HVH-3, HVH-4
(2) See accident profile - Temperature - Figure 3.1-1- Reference 59
(3) See accident profile - Pressure - Figure 3.1-2 - Reference 59
(4) See Section 1.3.2 of Reference 59
(5) See Section 3.2.8 of Reference 59 for evaluation
(6) Test performed on selected motor components - not part of LOCA simulated environmental exposure | R2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: ALL Plant ID No. SEE NOTE(1)	Operating Time	CONTINUOUS	105 hrs.	1	2,43	SIMULTANEOUS TEST	NONE
Component: ELECTRICAL PENETRATION	Temperature (°F)	(2)	340	1	2,3,4,43	SIMULTANEOUS TEST	NONE
Manufacturer: CROUSE-HINDS	Pressure (PSIA)	(3)	75	1	2,3,4,43	SIMULTANEOUS TEST	NONE
Model Number: 1.2.2 (745) 1.2.5 (751) 1.2.2 (747) 1.2.4 (749)	Relative Humidity (%)	100	100	1	2,4,43	SIMULTANEOUS TEST	NONE
Function: ACCIDENT CONDITION MONITORING	Chemical Spray	-	H_3BO_3 NaOH		43	SIMULTANEOUS TEST	NONE
Accuracy: Spec: Demon:	Radiation	1.4×10^7	2.13×10^8	(6)	43	SEQUENTIAL TEST (7)	NONE (5)
Service: PROVIDE CABLE CONTINUITY THROUGH CONTAINMENT SHELL Location: CONTAINMENT 234' - 246'	Aging	40	524 hrs. @ 150 C (40 yrs)	1	43	SEQUENTIAL TEST (7)	NONE
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence	NOT APPLICABLE					

NOTES:

(1) Data this sheet applies to penetrations B-1,B-2,B-5,B-9,C-1,C-2,C-3,C-4,C-6,C-8,C-9,D-1,D-2,D-3,D-5,D-8,D-9

(2) See accident profile - Temperature - Figure 3.1.1 - Reference 59

(3) See accident profile - Pressure - Figure 3.1.2 - Reference 59

(4) See Section 3.2.1 of Reference 59 for evaluation

(5) Qualification established for penetration cartridge only. Pigtail cable requires separate testing as reported in Section 3.2.1 - Reference 59

(6) See Section 1.3.2 of Ref. 59

(7) Test performed prior to LOCA simulated environmental exposure R2

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (6)		
System: ALL Plant ID No. SEE NOTE(1)	Operating Time	1 HR.-1 DAY	67 HRS.	38	23	SIMULTANEOUS TEST	NONE
Component: TRANSMITTER	Temperature (°F)	(2)	350	38	23	SIMULTANEOUS TEST	NONE
Manufacturer: ROSEMOUNT	Pressure (PSIA)	(3)	135	38	23	SIMULTANEOUS TEST	NONE
Model Number: 1153A	Relative Humidity (%)	100	100		23	SIMULTANTEST	NONE
Function: REPLACEMENT COMPONENT	Chemical Spray	H_3BO_3 NaOH	H_3BO_3 NaOH		23,41	SIMULTANEOUS TEST	NONE
Accuracy: Spec: ± ¼% Demon:	Radiation	5.0×10^6	4.4×10^7	(5)	23	SEQUENTIAL TEST (7)	(4)
Service: Location: CONTAINMENT	Aging	-	NOT WITHIN MFGR. TEST PROGRAM				(4)
Flood Level Elev: 231.2' Above Flood Level: Yes No	Submergence						

R2

R2

NOTES:

(1) Replacement transmitter to be supplied for: PT-444, PT-445, PT-455, PT-456, PT-457, LT-474, LT-475, LT-476, LT-477, LT-484, LT-486, LT-487, LT-494, LT-495 LT-496, LT-497, LT-459, LT-460, LT-461, FT-474, FT-475, FT-484, FT-485, FT-494, FT-495, LT-485

(2) See accident profile - Temperature - Figure 3.1-1 - Reference 59

(3) See accident profile - Pressure - Figure 3.1-2 - Reference 59

(4) Replacement transmitters tested under IEEE 323-1971 format, Rosemount currently performing transmitter testing to meet IEEE-323-1974 requirements.

(5) See Section 1.2.3 - Reference 59

(6) See Section 3.2.1 for evaluation

(7) Test performed prior to LOCA simulated environmental exposure R2

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (5)		
System: ALL Plant ID No. SEE NOTE (1)	Operating Time	5 min.	30 days	40	47	Simultaneous Test	None
Component: SOLENOID, VALVE	Temperature (°F)	(2)	346	40	47	Simultaneous Test	None
Manufacturer: ASCO	Pressure (PSIA)	(3)	125	40	47	Simultaneous Test	None
Model Number: NP831665E NP8316E35E 206-381-2U	Relative Humidity (%)	100	100	40	47	Simultaneous Test	None
Function: REPLACEMENT COMPONENT Accuracy: Spec: Demon:	Chemical Spray	H_3BO_3 NaOH	H_3BO_3 NaOH		47	Simultaneous Test	None
Service:	Radiation	9.5×10^5	2.0×10^8	(4)	47	Sequential Test (6)	None
Location: CONTAINMENT 283'	Aging	–	40 yrs. & 4.4 yrs.	(5)	47	Sequential Test (6)	None
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence	Not Applicable					

R2

NOTES:

(1) Replacement solenoid valves to be supplied for: V12-7, V12-9, V12-11, V12-13, CVC-200A, CVC-200B, CVC-200C | R2
(2) See accident profile - Temperature - Figure 3.1-1- Reference 59
(3) See accident profile - Pressure - Figure 3.1-2- Reference 59
(4) See Section 1.3.2 - Reference 59
(5) See Section 3.2.6 - Reference 59, for evaluation
(6) Test performed prior to LOCA simulated environmental exposure | R2

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: ALL Plant ID No. Component: CABLE 4/C #16, 2/C #16, Shielded Manufacturer: CONTINENTAL WIRE & CABLE Model Number: CC2115 Function: FIELD CABLE Accuracy: Spec: Demon: Service: INSTRUMENTATION Location: CONTAINMENT	Operating Time	CONTINUOUS	30 days		46,60	SIMULTANEOUS TEST/ ANALYSIS	NONE
	Temperature (°F)	(2)	340	5	46	SIMULTANEOUS TEST	NONE
	Pressure (PSIA)	(3)	115		46	SIMULTANEOUS TEST	NONE
	Relative Humidity (%)	100	100		46	SIMULTANEOUS TEST	NONE
	Chemical Spray		H_3BO_3		46	SEQUENTIAL TEST	NONE
	Radiation	1.4×10^7	1.0×10^8	(1)	46,60	SEQUENTIAL TEST	NONE
	Aging		40 years	5	60	ANALYSIS	NONE
Flood Level Elev: 231.2' Above Flood Level: Yes No	Submergence	NOT APPLICABLE					

R2

NOTES:

(1) See Section 1.3.2 of Reference 59
(2) See accident profile - Temperature - Figure 3.1.1 - Reference 59
(3) See accident profile - Pressure - Figure 3.1.2- Reference 59

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD (4)	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: ALL	Operating Time	CONTINUOUS	50 DAYS		49	SIMULTANEOUS TEST	NONE
Plant ID No. Component: CABLE 3/C #16, 2/C #16, 500 MCM, 3/C 19/#22	Temperature (°F)	(2)	346	6	49	SIMULTANEOUS TEST	NONE
Manufacturer: KERITE	Pressure (PSIA)	(3)	128		49	SIMULTANEOUS TEST	NONE
Model Number: HIGH TEMP, FIRE RESISTANT	Relative Humidity (%)	100	100		49	SIMULTANEOUS TEST	NONE
Function: FIELD CABLE	Chemical Spray		H_3BO_3 NaOH		49	SIMULTANEOUS TEST	NONE
Accuracy: Spec: Demon:	Radiation	1.4×10^7	2.0×10^8	(1)	49	SIMULTANEOUS TEST	NONE
Service: CONTROL AND LOW POWER Location: CONTAINMENT	Aging		40 YEARS	6	49	SEQUENTIAL TEST	NONE
Flood Level Elev: 231.2' Above Flood Level: Yes No	Submergence	NOT APPLICABLE					

R1

R2

NOTES:

(1) See Section 1.3.2 of Reference 59
(2) See accident profile - Temperature - Figure 3.1.1 - Reference 59
(3) See accident profile - Pressure - Figure 3.1.2 - Reference 59
(4) See Section 3.2.4 of Reference 59

R1

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (3)		
System: CHEMICAL & VOLUME Plant ID No. CVC-381 Component: MOTOR OPERATOR	Operating Time	(1)	30 DAYS	30	57, 58	SIMULTANEOUS TEST/ ANALYSIS	NONE
	Temperature (°F)	AMBIENT	250	35	57, 58	SIMULTANEOUS TEST	NONE
Manufacturer: LIMITORQUE	Pressure (PSIA)	ATMOS.	25	35	57, 58	SIMULTANEOUS TEST	NONE
Model Number: SMB-00	Relative Humidity (%)	AMBIENT	100	35	57, 58	SIMULTANEOUS TEST	NONE
Function: REACTOR COOLANT PUMP SEAL WATER RETURN Accuracy: Spec: Demon:	Chemical Spray	NOT REQUIRED	H_3BO_3 NaOH		57, 58	SIMULTANEOUS TEST	NONE
Service: MOTOR OPERATED VALVE	Radiation	1.1×10^6	2.0×10^7	(2)	57, 58	SEQUENTIAL TEST (5)	NONE
Location: 240' REACTOR AUXILIARY BLDG.	Aging		40 YRS.		57, 58	SEQUENTIAL TEST/ANALYSIS	NONE
Flood Level Elev: (4) Above Flood Level: Yes No	Submergence	NOT APPLICABLE					

R2

R2

(1) To be used intermittantly during mitigation of LOCA
(2) See Section 1.3.2 of Reference 59
(3) See Section 3.2.3 of Reference 59 for evaluation
(4) Not involved in containment flood postulation
(5) Test performend prior to LOCA simulated environmental exposure

R2

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: ALL Plant ID No. Component: CABLE SPLICES (1)	Operating Time	CONTINUOUS	30 days		44	SIMULTANEOUS TEST	NONE
	Temperature (°F)	(2)	357		44	SIMULTANEOUS TEST	NONE
Manufacturer: RAYCHEM	Pressure (PSIA)	(3)	85		44	SIMULTANEOUS TEST	NONE
Model Number: 1000-12N, 500-12N, 300-12N, 200-12N, 115-6N, 070-6N	Relative Humidity (%)	100	100		44	SIMULTANEOUS TEST	NONE
Function: SINGLE CONDUCTOR AND MULTICONDUCTOR CABLE SPLICING	Chemical Spray		H_3BO_3 NaOH		44	SIMULTANEOUS TEST	NONE
Accuracy: Spec: Demon:	Radiation	1.4×10^7	2.0×10^8	(5)	44	SEQUENTIAL TEST (6)	NONE
Service: ELECTRICAL PENETRATIONS Location: CONTAINMENT 234' - 246'	Aging		40 years		44,61	SIMULTANEOUS TEST/ ANALYSIS	NONE
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence	NOT APPLICABLE					

R2

NOTES:

(1) Plant procedure developed and approved for installation and checkout - M-521 (Revision 0)
(2) See accident profile - Temperature - Figure 3.1.1 - Reference 59
(3) See accident profile - Pressure - Figure 3.1.2 - Reference 59
(4) See Section 3.2.5 of Reference 59 for evaluation
(5) See Section 1.3.2 of Reference 59
(6) Test performed prior to (5×10^7R) and after (1.5×10^8R) LOCA simulated environmental exposure R2

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION

System: ALL

Plant ID No.

Component: TERMINALS, CABLE (1)

Manufacturer: AMP

Model Number: 53548-1 (wire size - 16)

Function: CONDUCTOR BUTT SPLICE

Accuracy: Spec:
Demon:

Service: ELECTRICAL PENETRATIONS

Location: CONTAINMENT 234' - 246'

Flood Level Elev: 231.2'
Above Flood Level: Yes X No

ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS	
Parameter	Specification	Qualification	Specification	Qualification			
Operating Time	CONTINUOUS	30 days		62,63	SIMULTANEOUS TEST	NONE	R2
Temperature (°F)	(2)	286		62,63	SIMULTANEOUS TEST	NONE	R2
Pressure (PSIA)	(3)	60		62,63	SIMULTANEOUS TEST	NONE	R2
Relative Humidity (%)	100	100		62,63	SIMULTANEOUS TEST	NONE	
Chemical Spray		H_3BO_3 NaOH		62,63	SIMULTANEOUS TEST	NONE	
Radiation	1.4 x 10^7	1.5x10^7	(5)	62,63	SEQUENTIAL TEST (6)	NONE	R2
Aging		40 years		62,63	SEQUENTIAL TEST		
Submergence	NOT APPLICABLE						R2

NOTES:

(1) Plant procedure developed and approved for installation and checkout - M-521 (Revision 0)
(2) See accident profile - Temperature - Figure 3.1.1 - Reference 59
(3) See accident profile - Pressure - Figure 3.1.2 - Reference 59
(4) See Section 3.2.5 of Reference 59 for evaluation
(5) See Section 1.3.2 of Reference 59
(6) Test performed prior to LOCA simulated environmental exposure R2

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification (4)		
System: ALL Plant ID No.	Operating Time	CONTINUOUS	30 days		64,65	SIMULTANEOUS TEST	NONE
Component: TAPE, SILICON RUBBER	Temperature (°F)	(2)	346°F		64,65	SIMULTANEOUS TEST	NONE
Manufacturer: 3M/ELECTRO PRODUCTS DIVISION	Pressure (PSIA)	(3)	113 psig		64,65	SIMULTANEOUS TEST	NONE
Model Number: SCOTCH 70	Relative Humidity (%)	100	100		64,65	SIMULTANEOUS TEST	NONE
Function: CABLE TERMINATION PROTECTION Accuracy: Spec: Demon:	Chemical Spray		H_2BO_3 NaOH		64,65	SEQUENTIAL TEST	NONE
Service:	Radiation	1.4×10^7	2.0×10^8	(1)	64,65	SEQUENTIAL TEST	NONE
Location: CONTAINMENT	Aging		40 years		64,65		
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence				(5)		

|R2

NOTES:

(1) See Section 1.3.2 of Reference 59
(2) See accident profile - Temperature - Figure 3.1.1 - Reference 59
(3) See accident profile - Pressure - Figure 3.1.2 - Reference 59
(4) Qualification performed in conjunction with Kerite cable testing per IEEE 323-1974
(5) Not required

Facility: H. B. Robinson #2

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: TMI - 2.1.1 Plant ID No.	Operating Time	(1)					
Component: SWITCH, CONTROL	Temperature (°F)	AMBIENT	AMBIENT		39		(3)
Manufacturer: GEMCO	Pressure (PSIA)	ATMOS.	ATMOS.		39		(3)
Model Number: 404S2X4111	Relative Humidity (%)	AMBIENT	AMBIENT		39		(3)
Function:	Chemical Spray	NOT REQUIRED					
Accuracy: Spec: Demon: Service:	Radiation	1.4×10^3		(2)			
Location: REACTOR AUXILIARY BLDG.	Aging						
Flood Level Elev: N/A Above Flood Level: Yes No	Submergence						

NOTES:

(1) To be utilized during TMI-2 accident scenario per procedure
(2) Radiation level determined from Reactor Building Radiation Shielding Design Review
(3) No qualification required - Located in non-harsh environment

R3

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification (5)	Specification	Qualification		
System: TMI-2.1.3a Plant ID No. A (1) Component: ACCELEROMETER	Operating Time	(2)		53	52	SIMULTANEOUS TEST	(5)
	Temperature (°F)	(3)		53	52	SIMULTANEOUS TEST	(5)
Manufacturer: ENDEVCO	Pressure (PSIA)	(4)		53	52	SIMULTANEOUS TEST	(5)
Model Number: 2273AM20	Relative Humidity (%)	100		53	52	SIMULTANEOUS TEST	(5)
Function:	Chemical Spray	H_3BO_3 NaOH		53	52	SIMULTANEOUS TEST	(5)
Accuracy: Spec: Demon:	Radiation	2.0×10^8		53	52	SEQUENTIAL TEST	(5)
Service: Location: CONTAINMENT	Aging			53	52	SEQUENTIAL TEST	(5)
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence						

NOTES:

(1) Same data this sheet applies to B and C
(2) To be utilized during TMI-2 accident scenario per procedure
(3) See accident profile - Temperature - Figure 3.1.1 - Reference 59
(4) See accident profile - Pressure - Figure 3.1.2 - Reference 59
(5) Qualification testing not yet completed

R3

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: TMI-2.1.3a Plant ID No. A (1)	Operating Time	(2)		53	52	SIMULTANEOUS TEST	(5)
Component: PRE-AMPLIFIER	Temperature (°F)	(3)		53	52	SIMULTANEOUS TEST	(5)
Manufacturer: UNHOLTZ-DICKIE	Pressure (PSIA)	(4)		53	52	SIMULTANEOUS TEST	(5)
Model Number: 22CA-2TR	Relative Humidity (%)	100		53	52	SIMULTANEOUS TEST	(5)
Function:	Chemical Spray	H_3BO_3 NaOH		53	52	SIMULTANEOUS TEST	(5)
Accuracy: Spec: Demon:	Radiation	2.0×10^8		53	52	SEQUENTIAL TEST	(5)
Service: Location: CONTAINMENT	Aging			53	52	SEQUENTIAL TEST	(5)
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence						

NOTES:

(1)Same data this sheet applies to B and C
(2)To be utilized during TMI-2 accident scenario per procedure
(3)See accident profile - Temperature - Figure 3.1.1
(4)See accident profile - Pressure - Figure 3.1.2
(5)Qualification testing not yet complete

R3

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: TMI-2.1.3a Plant ID No.	Operating Time	(1)			39		(2)
Component: RELAY	Temperature (°F)	AMBIENT	AMBIENT		39		(2)
Manufacturer: WESTINGHOUSE	Pressure (PSIA)	ATMOS.	ATMOS.		39		(2)
Model Number: NBFD-22S	Relative Humidity (%)	AMBIENT	AMBIENT		39		(2)
Function:	Chemical Spray	NOT REQUIRED					
Accuracy: Spec: Demon: Service:	Radiation	NEGLIGIBLE					(2)
Location: REACTOR AUXILIARY BLDG.	Aging						
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence						

NOTES:

(1) To be utilized during TMI-2 accident scenario per procedure
(2) No qualification required - Located in non-harsh environment

R3

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: TMI-2.1.4 Plant ID No.	Operating Time	(1)					
Component: SWITCH, RESET	Temperature (^oF)	AMBIENT	AMBIENT		39		(3)
Manufacturer: GEMCO	Pressure (PSIA)	ATMOS.	ATMOS.		39		(3)
Model Number: 404PI331-PP1	Relative Humidity (%)	AMBIENT	AMBIENT		39		(3)
Function:	Chemical Spray	NOT REQUIRED					
Accuracy: Spec: Demon:	Radiation	1.5×10^2		(2)			(3)
Service: Location: REACTOR AUXILIARY BLDG.	Aging						
Flood Level Elev: N/A Above Flood Level: Yes No	Submergence						

NOTES:

(1) To be utilized during TMI-2 accident scenario per procedure
(2) Radiation level determined from Reactor Building Radiation Shielding Design Review
(3) No qualification required - Located in non-harsh environment

R3

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: TMI-2.1.3b Plant ID No. PT-500 (1)	Operating Time	(2)	67HRS.	53	23	SIMULTANEOUS TEST	NONE
Component: PRESSURE TRANSMITTER	Temperature (^oF)	(3)	350	53	23	SIMULTANEOUS TEST	NONE
Manufacturer: ROSEMOUNT	Pressure (PSIA)	(4)	135	53	23	SIMULTANEOUS TEST	NONE
Model Number: 1153GA-9	Relative Humidity (%)	100	100	53	23	SIMULTANEOUS TEST	NONE
Function:	Chemical Spray	H_3BO_3 NaOH	H_3BO_3 NaOH	53	23	SIMULTANEOUS TEST	NONE
Accuracy: Spec: Demon:	Radiation	2.0×10^8	4.4×10^7	(5)	23	SEQUENTIAL TEST (6)	(7)
Service: Location: CONTAINMENT	Aging		NOT WITHIN MFGR TEST PROGRAM				(7)
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence						

NOTES:

(1) Same data this sheet applies to PT-501, PT-456, PT-457
(2) To be utilized during TMI-2 accident scenario per procedure
(3) See accident profile - Temperature - Figure 3.1.1 - Reference 59
(4) See accident profile - Pressure - Figure 3.1.2 - Reference 59
(5) In containment radiation level established for purchase of component
(6) Test performed prior to LOCA simulated environmental exposure
(7) Rosemount test to IEEE 323-1971 format, currently transmitters under test to meet IEEE 323-1974 requirements

R3

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION

System: TMI-2.1.4

Plant ID No.

Component: SWITCH, SELECTOR

Manufacturer: GEMCO

Model Number: 404S34122EE8

Function:

Accuracy: Spec:
Demon:

Service:

Location: REACTOR AUXILIARY BLDG.

Flood Level Elev: N/A
Above Flood Level: Yes
No

ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
Parameter	Specification	Qualification	Specification	Qualification		
Operating Time	(1)					
Temperature (°F)	AMBIENT	AMBIENT		39		(3)
Pressure (PSIA)	ATMOS.	ATMOS.		39		(3)
Relative Humidity (%)	AMBIENT	AMBIENT		39		(3)
Chemical Spray	NOT REQUIRED					
Radiation	1.5×10^2		(2)			(3)
Aging						
Submergence						

NOTES:

(1) To be utilized during TMI-2 accident scenario per procedure
(2) Radiation level determined from Reactor Building Radiation Shielding Design Review
(3) No qualification required - Located in non-harsh environment

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: TMI-2.1.4 Plant ID No.	Operating Time	(1)					
Component: SOLENOID VALVE	Temperature (°F)	AMBIENT	AMBIENT		39		(3)
Manufacturer: ASCO	Pressure (PSIA)	ATMOS.	ATMOS.		39		(3)
Model Number: LB-8320A185	Relative Humidity (%)	AMBIENT	AMBIENT		39		(3)
Function:	Chemical Spray	NOT REQUIRED					
Accuracy: Spec: Demon: Service:	Radiation	2.5×10^5		(2)(4)			(3)
Location: REACTOR AUXILIARY BLDG.	Aging						
Flood Level Elev: N/A Above Flood Level: Yes No	Submergence						

NOTES:

(1) To be utilized during TMI-2 accident scenario per procedure
(2) Radiation level determined from Reactor Building Radiation Shielding Design Review
(3) Equipment not purchased to meet qualification requirements
(4) Radiation value being reviewed for revision of environment classification (to non-harsh)

R3

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: TMI-2.1.7 Plant ID No. FT-1425A(1)	Operating Time	(2)					
Component: TRANSDUCER	Temperature (°F)	AMBIENT			39		(4)
Manufacturer: CONTROLOTRON	Pressure (PSIA)	ATMOS.			39		(4)
Model Number: 240N-4CS80HT	Relative Humidity (%)	AMBIENT			39		(4)
Function:	Chemical Spray	NOT REQUIRED					
Accuracy: Spec: Demon: Service:	Radiation	NOT REQUIRED		(3)			(4)
Location: TURBINE DECK	Aging						
Flood Level Elev: N/A Above Flood Level: Yes No	Submergence						

NOTES:

(1) Same data this sheet applies to FT1425B, FT1425C
(2) To be utilized during TMI-2 accident scenario per procedure
(3) No measureable radiation level external to containment - Turbine Deck is exposed to weather
(4) No qualification required - Located in non-harsh environment

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: TMI-2.1.7 Plant ID No. FT-1426A(1)	Operating Time	(2)					
Component: TRANSDUCER	Temperature (°F)	AMBIENT			39		(4)
Manufacturer: CONTROLOTRON	Pressure (PSIA)	ATMOS.			39		(4)
Model Number: 240N-4CS80HT	Relative Humidity (%)	AMBIENT			39		(4)
Function:	Chemical Spray	NOT REQUIRED					
Accuracy: Spec: Demon:	Radiation	1.5×10^1		(3)			(4)
Service: Location: REACTOR AUXILIARY BLDG.	Aging						
Flood Level Elev: N/A Above Flood Level: Yes No	Submergence						

NOTES:

(1) Same data this sheet applies to FT1426B, FT1426C
(2) To be utilized during TMI-2 accident scenario per procedure
(3) Radiation level determined from Reactor Building Radiation Shielding Design Review
(4) No qualification required Located in non-harsh environment

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: TMI-2.1.7 Plant ID No.	Operating Time	(2)					
Component: COMPUTER, FLOW (1)	Temperature (°F)	AMBIENT			39		(4)
Manufacturer: CONTROLOTRON	Pressure (PSIA)	ATMOS.			39		(4)
Model Number: 241N	Relative Humidity (%)	AMBIENT			39		(4)
Function:	Chemical Spray	NOT REQUIRED					
Accuracy: Spec: Demon:	Radiation	NOT REQUIRED		(3)			
Service: Location: TURBINE DECK	Aging						
Flood Level Elev: N/A Above Flood Level: Yes No	Submergence						

NOTES:

(1) A total of six (6) flow computers are in use - one (1) for each transducer listed on sheets 9 and 10
(2) To be utilized during TMI-2 accident scenario per procedure
(3) No measureable radiation level external to containment -Turbine Deck is exposed to weather
(4) No qualification required - Located in non-harsh environment

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: TMI- ACRS-2 Plant ID No. LT-801A (1)	Operating Time	(4)					
Component: LEVEL TRANSMITTER	Temperature (°F)	(2)	300	53	54	SIMULTANEOUS TEST	NONE
Manufacturer: GEMS	Pressure (PSIA)	(3)	71	53	54	SIMULTANEOUS TEST	NONE
Model Number: XM52495	Relative Humidity (%)	100	100	53	54	SIMULTANEOUS TEST	NONE
Function: CONTAINMENT SUMP WATER LEVEL	Chemical Spray	H_3BO_3 NaOH	H_3BO_3 NaOH	53	54	SIMULTANEOUS TEST	NONE
Accuracy: Spec: Demon:	Radiation	2.0×10^8	2.0×10^8	53	54	SEQUENTIAL TEST	NONE
Service: WATER LEVEL MEASUREMENT Location: CONTAINMENT	Aging						(5)
Flood Level Elev: 231.2' Above Flood Level: Yes No X	Submergence		(6)				NONE

NOTES:

(1) Same data this sheet applies to LT-801B, 801C, LT-801D, LT-802A, LT-802B, LT-802C, LT-802D
(2) See accident profile - Temperature - Figure 3.1.1 - Reference 59
(3) See accident profile - Pressure - Figure 3.1.2 - REference 59
(4) To be utilized during TMI-2 accident scenario per procedure
(5) Equipment tested to IEEE-323-1971
(6) System designed to measure sequential flood levels

R3

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION

System: TML- ACRS-2

Plant ID No. LT-802A (1)

Component: LEVEL TRANSMITTER

Manufacturer: GEMS

Model Number: XM36495

Function: CONTAINMENT SUMP WATER LEVEL

Accuracy: Spec:
Demon:

Service: WATER LEVEL MEASUREMENT

Location: CONTAINMENT

Flood Level Elev: 231.2'
Above Flood Level: Yes
No X

ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
Parameter	Specification	Qualification	Specification	Qualification		
Operating Time	(2)					
Temperature (°F)	(3)	300	53	54	SIMULTANEOUS TEST	NONE
Pressure (PSIA)	(4)	71	53	54	SIMULTANEOUS TEST	NONE
Relative Humidity (%)	100	100	53	54	SIMULTANEOUS TEST	NONE
Chemical Spray	H_3BO_3 NaOH	H_3BO_3 NaOH	53	54	SIMULTANEOUS TEST	NONE
Radiation	2.0×10^8	2.0×10^8	53	54	SEQUENTIAL TEST	NONE
Aging						(5)
Submergence		(6)				NONE

NOTES:

(1) Same data this sheet applies to LT-802E
(2) To be utilized during TMI-2 accident scenario per procedure
(3) See accident profile - Temperature - Figure 3.1.1 - Reference 59
(4) See accident profile - Pressure - Figure 3.1.2 - Reference 59
(5) Equipment tested to IEEE 323-1971
(6) System designed to measure sequential flood levels

R3

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION

System: TMI - ALL

Plant ID No.

Component: CABLE

Manufacturer: ROCKBESTOS

Model Number: 2/C #14
5/C #14, 2/C SHIELDED #16
2/C SHIELDED #14,
3/C SHIELDED #16,
Function: 4/C SHIELDED #16

Accuracy: Spec:
Demon:

Service:

Location: CONTAINMENT & REACTOR AUXILIARY BLDG.

Flood Level Elev: 231.2'
Above Flood Level: Yes X
No

ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
Parameter	Specification	Qualification	Specification	Qualification		
Operating Time	(1)	30 DAYS		56	SIMULTANEOUS TEST	NONE
Temperature (°F)	(2)	346	53	56	SIMULTANEOUS TEST	NONE
Pressure (PSIA)	(3)	108	53	56	SIMULTANEOUS TEST	NONE
Relative Humidity (%)	100	100	53	56	SIMULTANEOUS TEST	NONE
Chemical Spray	H_3BO_3 NaOH	H_3BO_3 NaOH	53	56	SIMULTANEOUS TEST	NONE
Radiation	2.0×10^8	2.0×10^8	(4)	56	SEQUENTIAL TEST	NONE (5)
Aging		40 YRS.		56	SEQUENTIAL TEST	NONE
Submergence						

NOTES:

(1) To be utilized during TMI-2 accident scenario per procedure
(2) See accident profile - Temperature - Figure 3.1.1- Reference 59
(3) See accident profile - Pressure - Figure 3.1.2 - Reference 59
(4) In containment radiation level established for purchase of component
(5) Radiation exposure split into two parts - half before LOCA simulated environment test and half after

R3

SYSTEM COMPONENT EVALUATION WORK SHEET

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
	Parameter	Specification	Qualification	Specification	Qualification		
System: TMI - ALL Plant ID No.	Operating Time	(1)	30 DAYS		55	SIMULTANEOUS TEST	NONE
Component: CABLE, THERMOCOUPLE EXTENSION	Temperature (°F)	(2)	340	53	55	SIMULTANEOUS TEST	NONE
Manufacturer: SAMUEL B. MOORE	Pressure (PSIA)	(3)	120	53	55	SIMULTANEOUS TEST	NONE
Model Number: 2/C SHIELDED #16	Relative Humidity (%)	100	100	53	55	SIMULTANEOUS TEST	NONE
Function:	Chemical Spray	H_3BO_3 NaOH	H_3BO_3 NaOH	53	55	SIMULTANEOUS TEST	NONE
Accuracy: Spec: Demon: Service:	Radiation	2.0×10^8	2.0×10^8	(4)	55	SEQUENTIAL TEST	NONE (5)
Location: CONTAINMENT	Aging		40 YRS.		55,66	SEQUENTIAL TEST/ANALYSIS	NONE
Flood Level Elev: 231.2' Above Flood Level: Yes X No	Submergence						

NOTES:

(1) To be utilized during TMI-2 accident scenario per procedure
(2) See accident profile - Temperature - Figure 3.1.1 - Reference 59
(3) See accident profile - Pressure - Figure 3.1.2 - Reference 59
(4) In containment radiation level established for purchase of component
(5) Radiation exposure split into two parts - half before LOCA simulated environment and half after

R3

DOCUMENTATION REFERENCE SHEET

1. Specification CPL-R2-E3 - Containment Structure Electrical Penetrations

2. Westinghouse Letter CPL-77-550 (Electrical Penetrations)

3. Crouse-Hinds Quality Control Inspection Reports (Electrical Penetrations)

4. NPR Penetration - Steam Incident and Helium Leakage Tests - With Attached Stress Analysis Report

5. Ebasco Specification CPL-R2-E13, Electrical Cable, I&C

6. Ebasco Specification CPL-R2-E14, Electrical Cable, 4160V and 480V

7. Ebasco Specification CPL-R2-E-1, Motor Operators for Valves

8. Westinghouse Specification E-676258, Motor Operated Valves

9. Westinghouse Specification E-676270, Control Valves

10. Ebasco P.O. NY-435227 to McIntosh Equipment Corporation for Containment Level Switches

11. Ebasco Specification CPL-R2-IN-7, Level Switches

12. Westinghouse Specification 676410, Instruments, General, Inside Containment

13. Crouse-Hinds Connector Data, Electrical Penetrations

14. WCAP-7410-L, Volume I, Environmental Testing of ESF Related Equipment

15. WCAP-7410L, Volume II, Environmental Testing of ESF Related Equipment

16. WCAP-9003, Fan Cooler Motor unit Test

17. WCAP-7744-L, Environmental Testing of ESF Related Equipment

18. WCAP-7829-L, Fan Cooler Motor Unit Test

19. WCAP-8587, Environmental Qualification of Westinghouse NSSS Class 1E Equipment

20. H.B. Robinson Modification and Setpoint, Revision No. 212, MSLB Transmitter Shielding

21. Postulated Pipe Failure Analysis Outside of Containment

22. Rosemount Test Report 117415, Revision B, Model 1152 Transmitter

23. Rosemount Test Report 3788, Model 1153A Transmitter

24. Rosemount Product Data Sheet 2256, Model 1151 Transmitter

25. Rosemount Test Report 97215A, Model 1151 Transmitter

26. Rosemount Test Report 127227, Revision A, Model 1151 Transmitter

27. ASCO Service Bulletin, Solenoid Valves

28. WCAP-7153, Investigation of Chelmical Additions for Reactor Containment Sprays

29. Vendor Drawing 5379-4093, Motor Terminal Lead

30. Emergency Instructions (E.I.-1), Incident Involving Reactor Coolant System Depressurization

31. FSAR, p. 5.1.2-28, Electrical Penetrations

32. FSAR, p. 7.5-11, Environmental Capability

33. FSAR, pp. 6.3-14 to 6.3-20, Fan Cooler Evaluation

34. FSAR, p. 6.2-14, Motor Design Criteria

35. FSAR, pp. 6.2-31, 32, Pump & Valve Motor Criteria

36. FSAR, pp. 6.3-4, 6.3-10, Air Recirculation System Criteria

37. FSAR, p. 6.4-12, Containment Spray System Criteria

38. FSAR, Section 7, Amendment 7A, Component Environmental Testing Program

39. Standard Manufacturer's Testing Program to Meet Design Criteria

40. FSAR, p. 7.5-11, Operating Time Requirements

41. Rosemount Report 37821, Model 1153 Transmitter

42. Limitorque Test Report FP-3271

43. Qualification Tests for a Mocular Penetration, Report AB-11/12/13

44. Raychem Technical Report F-C4033-3, Tests of Raychem Thermofit Insulation Systems Under Simultaneous Exposure to Heat, Gamma Radiation, Steam, and Chemical Spray

45. AMP Test Report 110-11002, Qualification Test Report on AMP Radiation-Resistant PIDG Terminals

46. Continental Wire & Cable Company Technical Report F-C2935, Test of Electrical Cables Under Simulated Post-Accident Reactor Containment Service

47. ASCO Test Report AQS21678/TR, Revision A, Qualification Tests of Solenoid Valves by Environmental Exposure to Elevated Temperature, Radiation, Wear Aging, Seismic Simulation, Vibration Endurance, Accident Radiation, and LOCA Simulation

48. WCAP-9157, Environmental Qualification of Safety-Related Class 1E Process Instrumentation

49. Kerite Company Letter Dated August 5, 1980 - Enclosures: LOCA Qualification of Kerite 1000 Volt FR/FR Control Cable; LOCA Qualification of Kerite 1000 Volt HTK/FR Power Cable

50. Kerite Company Letter Dated October 21, 1980, in Response to CP&L Letter CO-02726, dated October 13, 1980, Requesting Qualification Data on Use of Scotch 70 Silicone Rubber Tape

51. Qualification Type Test Report B0003, Limitorque Valve Actuators for Class 1E Service Outside Primary Containment in Nuclear Power Station Service

52. Nuclear Qualification Test Procedure 548-8955, Revision A, dated January 7, 1981, Prepared for Babcock & Wilcox by Approved Engineering Test Laboratories

53. H.B. Robinson Steam Electric Plant-Unit 2 TMI Project Modification Design Criteria (CP&L June 1, 1980)

54. FIRL Report F-C3834, Supplementary Test of a Liquid Level Sensor Under Conditions Simulating a Loss-of-Coolant Accident Within Containment of a Nuclear Power Generating Station, dated March, 1974

55. Samuel Moore & Company, Dekoron Division, FIRL F-C3683, Qualification Tests of Electric Cables Under Conditions Simulating Normal Reactor Containment Service and a Loss-of-Coolant Accident, dated November, 1973

56. Rockbestos Company, Qualification of Firewall III Class 1E Electric Cable, dated July 7, 1977

57. Limitorque Valve Actuator Qualification for Nuclear Power Station Service, Report No. B0058

58. Final Report on the Evaluation of the Qualification of the Limitorque MOV, SMB Series Provided by the Limitorque Corporation for use in the H.B. Robinson Steam Electric Plant-Unit 2, Patel Engineers Technical Report PEI-TR_83-6-2

59. Environmental Qualification of Electrical Equipment, H.B. Robinson E. G. Plant-Unit 2, NRC-IE Bulletin 79-01B (90-Day Report), Revision 3, February 1, 1981

60. Final Report on the Evaluation of the Qualification of the Type CC-2115 Cable Provided by Continental Wire & Cable for use in the H.B. Robinson Steam Electric Plant-Unit 2, Patel Engineers Technical Report PEI-TR-83-6-10

61. Final Report on the Evaluation of the Qualification of the Thermofit Cable Splices Provided by Raychem Corporation for use in the H.B. Robinson Steam Electric Plant-Unit 2, Patel Engineers Technical Report PEI-TR-83-6-12

62. Qualification Test Report on In-Containment Cables for Carolina Power and Light Company, Raleigh, North Carolina, Wyle Laboratories Test Report 45307-1

63. Final Report on the Evaluation of the Qualification of the Model 53548-1 Connector Provided by AMP, Inc., for use in the H.B. Robinson Steam Electric Plant-Unit 2, Patel Engineers Technical Report PEI-TR-83-6-13

64. Tests of Electrical Cables Under Simultaneous Exposure to Gamma Radiation, Steam, and Chemical Spray While Electrically Energized, Franklin Institute Research Laboratory Report F-C 4020-1 & 2

65. Final Report on the Evaluation of the QUalification of the Scotch 70 Tape Provided by the 3M Company for use in the H.B. Robinson Steam Electric Plant-Unit 2, Patel Engineers Technical Report PEI-TR-83-6-14

66. Final Report on the Evaluation of the Qualification of the Thermocouple Extension Cable Provided by Samuel Moore and Company for usein the H.B. Robinson Steam Electric Plant-Unit 2, Patel Engineers Technical Report PEI-TR-83-6-11

67. Final Report on the Evaluation of the Qualification of Motors Provided by Westinghouse for use in the H.B. Robinson Steam Electric Plant-Unit 2, Patel Engineers Technical Report PEI-TR-83-6-8

68. Final Report on the Evaluation of the Qualification of the Model 176KF Thermocouples Provided by Rosemount for use in the H.B. Robinson Steam Electric Plant-Unit 2, Patel Engineers Technical Report PEI-TR-83-6-6

2.4 List of Electric Equipment Important to Safety

This section presents the list of electric equipment important to safety. This list was developed by reviewing the FSAR, Westinghouse Technical Descriptions, Emergency Instructions, System Flow Diagrams, and Plant Modifications. This list presents the equipment by the system with which it is associated. In Appendix C, Plant Safety-Related Systems and Display Instrumentation of the FRC TER, the H. B. Robinson systems list was compared with the systems requiring coverage by the DOR Guidelines and found to be acceptable. This comparison is reproduced below to aid in systems identification. Also included in the equipment list by system are in-place TMI-2 Lessons Learned equipment.

The list of electrical equipment important to safety is a dynamic one that will change with inclusion of modification packages, required design updates, mandated safety improvements, etc., and therefore, will be periodically reviewed and modified. Carolina Power & Light Company will maintain these revisions with its equipment qualification file available for audit and, upon request, availabe for future transmittal to NRC.

Function	System
Emergency Reactor Shutdown	Reactor Protection
	Engineered Safeguards Actuation
	Chemical and Volume Control
	Reactor Coolant
Containment Isolation	Main and Auxiliary Steam
	Main and Auxiliary Feedwater
	Containment Ventilation
	Chemical and Volume Control
	Safety Injection
	Residual Heat Removal
	Cooling Water
	Intake Cooling Water
Reactor Core Cooling	Safety Injection System

Function	System
Containment Heat Removal	Containment Spray
	Containment Air Recirculation
Core Residual Heat Removal	Residual Heat Removal
	Main Feedwater
	Auxiliary Feedwater
	Main Steam
	Safety Injection
	Cooling Water
Prevention of Significant Release of Radioactive Material to Environment	Containment Air Purification
	Containment Combustible Gas Control
	Post-Accident Sampling and Monitoring
Supporting Systems	Emergency Power
	HVAC

(69160NH)

LIST OF ELECTRIC EQUIPMENT IMPORTANT TO SAFETY

Notes Listed in Table

(1) Component is not exposed to DBE (located in non-harsh environment.) No qualification required.

(2) Final evaluation of qualification is pending completion of test program/receipt of test report. See schedule for further information (Section 2.2).

(3) Equipment qualified - see Evaluation Work Sheet in Section 2.3.

(4) Equipment to be replaced with a significantly more qualified unit.

(5) Equipment not used as primary source of information. No qualification required.

(6) Plant I.D. number not available.

(7) Included as part of electrical penetration assemblies.

SYSTEM: SAFETY INJECTION

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
FT-940	Flow Transmitter	Rosemount 1153A	(1)
FT-943	Flow Transmitter	Rosemount 1153A	(1)
PT-934	Pressure Transmitter	Rosemount 1153A	(1)
PT-940	Pressure Transmitter	Rosemount 1153A	(1)
PT-943	Pressure Transmitter	Rosemount 1153A	(1)
PT-950	Pressure Transmitter	Rosemount 1153A	(1)
PT-951	Pressure Transmitter	Rosemount 1153A	(1)
PT-952	Pressure Transmitter	Rosemount 1153A	(1)
PT-953	Pressure Transmitter	Rosemount 1153A	(1)
PT-954	Pressure Transmitter	Rosemount 1153A	(1)
PT-955	Pressure Transmitter	Rosemount 1153A	(1)
LS-1925A	Level Switch	Madison 5602	(5)
LS-1925B	Level Switch	Madison 5602	(5)
V-841A	Valve, Solenoid	ASCO	(1)
V-841B	Valve, Solenoid	ASCO	(1)
V-866A	Valve, Motor Operator	Limitorque SMB-00	(4)
V-866B	Valve, Motor Operator	Limitorque SMB-00	(4)
V-867A	Valve, Motor Operator	Limitorque SMB-00	(1)
V-867B	Valve, Motor Operator	Limitorque SMB-00	(1)
V-869	Valve, Motor Operator	Limitorque SMB-00	Yes (3)
V-870A	Valve, Motor Operator	Limitorque SMB-00	(1)
V-870B	Valve, Motor Operator	Limitorque SMB-00	(1)
V-878A	Valve, Motor Operator	Limitorque SMB-00	(1)

SYSTEM: SAFETY INJECTION (CONTINUED)

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
V-878B	Valve, Motor Operator	Limitorque SMB-00	(1)
V-880A	Valve, Motor Operator	Limitorque SMB-0	(1)
V-880B	Valve, Motor Operator	Limitorque SMB-0	(1)
V-880C	Valve, Motor Operator	Limitorque SMB-0	(1)
V-880D	Valve, Motor Operator	Limitorque SMB-0	(1)
SI-A	Safety Injection Pump Motor	Westinghouse 509US	(1)
SI-B	Safety Injection Pump Motor	Westinghouse 509US	(1)
SI-C	Safety Injection Pump Motor	Westinghouse 509US	(1)
CS-A	Containment Spray Pump, Motor	Westinghouse 444TS	(1)
CS-B	Containment Spray Pump, Motor	Westinghouse 444TS	(1)
C-3	Electrical Penetration	Crouse-Hinds	Yes (3)
D-2	Electrical Penetration	Crouse-Hinds	Yes (3)
D-8	Electrical Penetration	Crouse-Hinds	Yes (3)
D-9	Electrical Penetration	Crouse-Hinds	Yes (3)

SYSTEM: REACTOR COOLANT

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
LT-459	Level Transmitter	Rosemount 1153"A"	(2)
LT-460	Level Transmitter	Rosemount 1153A	(2)
LT-461	Level Transmitter	Rosemount 1153A	(2)
PT-444	Pressure Transmitter	Rosemount 1153A	(2)
PT-445	Pressure Transmitter	Rosemount 1153A	(2)
PT-455	Pressure Transmitter	Rosemount 1153A	(2)
PT-456	Pressure Transmitter	Rosemount 1153A	(2)
PT-457	Pressure Transmitter	Rosemount 1153"A"	(2)
B-2	Electrical Penetration	Crouse-Hinds	Yes (3)
B-5	Electrical Penetration	Crouse-Hinds	Yes (3)
B-9	Electrical Penetration	Crouse-Hinds	Yes (3)

SYSTEM: MAIN STEAM

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
FT-474	Flow Transmitter	Rosemount 1153A	(2)
FT-475	Flow Transmitter	Rosemount 1153A	(2)
FT-484	Flow Transmitter	Rosemount 1153A	(2)
FT-485	Flow Transmitter	Rosemount 1153A	(2)
FT-494	Flow Transmitter	Rosemount 1153A	(2)
FT-495	Flow Transmitter	Rosemount 1153A	(2)
PT-474	Pressure Transmitter	Rosemount 1151	(1)
PT-475	Pressure Transmitter	Rosemount 1151	(1)
PT-476	Pressure Transmitter	Rosemount 1151	(1)
PT-484	Pressure Transmitter	Rosemount 1151	(1)
PT-485	Pressure Transmitter	Rosemount 1151	(1)
PT-486	Pressure Transmitter	Rosemount 1151	(1)
PT-494	Pressure Transmitter	Rosemount 1151	(1)
PT-495	Pressure Transmitter	Rosemount 1151	(1)
PT-496	Pressure Transmitter	Rosemount 1151	(1)
PT 464	Pressure Transmitter	Rosemount 1151	(1)
PT 466	Pressure Transmitter	Rosemount 1151	(1)
PT 468	Pressure Transmitter	Rosemount 1151	(1)
V1-3A	Valve, Solenoid	ASCO LBX831614	(1)
V1-3B	Valve, Solenoid	ASCO LBX831614	(1)
V1-3C	Valve, Solenoid	ASCO LBS831614	(1)
B-1	Electrical Penetration	Crouse-Hinds	Yes (3)
C-1	Electrical Penetration	Crouse-Hinds	Yes (3)

SYSTEM: FEEDWATER

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
LT-474	Level Transmitter	Rosemount 1153A	(2)
LT-475	Level Transmitter	Rosemount 1153A	(2)
LT-476	Level Transmitter	Rosemount 1153A	(2)
LT-477	Level Transmitter	Rosemount 1153A	(2)
LT-484	Level Transmitter	Rosemount 1153A	(2)
LT-485	Level Transmitter	Rosemount 1153A	(2)
LT-486	Level Transmitter	Rosemount 1153A	(2)
LT-487	Level Transmitter	Rosemount 1153A	(2)
LT-494	Level Transmitter	Rosemount 1153A	(2)
LT-495	Level Transmitter	Rosemount 1153A	(2)
LT-496	Level Transmitter	Rosemount 1153A	(2)
LT-497	Level Transmitter	Rosemount 1153A	(2)
V-478	Valve, Solenoid	ASCO RU8302B26	(1)
V-479	Valve, Solenoid	ASCO RU8302B26	(1)
V-488	Valve, Solenoid	ASCO RU8302B26	(1)
V-489	Valve, Solenoid	ASCO RU8302B26	(1)
V-498	Valve, Solenoid	ASCO RU8302B26	(1)
V-499	Valve, Solenoid	ASCO RU8302B26	(1)
AFW-A	Feedwater Pump, Motor	Westinghouse 509US	(1)
AFW-B	Feedwater Pump, Motor	Westinghouse 509US	(1)
C-1	Electrical Penetration	Crouse-Hinds	Yes (3)
C-2	Electrical Penetration	Crouse-Hinds	Yes (3)
C-4	Electrical Penetration	Crouse-Hinds	Yes (3)
C-9	Electrical Penetration	Crouse-Hinds	Yes (3)

SYSTEM: AUXILIARY COOLING

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
V-626	Valve, Motor Operator	Limitorque SMB-00	(1)
V-716A	Valve, Motor Operator	Limitorque SMB-00	(1)
V-716B	Valve, Motor Operator	Limitorque SMB-00	(1)
V-730	Valve, Motor Operator	Limitorque SMB-00	(1)
V-735	Valve, Motor Operator	Limitorque SMB-00	(1)
V-744A	Valve, Motor Operator	Limitorque SMB-3	(4)
V-744B	Valve, Motor Operator	Limitorque SMB-3	(4)
RHR-A	Residual Heat Removal Pump, Motor	Westinghouse 506UPZ	Yes (3)
RHR-B	Residual Heat Removal Pump, Motor	Westinghouse 506UPZ	Yes (3)
V-860A	Valve, Motor Operator	Limitorque SMB-0	Yes (3)
V-860B	Valve, Motor Operator	Limitorque SMB-0	Yes (3)
V-861A	Valve, Motor Operator	Limitorque SMB-0	Yes (3)
V-861B	Valve, Motor Operator	Limitorque SMB-0	Yes (3)
V-863A	Valve, Motor Operator	Limitorque SMB-00	Yes (3)
V-863B	Valve, Motor Operator	Limitorque SMB-00	Yes (3)
D-2	Electrical Penetration	Crouse-Hinds	Yes (3)

SYSTEM: REACTOR PROTECTION

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
TE-412B	Temperature Element	Rosemount 176KF	Yes (3)
TE-412D	Temperature Element	Rosemount 176KF	Yes (3)
TE-422B	Temperature Element	Rosemount 176KF	Yes (3)
TE-422D	Temperature Element	Rosemount 176KF	Yes (3)
TE-432B	Temperature Element	Rosemount 176KF	Yes (3)
TE-432D	Temperature Element	Rosemount 176KF	Yes (3)
C-4	Electrical Penetration	Crouse-Hinds	Yes (3)
C-9	Electrical Penetration	Crouse-Hinds	Yes (3)

SYSTEM: SERVICE AND COOLING WATER

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
SW-A	Service Water Pump, Motor	Westinghouse 509P20	(1)
SW-B	Service Water Pump, Motor	Westinghouse 509P20	(1)
SW-C	Service Water Pump, Motor	Westinghouse 509P20	(1)
SW-D	Service Water Pump, Motor	Westinghouse 509P20	(1)
SWB-A	Service Water Booster Pump, Motor	Westinghouse 404TS	(1)
SWB-B	Service Water Booster Pump, Motor	Westinghouse 404TS	(1)

SYSTEM: CHEMICAL AND VOLUME CONTROL

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
CVC-200A	Valve, Solenoid	ACSO 206-381-2U	Yes (3)
CVC-200B	Valve, Solenoid	ASCO 206-381-2U	Yes (3)
CVC-200C	Valve, Solenoid	ASCO 206-381-2U	Yes (3)
CVC-381	Valve, Motor Operator	Limitorque SMB-000	Yes (3)
C-3	Electrical Penetration	Crouse-Hinds	Yes (3)
D-9	Electrical Penetration	Crouse-Hinds	Yes (3)

SYSTEM: HVAC

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
V12-6	Valve, Solenoid	ASCO LB8211C32	(1)
V12-7	Valve, Solenoid	ASCO NP831665E	Yes (3)
V12-8	Valve, Solenoid	ASCO LB8316B25	(1)
V12-9	Valve, Solenoid	ASCO NP8316E35E	Yes (3)
V12-10	Valve, Solenoid	ASCO LB8316B15	(1)
V12-11	Valve, Solenoid	ASCO NP8316E35E	Yes (3)
V12-12	Valve, Solenoid	ASCO LB8316B15	(1)
V12-13	Valve, Solenoid	ASCO NP8316E35E	Yes (3)
HVH-1	Fan, Motor	Westinghouse 685.5-S	Yes (3)
HVH-2	Fan, Motor	Westinghouse 685.5-S	Yes (3)
HVH-3	Fan, Motor	Westinghouse 685.5-S	Yes (3)
HVH-4	Fan, Motor	Westinghouse 685.5-S	Yes (3)
C-3	Electrical Penetration	Crouse-Hinds	Yes (3)
C-6	Electrical Penetration	Crouse-Hinds	Yes (3)
C-8	Electrical Penetration	Crouse-Hinds	Yes (3)
D-1	Electrical Penetration	Crouse-Hinds	Yes (3)
D-3	Electrical Penetration	Crouse-Hinds	Yes (3)
D-5	Electrical Penetration	Crouse-Hinds	Yes (3)

SYSTEM: EMERGENCY POWER SUPPLY REQUIREMENTS FOR THE PRESSURIZER HEATERS, POWER OPERATED RELIEF AND BLOCK VALVES, AND PRESSURIZER LEVEL INDICATORS IN PWR'S (NUREG-0578, PARA. 2.1.1)

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
(6)	Switch, Control	GEMCO 404S2X4111	(1)
2/C Shielded #16	Instrumentation Cable	Samuel Moore	Yes (3)

SYSTEM: INFORMATION TO AID OPERATORS IN ACCIDENT DIAGNOSIS AND CONTROL (NUREG-0578, PARA. 2.1.3)

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
(6)	Accelerometer	Endevco 2273AM20(A)	(2)
(6)	Accelerometer	Endevco 2273AM20(B)	(2)
(6)	Accelerometer	Endevco 2273AM20(C)	(2)
(6)	Preamplifier	Unholtz-Dickie #22CA-2TR(A)	(2)
(6)	Preamplifier	Unholtz-Dickie #22CA-2TR(B)	(2)
(6)	Preamplifier	Unholtz-Dickie #22CA-2TR(C)	(2)
(6)	Signal Conditioner	Unholtz-Dickie #P22MHA-1(A)	(1)
(6)	Signal Conditioner	Unholtz-Dickie #P22MHA-1(B)	(1)
(6)	Signal Conditioner	Unholtz-Dickie #P22MHA-1(C)	(1)
(6)	Relay	Westinghouse NBFD-2S	(1)
(6)	Relay	Westinghouse NBFD-22S	(1)
(6)	Core Cooling Monitor	Westinghouse 6083D83601A(A)	(1)
(6)	Core Cooling Monitor	Westinghouse 6083D83601A(B)	(1)
PT-500	Pressure Transmitter	Rosemount 1153A	(2)
PT-501	Pressure Transmitter	Rosemount 1153A	(2)
PT-456	Pressure Transmitter	Rosemount 1153A	(2)
PT-457	Pressure Transmitter	Rosemount 1153A	(2)
2/C Shielded #16	Instrumentation Cable	Samuel Moore	Yes (3)
3/C #12	Power Cable		(1)
2/C Shielded #16	Thermocouple Extension Cable		(1)
Heat Shrink Tubing	Cable Splice	Raychem	Yes (3)
AMP #16	Terminal Lug		Yes (3)
2/C #14	Instrumentation Cable		(1)

SYSTEM: CONTAINMENT ISOLATION PROVISIONS FOR PWR'S AND BWR'S (NUREG-0578, PARA. 2.1.4)

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
(6)	Valve, Solenoid	ASCO-LB-8320A-185	Yes (3)
(6)	Switch, Selector	GEMCO 404S34122EE8	(1)
(6)	Relay	Westinghouse NBFD-22A	(1)
(6)	Switch, Reset	GEMCO 404P1331-PP1	(1)
2/C #14	Instrumentation Cable		(1)
5/C #14	Instrumentation Cable		(1)
2/C Shielded #16	Instrumentation Cable		(1)
2/C Shielded #14	Instrumentation Cable		(1)
Heat Shrink Tubing	Cable Splice		(1)
AMP #16	Terminal Lug		(1)

SYSTEM: IMPROVED AUXILIARY FEEDWATER SYSTEM RELIABILITY FOR PWR'S (NUREG-0578, PARA. 2.1.7)

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
FT- 1425A	Transducer	Controlotron 240N-4CS80HT	(1)
FT- 1425B	Transducer	Controlotron 240N-4CS80HT	(1)
FT- 1425C	Transducer	Controlotron 240N-4CS80HT	(1)
FT- 1426A	Transducer	Controlotron 240N-4CS80HT	(1)
FT- 1426B	Transducer	Controlotron 240N-4CS80HT	(1)
FT- 1426C	Transducer	Controlotron 240N-4CS80HT	(1)
(6)	Computer, Flow	Controlotron 241N	(1)
(6)	Meter, Panel	Controlotron 242N-4	(1)
2/C #12	Power Cable		(1)

SYSTEM: INSTRUMENTATION TO FOLLOW THE COURSE OF AN ACCIDENT (NUREG-0578, PARA. 2.1.8)

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
(6)	Monitor, Radiation	Victoreen 856-857-858	(1)
(6)	Monitor, Radiation	Victoreen 856-857-858	(1)
2/C #16	Instrumentation Cable		(1)
9/C #18	Instrumentation Cable		(1)

SYSTEM: SAFETY INJECTION (CONTAINMENT WATER LEVEL) (ACRS-2)

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
LT-801A	Level Transmitter	Gems XM52495	(2)
LT-801B	Level Transmitter	Gems XM52495	(2)
LT-801C	Level Transmitter	Gems XM52495	(2)
LT-801D	Level Transmitter	Gems XM52495	(2)
LT-801E	Level Transmitter	Gems XM36495	(2)
LT-802A	Level Transmitter	Gems XM52495	(2)
LT-802B	Level Transmitter	Gems XM52495	(2)
LT-802C	Level Transmitter	Gems XM52495	(2)
LT-802D	Level Transmitter	Gems XM52495	(2)
LT-802E	Level Transmitter	Gems XM36495	(2)
(6)	Receiver	Gems RE-36562	(1)
3/C Shielded #16	Instrumentation Cable		Yes (3)
4/C Shielded #16	Instrumentation Cable		Yes (3)
3/C #12	Power Cable		Yes (3)
AMP #16 Insulated	Terminal Lug		Yes (3)
Heat Shrink Tubing	Cable Splice		Yes (3)

SYSTEM: VARIOUS

COMPONENTS

Plant I.D. No.	Generic Name	Manufacturer/Model	Qualified
2/C Shielded #16	Instrumentation Cable	Continental Wire & Cable	Yes (3)
AMP #16/9 Insulated	Terminal Lug	AMP	Yes (3)
3/C #19/22	Cable	Kerite	Yes (3)
Heat Shrink Tubing	Cable Splice	Raychem	Yes (3)
Silicone Rubber Tape #70	Connection Protection	3M-Scotch	Yes (3)
2/C #16, 3/C #16	Control Cable	Kerite	Yes (3)
1C 500 MCM	Power Cable	Kerite	(1)
Crouse-Hinds RPC-317-160-SOIN/ S08N	Connector, Electrical	Crouse-Hinds	Yes (7)
Crouse-Hinds RPC-117-150-POIN/ P08N	Connector, Electrical	Crouse-Hinds	Yes (7)

3.0 RESPONSE TO NRC SAFETY EVALUATION REPORT FOR ENVIRONMENTAL QUALIFICATION OF SAFTEY RELATED ELECTRICAL EQUIPMENT FOR H. B. ROBINSON STEAM ELECTRIC PLANT UNIT NO. 2

3.1 Resolution of Deficiencies Identified in FRANKLIN RESEARCH CENTER Technical Evaluation Report

This section is divided into two (2) areas. The first responds to the FRC TER qualification deficiencies identified in Tables 4-1, 4-2, 4-3, and 4-4. The second responds to the questions transmitted by the NRC Safety Evaluation Report, dated January 5, 1983.

The FRC TER combines the H. B. Robinson Master List equipment and the SCEW sheets into a generic list presented in tabular form on page 4-21 of the TER, titled Equipment Environmental Qualification, Equipment Item Checksheet Index H. B. Robinson 2. Thirty-two (32) components are listed. Each of these components will be addressed in the same sequence as in the TER with a critique on its re-evaluation and current classification which is utilized in Section 2.1, List of Qualified Equipment, and Section 2.2, Schedule for Achievement of Compliance to Equipment Qualification per 10CFR50.49. Technical information used in re-evaluation is referenced within the critiques and is located within the Addendum (Section 4.0 of this report) to maintain brevity in this section.

3.1.1 Resolution of Major Deficiencies Identified in FRC TER

TER Equipment Item No. 1
Solenoid Valve Located in the Reactor Auxiliary Building
ASCO Model LB8320A185

The ASCO solenoid valve (TMI Action Plan Item II.E.4.2) is a commercial grade unit which has not been subjected to IEEE 323-1974 environmental qualification. A materials list has been obtained and an analysis performed to determine its suitability. The operating temperature of Model 8320 was questioned in the TER. The procured and installed ASCO valve model LB has a high temperature coil rated at 130°C operation. Since these valves are equipped with high-temperature coils, the ambient temperatures are not high enough to cause a problem. A radiation analysis has been performed and an acceptable level for the valve established. The radiation levels at the location have been reviewed and found to be 2.5×10^5.

TER Equipment Item No.'s 2, 3, and 4
Solenoid Valves Located in Containment
ASCO Models NP831665E, NP8316E35E, 206-381-2U
Plant I.D. V12-7, -9, -11, -13; CVC-200A, B, C

No deficiencies were identified for these items.

TER Equipment Item No. 5
Motorized Valve Actuator Located in Containment
Limitorque Model SMB-00 with Peerless Motor, Class B Insulation
Quantity (Plant I.D.): 2 (V-866A, B)

The subject MOV's, required for actuation of hot leg injection valves, have not yet been qualified for inside containment accident and post-accident service at H. B. Robinson Unit 2. Carolina Power & Light Company proposes to modify the MOV's with suitably qualified equipment. Under review is the redesigned Limitorque drive motor developed especially for Class IE operation. Limitorque is currently pursuing qualification of this equipment to IEEE Standard 323-1974. As soon as qualification documentation is made available and reviewed against the H. B. Robinson Unit 2 requirements, a decision to replace the motors will be made. Refer to Section 2.2 for proposed action on this item.

TER Equipment Item No. 6
Motorized Valve Actuators Located in Containment
Limitorque Model SMB-3 with Reliance Motor (Class H Insulation)
Motor Brake, Class B Insulation
Quantity (Plant I.D.): 2 (V-744A, B)

The subject MOV's required for actuation of reactor core deluge valves, have not yet been qualified for inside containment accident and post-accident service at H. B. Robinson Unit 2. Carolina Power & Light Company proposes to replace the MOV's with suitably qualified equipment. Carolina Power & Light Company is considering using Limitorque Model SB actuators as replacement items. Limitorque is currently pursuing qualification of this equipment to IEEE Standard 323-1974. As soon as qualification documentation is made available and reviewed against the H. B. Robinson Unit 2 requirements, a decision to replace the actuators will be made. Refer to Section 2.2 for proposed action on this item.

TER Equipment Item No.'s 7 & 8
Motorized Valve Actuators Located in the Reactor Auxiliary Building
Limitorque SMB-000, SMB-00, SMB-0
Plant I.D.: V-860A, B; V-861A, B; V-863A, B; V-869; CVC-381

The TER questioned the adequacy of the qualification evidence, similarity, aging degradation, and qualified life. A report, based on test documentation not previously referenced, has been prepared which shows these actuators to be qualified for use at H. B. Robinson Unit 2. Based on this documentation, these items are considered qualified and have been entered into Section 2.1, List of Qualified Equipment.

(Reference Patel Engineers Technical Report PEI-TR-83-6-2; Technical sections of this report are included in Section 4.0, Addendum.)

TER Equipment Item No.'s 9, 10, 11
Flow and Pressure Transmitters Located in Reactor Auxiliary Building
Fisher and Porter Model Nos. 10B2496 and 50EP1041
Quantity (Plant I.D.):
2 Flow (FT-940, FT-943)
3 Pressure (PT-934, PT-940, PT-943)

These items have been replaced under CP&L's program of updating H. B. Robinson Unit 2 transmitters which began prior to the NRC electrical equipment qualification program. Therefore, no additional review will be made of these items. The instrumentation identified under these item numbers have been transferred to SCEW Sheet No. 19 as replaced equipment.

TER Equipment Item No.'s 12, 13, 14, 15
Pressure, Level, and Flow Transmitters Located in Containment
Rosemount Model 1153 Series A
Quantity (Plant I.D.):
7 Pressure (PT-444, PT-445, PT-455, PT-456, PT-457, PT-500, PT-501)
16 Level (LT-459, LT-460, LT-461, LT-474, LT-475, LT-476, LT-477, LT-484, LT-485, LT-486, LT-487, LT-494, LT-495, LT-496, LT-497)
6 Flow (FT-474, FT-475, FT-484, FT-485, FT-494, FT-495)

The Rosemount Model 1153 Series A transmitters located in containment have not yet been qualified for accident and post-accident service at H. B. Robinson Unit 2. It is CP&L's understanding that Rosemount has completed a test program on their Model 1153 Series D units demonstrating qualification to IEEE Standard 323-1974. The test report is scheduled to be available in mid-June, 1983. When available, the test report will be reviewed to ascertain applicability to H. B. Robinson Unit 2 transmitters. Series A and D transmitters are generically similar units and it is judged that a similarity analysis to supplement the test report will provide conclusive qualification documentation. In the event that additional analysis does not provide adequate evidence of qualification, the possibility of upgrading the installed units to Series D configuration will be investigated.

Refer to Section 2.2 for proposed action on this item.

TER Equipment Item No.'s 16 & 17
Level Transmitters Located in Containment
Gems Models XM52495 and SM36495
Quantity (Plant I.D.): 8 (LT-801A, B, C, D; LT-802A, B, C, D)

The Gems level transmitters located in containment have not yet been qualified for accident and post-accident service at H. B. Robinson Unit 2. Generically similar units have completed qualification testing to IEEE Standard 323-1974 by the manufacturer. It is CP&L's

intention to qualify the installed units by demonstrating similarity on the component level to the units under test. When available, the test report will be reviewed and a similarity analysis performed to generate conclusive qualification documentation.

Refer to Section 2.2 for proposed action on this item.

TER Equipment Item No. 18
Temperature Element Located in Containment
Rosemount Model No. 176KF
Quantity (Plant I.D.): 6 (TE412B, D; TE422B, D; TE432B, D)

The TER questioned the adequacy of the evidence of qualification, aging degradation, qualified life, temperature/pressure duration, spray criteria, functional testing, and instrument accuracy. Data which addresses the aging mechanisms of the materials in these RTD's has been used to establish a qualified life. Analysis of the test data and operating requirements shows the test duration, spray, and instrument accuracy to be adequate. A report was prepared which shows this qualification.

(Reference Patel Engineers Technical Report PEI-TR-83-6-6; Technical sections of this report are included in Section 4.0, Addendum.)

TER Equipment Item No. 19
Level Switch Located in Containment
Madison Model 5602
Plant I.D.: LS-1925A, B

These switches are no longer used as the primary source of information. They no longer serve a primary safety function and, therefore, need not be qualified.

Refer to NRC SER on H. B. Robinson Unit No. 2 JCO's, dated March 29, 1983, for further evaluation.

TER Items No.'s 20 & 21
Accelerometers and Preamps Located in Containment
Endevco 2273AM20 and Unholtz-Dickie 22CA-2TR
Plant I.D.: Not Given

These items were identified as being in a test program. The test program is due for completion in June, 1983. No deficiencies were otherwise identified.

Refer to Section 2.2 for proposed action on these items.

TER Item No.'s 22 & 23
Motors Located in Containment and in the Reactor Auxiliary Building
Westinghouse Models 685.5S and 506UPZ
Plant I.D.: HVH-1, 2, 3, 4; RHR-A, B

The TER questioned the adequacy of the evidence of qualification, similarity, aging degradation, and qualified life. Reports and documentation from Westinghouse not previously referenced have been used in reports to show these motors to be qualified to the H. B. Robinson Unit 2 environment. This report addresses all deficiencies identified in the TER. (Reference - Patel Engineers Technical Report PEI-TR-83-6-10 - Technical sections of this report are included in Section 4.0, Addendum.) Based on the referenced documentation, these items are considered qualified and have been entered into Section 2.1, List of Qualified Equipment.

TER Item No. 24
Electrical Penetration Assemblies
Crouse-Hinds
Plant I.D.: B-1, -2, -5, -9; C-1, -2, -3, -4, -6, -8, -9; D-1, -2, -3, -5, -8, -9

The TER identified these items as not having their documentation made available. This documentation was previously sent to FRC in 1982 at their request but was apparently not used in their review. A duplicate set of documentation has been included with this submittal for evaluation purposes. This item is considered qualified per CP&L evaluation and appears in Section 2.1, List of Qualified Equipment. No other deficiencies were identified.

TER Equipment Item No. 25
Electrical Cable Located in Containment
Continental Wire & Cable CC-2115

The TER identified deficiencies associated with aging degradation, qualified life, temperature/pressure duration, and chemical spray. The test report was reviewed and supplementary information obtained which shows the cable to be qualified for use in H. B. Robinson Unit 2. A report has been prepared which shows the cable to be qualified for use in H. B. Robinson Unit 2. This report shows that all deficiencies identified are addressed.

(Reference Patel Engineers Technical Report PEI-TR-83-6-10; Technical Sections of this report are included in Section 4.0, Addendum.)

TER Equipment Item No.'s 26, 27, & 28
Electrical Cable
Kerite and Rockbestos

No deficiencies were identified for these cables.

TER Equipment Item No. 29
Electrical Cable
Samuel Moore

The TER identified aging degradation and qualified life as the deficiencies for this item. An analysis was performed using the test documentation and additional data to establish a qualified life. This resolves the deficiency identified. The qualified life established was in excess of 40 years.

(Reference Patel Engineers Technical Report PEI-TR-83-6-11; Technical sections of this report are included in Section 4.0, Addendum.)

TER Equipment Item No. 30
Electrical Cable Splice
Raychem

The TER identified aging degradation and qualified life as the deficiencies for this item. An analysis was performed using the test documentation and additional data to establish a qualified life. This resolves the deficiency identified. The qualified life established was in excess of 40 years.

(Reference Patel Engineers Technical Report PEI-TR-83-6-12; Technical sections of this report are included in Section 4.0, Addendum.)

TER Equipment Item No. 31
Electrical Connector
AMP 53548-1

The TER identified the deficiency for this item as inadequate similarity between test and installed equipment. These items were part of another test program and were qualified to the H. B. Robinson Unit 2 environment. A report was prepared which shows this qualification.

(Reference Patel Engineers Technical Report PEI-TR-83-6-13; Technical sections of this report are included in Section 4.0, Addendum.)

TER Equipment Item No. 32
Electrical Tape
3M Scotch 70

The TER identified similarity of tested and installed equipment as the deficiency. Additional test reports were used in preparing a report which documents the qualification of this item to H. B. Robinson Unit 2.

(Reference Patel Engineers Technical Report PEI-TR-83-6-14; Technical sections of this report are included in Section 4.0, Addendum.)

3.1.2 Response to Questions Included in NRC Safety Evaluation Report (SER) dated January 5, 1983

Justification for Continued Operation

The SER required submission of justification for continued operation (JCO) for items in NRC categories IB, IIA, and IIB for which such information was not previously submitted to NRC or FRC. By letter dated February 11, 1983, CP&L responded to this request by indicating that necessary justification has been provided in previous submittals. This conclusion was based on a review of the material previously submitted and the TER-Appendix D conclusions. Subsequent telephone communications with NRC determined the need to submit additional JCO information on IIB Item Nos. 16 and 17. CP&L submitted this JCO information by letter on March 4, 1983 to NRC for review. After review NRC issued an SER transmitted by letter, dated March 29, 1983, which accepted all Category IIB items as justified for continued operation.

NRC has transmitted a "clarification" letter concerning JCO response dated April 28, 1983, which requires a re-review of H. B. Robinson Unit No. 2 Categories IB, IIA and IV items. This is currently an on-going effort for compliance and will be addressed by CP&L in the response to that letter.

Resolution of Deficiencies of Equipment Assigned to NRC Category IIB

Resolution is identified within Section 3.1.1 under the stated equipment item numbers 12, 13, 14, 15, 16, and 17.

Resolution of Submergence

The concern regarding submergence asks for an evaluation of the effect of submergence on specific level transmitters and in general for equipment outside containment. A study will be performed to evaluate the effect of new mounting of the transmitters, the rate of flood to determine useful time, and the effects of emergency procedures on requirement for these instrument readings. For equipment outside containment, modifications to Auxiliary Building areas due to fire protection requirements will be studied to evaluate drain paths and water accumulations. Existing reports document no detrimental effects due to water build-up, but do not account for recent modifications. A report on both these studies concerning submergence of safety-related electrical equipment in harsh environment areas and the Auxiliary Building will be completed by March 31, 1985.

Operating Times

Review of operating procedures, emergency procedures, and previous submittals indicates that the operating times shown on SCEWS are appropriate. All items required for long-term mitigation of an event are identified in the master list given in Revision 3 of H. B.

Robinson Unit 2 79-01B submittal. A separate submittal was made for Regulatory Guide 1.97 equipment and a schedule for compliance was included. This was transmitted to NRC on April 15, 1983.

As additional equipment is added to the list of safety-related items, operating times will be reviewed for inclusion on the appropriate SCEWS.

Temperature Profile Outside Containment and Radiation

The staff requested additional information to resolve concerns regarding the acceptability of the temperature profile outside containment and radiation levels postulated to exist following a LOCA. Review of previous submittals and the Franklin TER did not reveal anything which would change the positions presented in those previous submittals. The Franklin TER stated within Sections 4.3.2.3 and 4.3.2.4 that a satisfactory response to the NRC concerns were provided. If additional specific information is required, it can be provided upon request. However, we do not feel complete resubmission of previous information is necessary at this time.

3.2 Proprietary Information Review

As requested within the initial H. B. Robinson Unit No. 2 NRC SER letter dated January 5, 1983, a review of the TER was performed in conjunction with equipment suppliers who had designated their evaluations as proprietary. Due to extended time in responding by suppliers, a delay in CP&L's response on this issue was requested and granted by NRC. After all responses were received, a summary letter was sent to NRC on March 18, 1983 listing the items, Equipment and SER page numbers which were still stated to be proprietary. All other proprietary pages not specifically mentioned in this letter have been released by the suppliers from their prior proprietary classification.

The March 18, 1983 letter conforms with the requirements of the SER and does not need further updating at this time.

TECHNICAL REPORT
PEI-TR-83-6-2
April 14, 1983

FINAL REPORT ON THE EVALUATION OF THE QUALIFICATION OF THE LIMITORQUE MOV, SMB SERIES PROVIDED BY THE LIMITORQUE CORPORATION FOR USE IN THE H.B. ROBINSON STEAM ELECTRIC PLANT - UNIT 2

by
Michael M. Hall

Prepared for

CAROLINA POWER AND LIGHT COMPANY
Raleigh, North Carolina

Contract No.: 82-NPED-04
PEI Job No.: 8310

patel engineers
huntsville, alabama

REPORT NO.: PEI-TR-83-6-2

PREPARED BY: Michael M. Hall, Sr. Project Engineer

TWH

APPROVED BY: Ralph L. Morris, Director

Q.A. REVIEW: M.J. Kimbrell, Director, Product Assurance

ORIGINAL ISSUE: April 14, 1983

REVISIONS

REV. NO.	REV. DATE	REV. BY	CHECKED BY	Q.A. BY	DESCRIPTION OF CHANGES AND PAGES REVISED

TABLE OF CONTENTS

INTRODUCTION AND SUMMARY

This document is designed to assess qualification documentation of Class 1E equipment to the H.B. Robinson Steam Electric Plant - Unit 2 (HBR-2) specific requirements. It is divided into four (4) sections. They are as follow:

SECTION I. EQUIPMENT IDENTIFICATION/QUALIFICATION REQUIREMENTS

SECTION II. QUALIFICATION DOCUMENTATION ASSESSMENT

SECTION III. QUALIFICATION JUSTIFICATION ANALYSIS

SECTION IV. CONCLUSIONS

The Limitorque valve actuators assessed (see below) were judged qualified to all postulated normal and accident conditions within the Reactor Auxiliary Building at HBR-2. This conclusion applies to MOV's with Class B motors fitted with either melamine or phenolic limit and torque switches.

Plant I.D.	Model	System	Safety-Related Function
CVC-381	SMB-000	Chemical and Volume	Reactor Coolant Pump Seal Water Return
V-860A, B	SMB-0	Auxiliary Cooling	CV Sump to RHR Suction
V-861A, B	SMB-0	Auxiliary Cooling	CV Sump to RHR Suction
V-863A, B	SMB-00	Auxiliary Cooling	RHR Discharge to SI Spray System
V-869	SMB-00	Safety Injection	Hot Leg Injection Boron Injection

SECTION I. EQUIPMENT IDENTIFICATION/QUALIFICATION REQUIREMENTS

1. **EQUIPMENT DESCRIPTION**

System: See Introduction & Summary

Component I.D.: See Introduction & Summary

Manufacturer: Limitorque

Equipment Type: MOV

Serial No.: N/A

Model No.: See Introduction & Summary

Location: Reactor Auxiliary Building

Safety-Related Function: See Introduction and Summary

2. **QUALIFICATION SPECIFICATIONS**

a. **Applicable Standards**

DOR Guidelines	X
NUREG-0588, Cat. I	
NUREG-0588, Cat. II	

b. **Normal Service Conditions**

Temperature: 100^{o}F Maximum, 85^{o}F Average, 70^{o}F Minimum

Pressure: Atmospheric

Radiation: Negligible

Relative Humidity: 20% to 90%

Cycling: 50 cycles per year

Voltage: 440 VAC, 3-Phase

Current: Various

Frequency: 60 Hz

c. **Design Basis Events**

Temperature:	100^{o}F Maximum
Operating Time:	30 days
Radiation:	$1.1x10^{6}$ rads gamma (includes 10% margin)
Relative Humidity:	20% to 90%
Submergence:	Yes ____ No X
Chemical Spray:	Yes ____ No X
Mode:	Active X Passive ____ Fail-Safe ____

SECTION II. QUALIFICATION ASSESSMENT

1. **QUALIFICATION DOCUMENTATION**

a. **Title:** Limitorque Valve Actuator Qualification for Nuclear Power Station Service

Report No.: B0058 **Date:** January 11, 1980

Source: Limitorque Corporation

2. **QUALIFICATION DOCUMENTATION ANALYSIS**

a. **Design Basis Event Analysis**

LOCA Simulation Profiles: See Figures 1 and 2.

	Yes	No*	N/A
1) Are all peak temperature/pressure and time requirements during the transient phase enveloped?			X
2) Are all temperature/pressure and time requirements during the post-accident phase enveloped?		X	
3) Are margins as applied consistent with those defined in NUREG-0588, IEEE 323-1974, and/or the DOR Guidelines, as applicable?	X		
4) Are the functional tests as performed adequate to demonstrate that the functional requirements (accuracy, repeatability, insulation resistance, etc.) for the equipment can be met?	X		
5) Was the accident radiation requirement enveloped by the test? If yes, to what level? 2.0×10^7 rads gamma*	X		
6) If submergence is a requirement, does the test demonstrate acceptable operation?			X

	Yes	No*	N/A
7) Was the requirement for chemical spray enveloped?			X
8) Were all known synergisms accounted for in the test sequence?	X		
9) If failures occurred during the test program, are adequate justifications provided in the form of a failure analysis such that the qualification is not negated?	X		

* Note: Reference 1.a, Appendix D (Report B0003) documents testing to $2.0x10^7$ rads gamma for actuators fitted with phenolic limit and torque switches. Reference 1.a, Appendix B (Report 600376A) documents testing to $2.04x10^8$ rads gamma for actuators fitted with melamine limit and torque switches.

b. **Normal Service Conditions Analysis**

	Yes	No*	N/A
1) Does the aging analysis provided in the supporting documentation provide for a 40-year qualified life at the HBR-2 defined service temperature?		X	
2) Was the aging analysis performed using Arrhenius techniques?		X	
3) Is the aging analysis auditable?		X	
4) Was the radiation requirement accomplished by the radiation test?	X		
5) If any radiation exemptions were utilized, are they auditable?			X
6) Was the operational cycle aging requirement accomplished by the cycle aging test?	X		
7) If any cycle aging exemptions were utilized, are they auditable?			X

		Yes	No*	N/A
8)	Did the equipment perform successfully at the extremes of its normal service conditions (temperature, radiation, pressure, voltage, current, humidity, etc.) as required by IEEE 323-1974 and NUREG-0588?	X		
9)	Were the functional tests performed adequate to demonstrate operability parameters as seen in service?	X		
10)	Are the acceptance/failure criteria clearly defined?	X		
11)	If failures occurred during the test program, are adequate justifications provided in the form of a failure analysis such that the qualification is not negated?			X
12)	Are all known synergisms accounted for in the test program?	X		

* All questions marked "No" require additional analysis to justify qualification. Section III of this report contains the additional analysis to resolve the qualification deficiencies and justify qualification.

3. CONCLUSIONS AND RECOMMENDATIONS

Reference 1.a fulfills all requirements of the DOR Guidelines except for those items listed in Paragraph 4, below.

4. OUTSTANDING ITEMS REQUIRING RESOLUTION

- o Time-Temperature Effects
- o Degradation Equivalency
- o Reference Auditability

Section III of this document provides additional analyses to resolve these outstanding items.

F-C3441

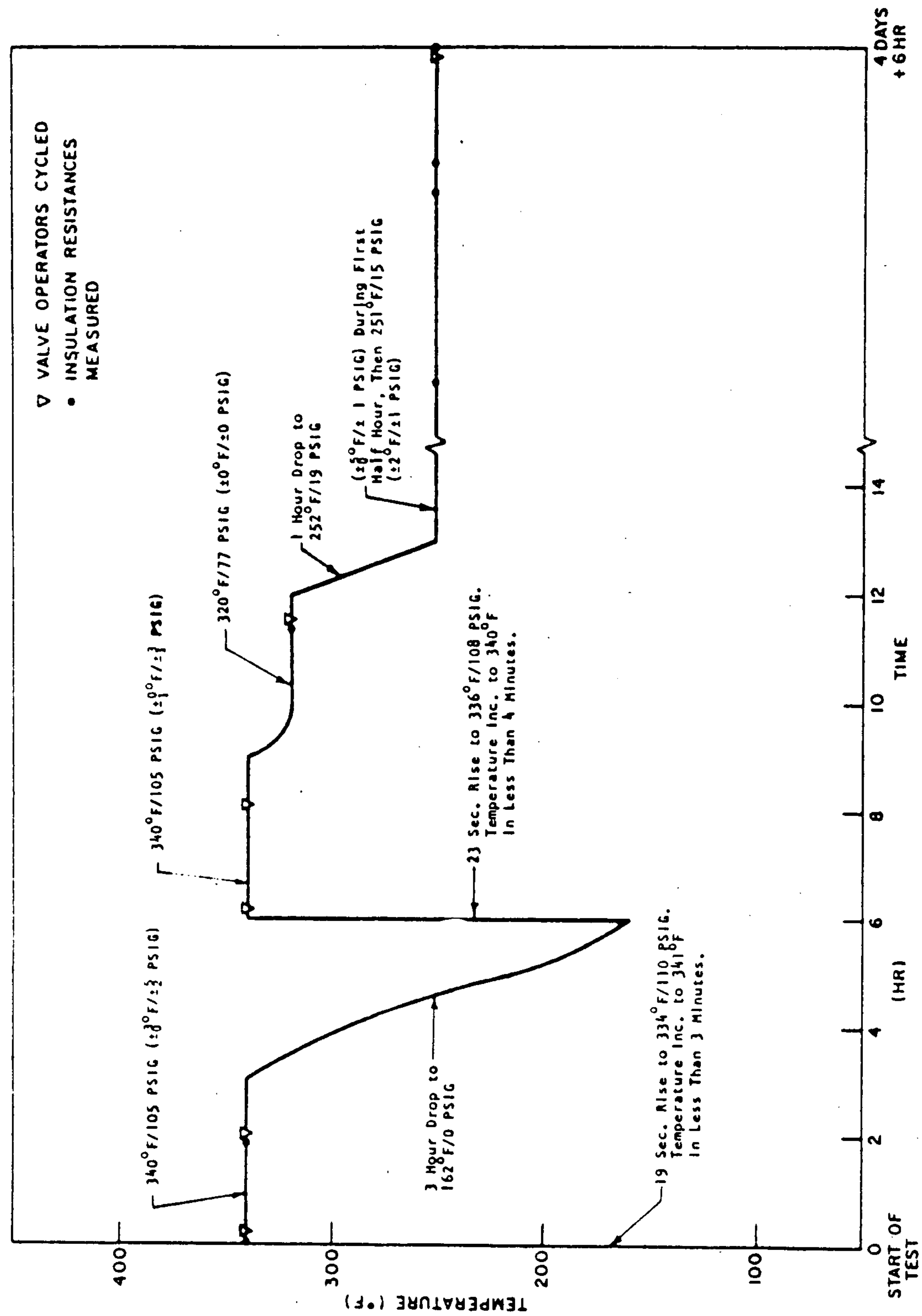


FIGURE 1

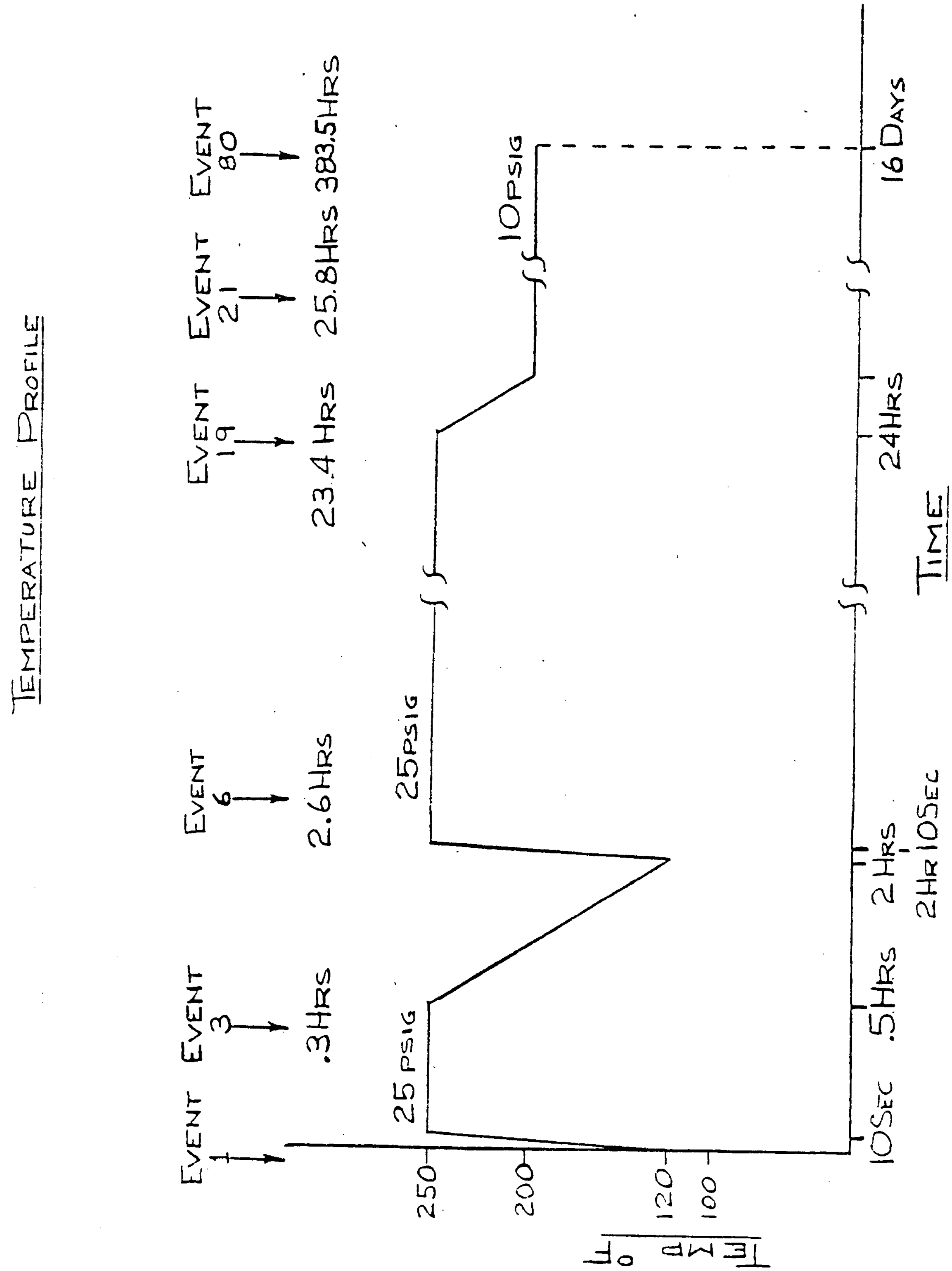

TEMPERATURE PROFILE
EVENT 1
EVENT 3
EVENT 6
EVENT 19
EVENT 21
EVENT 80
.3HRS
2.6HRS
23.4 HRS
25.8HRS
383.5HRS
25 PSIG
25PSIG
10PSIG
250
200
120
100
TEMP °F
10SEC
.5HRS
2 HRS
2HR 10SEC
24HRS
16 DAYS
TIME

FIGURE 2

SECTION III. QUALIFICATION JUSTIFICATION ANALYSIS

Where qualification parameters are not clearly defined, when new research highlights potential problem areas, or when the plant requirements are not met, analysis must be performed to augment the existing qualification documentation. The intent of this section is to summarize the results of this analysis. From these results, a specific program is recommended, if required, to maintain the qualification status of the Class 1E equipment.

For the Limitorque MOV's, the following areas were analyzed:

- o 1.0 Time-Temperature Effects
- o 2.0 Degradation Equivalency
- o 3.0 Reference Auditability

1.0 TIME-TEMPERATURE EFFECTS

Aging effects on all Class 1E equipment must be considered and included in the qualification program. For time-temperature effects, the present state-of-the-art allows artificial acceleration of these effects associated with organic materials by increasing the temperature. The deterioration due to these effects is judged to be insignificant for metallic materials. Therefore, the aging of the Class 1E equipment will be based on its nonmetallic materials.

For many organic materials, it is known that the degradation process can be defined by a single temperature-dependent reaction that follows the Arrhenius equation (References 1 and 2):

$$k = A \exp(-Ea/k_B T) \tag{1}$$

where,

k	=	reaction rate
A	=	frequency factor
exp	=	exponent to base e
Ea	=	activation energy
k_B	=	Boltzmann's Constant
T	=	absolute temperature

It is further noted that, for many reactions, the activation energy can be considered to be constant over the applicable temperature range. Equation (1) can be transformed into a form which yields an acceleration factor.

The acceleration factor is defined as t_2/t_1.

The equation is:

$$t_2/t_1 = \exp\left(-(Ea/k_B)(1/T_1 - 1/T_2)\right) \quad (2)$$

where,

t_1 = accelerated aging time at temperature T_1

t_2 = normal service time at temperature T_2

exp = exponent to base e

Ea = activation energy (eV)

k_B = Boltzmann's Constant (8.617×10^{-5} eV/^{o}K)

T_1 = accelerated aging temperature (^{o}K)

T_2 = normal service temperature (^{o}K)

The transformation of the reaction rate form of the Arrhenius equation to an acceleration form is accomplished as follows:

Life is assumed to be inversely proportional to the chemical reaction rate (References 1 and 2). In terms of life, and after converting to Napierian base logarithm, Equation (1) becomes:

$$\ln(\text{life}) = (Ea/k_B)(1/T) + \text{Constant} \quad (3)$$

Equation (3) has the algebraic form:

$$y = mx + b \quad (4)$$

where,

y = ln (life)

x = 1/T

m = Ea/k_B, constant for single dominant reactions

b = constant

The constants, m and b, can be estimated by fitting the experimental data in the form of ln (life) versus 1/T into the above simple linear relationship.

The derivation of an acceleration factor is accomplished by taking the difference between any two points of the linear relationship.

Thus, if we substitute t for life into Equation (3), we obtain:

$$\ln t = (Ea/k_B)(1/T) + \text{Constant} \quad (5)$$

For the set of points (t_1, T_1), Equation (5) becomes:

$$\ln t_1 = (Ea/k_B)(1/T_1) + \text{Constant} \quad (6)$$

For the set of points (t_2, T_2), Equation (5) becomes:

$$\ln t_2 = (Ea/k_B)(1/T_2) + \text{Constant} \quad (7)$$

Subtracting Equation (6) from Equation (7) yields:

$$\ln t_2 - \ln t_1 = (Ea/k_B)(1/T_2) + \text{Constant} - (Ea/k_B)(1/T_1) - \text{Constant} \quad (8)$$

Simplifying and rearranging Equation (8) yields:

$$\ln (t_2/t_1) = -(Ea/k_B)(1/T_1 - 1/T_2) \quad (9)$$

Taking antilogarithm yields:

$$t_2/t_1 = \exp(-(Ea/k_B)(1/T_1 - 1/T_2)) \quad (10)$$

Equation (10) is the same as Equation (2).

The qualified life of the nonmetallics in the equipment is determined by solving Equation (10) for t_2.

$$t_2 = t_1/\exp((Ea/k_B)(1/T_1 - 1/T_2)) \quad (11)$$

The Limitorque MOV's have three (3) postulated service temperatures during the 40-year service life (see Section I, 2.b., of this report). Therefore, the above equation is modified to:

$$Q.L. = t_1/\sum_{x=2}^{n+1} P_x \exp((Ea/k_B)(1/T_1 - 1/T_x)) \quad (12)$$

where,

t_1 = aging time

T_1 = aging temperature

T_x = service temperature

P_x = fraction of 40-year life at T_x

Ea/k_B = activation energy/Boltzmann's Constant

Since, in most cases, it is not practical to independently accelerate the time-temperature effects of each nonmetallic material, a determination is made as to which material has the lowest activation energy. The time-temperature effects are then accelerated based upon the lowest activation energy for conservatism. This assures that the degradation of each age-sensitive component is accelerated to at least the equivalent degradation as that to be encountered during the operating life.

1.1 Specific Analysis of Time-Temperature Effects

1.1.1 Expected Life (Valve Operator)

The expected life of each nonmetallic material in the equipment (reference Table I) is determined by substituting experimental data into Equation (3) for the applicable slope (Ea/k_B) and constant, then evaluating the equation for time to loss of a specified physical property for each nonmetallic material, utilizing a specific baseline temperature.

For conservatism, the worst-case service temperature (100^oF) is selected as the baseline temperature.

Metals are judged insensitive for time-temperature effects.

Of the safety-related nonmetallic materials in the Limitorque MOV's, the Flamtrol wire insulation (polyolefin) was determined to have the lowest expected life.

Using the slope and intercept of this material in Equation (3) as an example,

$$\ln (\text{life}) = 10324.33892\ (1/T) - 15.84517969$$

and substituting the worst-case temperature, $T=310.8^oK$ (100^oF), results in:

ln (life)	=	17.37578930
or expected life	=	35,172,999 hours
or expected life	=	4,015 years

Table I summarizes the calculated expected life of each nonmetallic material in the Limitorque valve operators.

Based on the expected lives of the nonmetallic materials, the Limitorque valve operators identified in the Introduction and Summary can be considered insensitive to time-temperature effects for 1,338 years and fully qualified for 40 years.

1.1.2 Expected Life (Class B Motors - AC or DC)

The expected life of the Limitorque Class B motor insulation system at 100°F, as evaluated in Equation (3), is greater than 11,400 years.

The remaining components of the Limitorque MOV motors, mechanical frame, and bells (2), shaft, rotor (less windings), and bearings are all metallic in nature and are not subject to any aging due to time-temperature effects, with the exception of the bearings. The subject bearing system is of the rolling ball type. Rolling element bearings are not infinite life devices.

In accordance with AFBMA Standard No. 9, a large group of identical bearings, identically loaded, operated at the same speed, and properly lubricated, will have a failure rate as a function of operating time, not as a function of time-temperature effects. Therefore, a true "qualified life" cannot be established for randomly operated units.

Manufacturers normally recommend that the bearings be treated as a replaceable element by the end user. A maintenance program should be established in accordance with the manufacturer's instruction manual to maintain the bearing and lubrication system qualification.

Thus, the motors are judged qualified for time-temperature effects for the full 40-year life.

1.1.3 Summary

Considering the insensitivity of the Limitorque MOV's to time-temperature effects at 100°F, the subject Limitorque MOV's with AC or DC motors (Class B insulation system), Model SMB Series, are judged qualified for time-temperature effects for the full 40-year life.

2.0 DEGRADATION EQUIVALENCY ANALYSIS

A review of the test profiles (see Figures 1 and 2) shows that the plant postulated DBA duration (30 days) is not enveloped by the test conditions. Since the materials follow an Arrhenius relationship, the requirements at one time and temperature can be transferred to another set of time-temperature coordinates using the relationship:

$$t_1 = \sum_{x=2}^{n+1} t_x / \exp\left((Ea/k_B)(1/T_x - 1/T_1)\right) \qquad (13)$$

where,

t_1 = equivalent time at T_1

t_x = time at temperature T_x

T_x = accident temperature above T_1

Ea = activation energy (eV)

k_B = Boltzmann's Constant (8.617×10^{-5})

2.1 Specific Degradation Equivalency Analysis

For the subject equipment, the test conditions reported in Reference 1.a, Appendices B and D, exceed the worst-case accident conditions for the initial 4 and 16 days, respectively, but do not envelop the entire postulated post-accident phase in duration.

A time-temperature equivalency can be derived to show that the test conditions exceed the plant postulated post-accident conditions (30 days at 100°F).

2.1.1 Limitorque MOV with Melamine Switches

Reference 1.a, Appendix B (Report 600376A) documents testing performed on MOV's fitted with melamine limit and torque switches.

Using Equation (13), the Arrhenius parameters in Table I, and the applicable accident test profile of Section II (Figure 1), the total equivalent time at 100°F for the melamine switch material is shown in the following table.

Material	Test Profile Equivalent Time at 100°F	Plant Postulated Post-Accident Duration at 100°F
Melamine (Filled) (Ea = 1.35 eV)	3,542 years	30 days

Thus, it is demonstrated that the accident test exposed the melamine switch material to greater thermal degradation than the postulated post-accident conditions.

2.1.2 Limitorque MOV with Class B Motor and Phenolic Switches

Reference 1.a, Appendix D (Report B0003) documents testing performed on an MOV fitted with a Class B motor and phenolic limit and torque switches.

Using Equation (13), the Arrhenius parameters in Table I, and the applicable accident test profile of Section II (Figure 2), the total equivalent time at 100°F for the MOV material with the lowest activation energy is shown in the following table.

Material	Test Profile Equivalent Time at 100°F	Plant Postulated Post-Accident Duration at 100°F
Flamtrol Wire Insulation (Ea = .89 eV)	3,373 days	30 days

Thus, using the lowest activation energy method, it is demonstrated that the Limitorque MOV accident test exposed the nonmetallic materials to a greater thermal degradation than the postulated post-accident conditions.

3.0 REFERENCES

In accordance with IEEE 323-1974, all references listed below, including those with Arrhenius or radiation data, are auditable at Patel Engineers.

1. "IEEE Guide for the Statistical Analysis of Thermal Life Test Data," IEEE 101-1972, Library Code 102-82.

2. Handbook of Engineering Fundamentals, Wiley, 1975, Library Code 103-82.

3. "Limitorque Valve Actuator Qualification for Nuclear Power Station Service," Report B0058, Limitorque Corporation, dated 1/11/80.

4. "Conax Report IPS-325," DuPont, Bulletins A-99064 and V-D-3-301 and Reference 2.23 of IPS-325, Library Code 135-82.

5. Societe' Francaise Hoechst Letter with Thermal Life Data for Rutaform 156 and Melamine Phenol Type 182, M. Collignon, Question Technique 135, March 25, 1980, Library Code 012-82.

6. Arrhenius Plot from "Qualification of Firewall III Class 1E Electric Cables (Chemically Crosslinked Insulation)," Rockbestos Company, QR No. 1807, Library Code 125-82.

7. Durez U.L. File E-39252, Volume I, Section 1 (7/16/68), and Volume I, Section 8 (11/20/78), Hooker Chemicals and Plastic Corporation, Library Code 008-82A.

8. "Raychem-Flamtrol Qualification to IEEE Standard 383," Raychem Corporation, Library Code 272-82.

9. "Limitorque Valve Actuator Qualification for Nuclear Power Station Service," Limitorque Corporation, No. B0058, pp. 10 and 12, Library Code 183-82.

SECTION IV. CONCLUSIONS

Based on the comparison of the qualification test documentation to the normal and accident service conditions postulated for the Reactor Auxiliary Building, the Limitorque MOV is judged to possess a 40-year qualified life at HBR-2.

This conclusion is based on analyses performed in the following areas:

- Time-Temperature Effects - Based on the expected life calculations and using the temperatures specified in Paragraph 1.1, Section III, the equipment is judged to possess a qualified life of greater than 40 years.

- Post-Accident Degradation Equivalency - A time-temperature equivalence was derived to verify that the test conditions (described in Section II) exceed the HBRSEP worst-case post-accident conditions. It was shown that the test conditions equate to a period of at least 3,373 days at 100°F in comparison with the required 30 days.

- Recommendations - It is recommended that a lubrication and preventative maintenance program be established in accordance with Appendix A of Reference 3 and plant operating experience.

- Cycle Life - The cycle life of these actuators is limited to 1,983 cycles (reference Appendix I).

TABLE I. LIST OF NONMETALLIC MATERIALS AND THEIR AGING MECHANISMS

Item No.	Item/Manufacturer	Mfg. Rating	Service Environmental Conditions	Materials	Aging Mechanisms: Radiation Threshold (Rads Gamma)	Aging Mechanisms: Activation Energy (eV)	Aging Mechanisms: Cycling	Expected Life
1.0	Valve Actuator, Limitorque Model SMB Series	150°F	100°F Max. (Assumed for 100% of life)				50 cycles/yr	
1.1	Seals	400°F		Viton (Assume Similar to Viton E-60C)		1.16 (Ref 4)	N/A	**NSR
1.2	Gaskets			Anchorite (Polyvinyl Chloride or Polyethylene)		1.15 (Ref 5) 1.34 (Ref 6)	N/A	**NSR
1.3	Grease	300°F		Nebula EP-1		Unknown	N/A	Unknown
1.4	Limit Switch Lubricant	-65°F to 250°F		Beacon 325		Unknown	N/A	Unknown
1.5	Limit Switch and Torque Switch	300°F		Durez General Purpose Phenolic (Assume Durez 791)		1.02 (Ref 7)	50 cycles/yr	Greater than 3.4×10^4 Yrs
				OR				
		230°F		Melamine (Assume Filled Melamine)		1.35 (Ref 5)	"	Greater than 3,542 Yrs
1.6	Flamtrol Wire, Raychem Chemical Company	194°F		Polyolefin		0.89 (Ref 8)	N/A	Greater than 4.0×10^3 Yrs
1.7	Firewall III, Rockbestos	"		Crosslinked Polyethylene		1.34 (Ref 6)	N/A	Greater than 5.7×10^4 Yrs
1.8	Motor (AC or DC)	266°F		Class B Insulation System		*.93 (Ref 9)	N/A	Greater than 1.1×10^4 Yrs

* For Limitorque Class B Insulation Systems
** Not Safety Related (see Reference 3)

TECHNICAL REPORT
PEI-TR-83-6-6
May 17, 1983

FINAL REPORT ON THE EVALUATION OF THE QUALIFICATION OF THE MODEL 176KF THERMOCOUPLES PROVIDED BY ROSEMOUNT, INC. FOR USE IN THE H.B. ROBINSON STEAM ELECTRIC PLANT-UNIT 2

by
Fredrick L. Roy

Prepared for

CAROLINA POWER AND LIGHT COMPANY
Raleigh, North Carolina

Contract No.: 82-NPED-04
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patel engineers
huntsville, alabama

PRELIMINARY

REPORT NO.: PEI-TR-83-6-6

PREPARED BY: Fredrick L. Roy
Fredrick L. Roy, Program Manager

APPROVED BY: ______________
Ralph L. Morris, Director

Q.A. REVIEW: ______________
M.J. Kimbrell, Director, Product Assurance

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TABLE OF CONTENTS

INTRODUCTION AND SUMMARY

This document, designed to assess qualification documentation of Class 1E equipment to the H.B. Robinson Steam Electric Plant-Unit 2 (HBR-2) specific requirements, is divided into four (4) sections, as follow:

SECTION I. EQUIPMENT IDENTIFICATION/QUALIFICATION REQUIREMENTS

SECTION II. QUALIFICATION DOCUMENTATION ASSESSMENT

SECTION III. QUALIFICATION JUSTIFICATION ANALYSIS

SECTION IV. CONCLUSIONS

The Rosemount 176KF RTD assessed has been judged qualified to the DOR Guidelines for all postulated normal and extreme service conditions within Containment at HBR-2. The analysis performed demonstrates qualification in excess of a 40-year life.

SECTION I. EQUIPMENT IDENTIFICATION/QUALIFICATION REQUIREMENTS

1. EQUIPMENT DESCRIPTION

System:	Reactor Protection	Component I.D.:	TE-412B, D TE-422B, D TE-434B, D
Manufacturer:	Rosemount, Inc.	Equipment Type:	RTD
Serial No.:	Various	Model No.:	176KF

Location: Containment - Elevation 243' 0"

Safety-Related Function: Detect steam line break

2. QUALIFICATION SPECIFICATIONS

a. Applicable Standards

DOR Guidelines	X
NUREG-0588, Cat. I	
NUREG-0588, Cat. II	

b. Normal Service Conditions

Temperature: $120^{\circ}F$ for 84% of qualified life
$88^{\circ}F$ for 16% of qualified life

Radiation: $1x10^6$ rads gamma (air equivalent) TID

Relative Humidity: 20% to 90%

c. Design Basis Events

Accident Profile: See Figures 1 and 2

Source:

MSLB	X
HELB	
LOCA	X*

Operating Time: 1 hour

* Not required for LOCA mitigation.

Radiation:	1.4×10^{7} rads gamma			
Relative Humidity:	100%			
Submergence:	Yes	___	No	X
Demineralized Water Spray:	Yes	___	No	X
Mode:	Active	X		
	Passive	___		
	Fail-Safe	___		

d. Functional Requirements

Accuracy	$\pm 5\%$

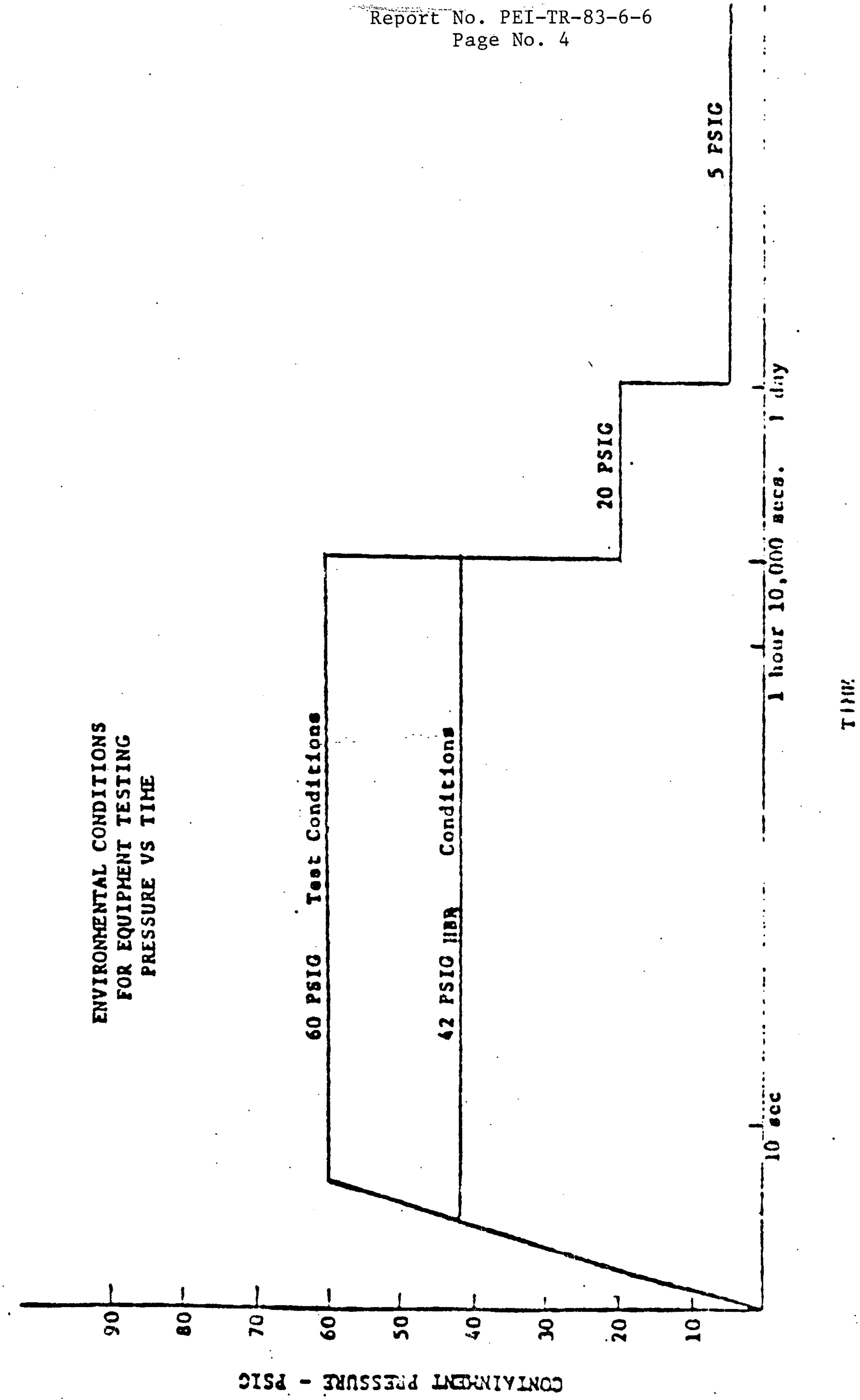

Figure 1: Containment Pressure vs. Time Following LOCA/MSLB [17]

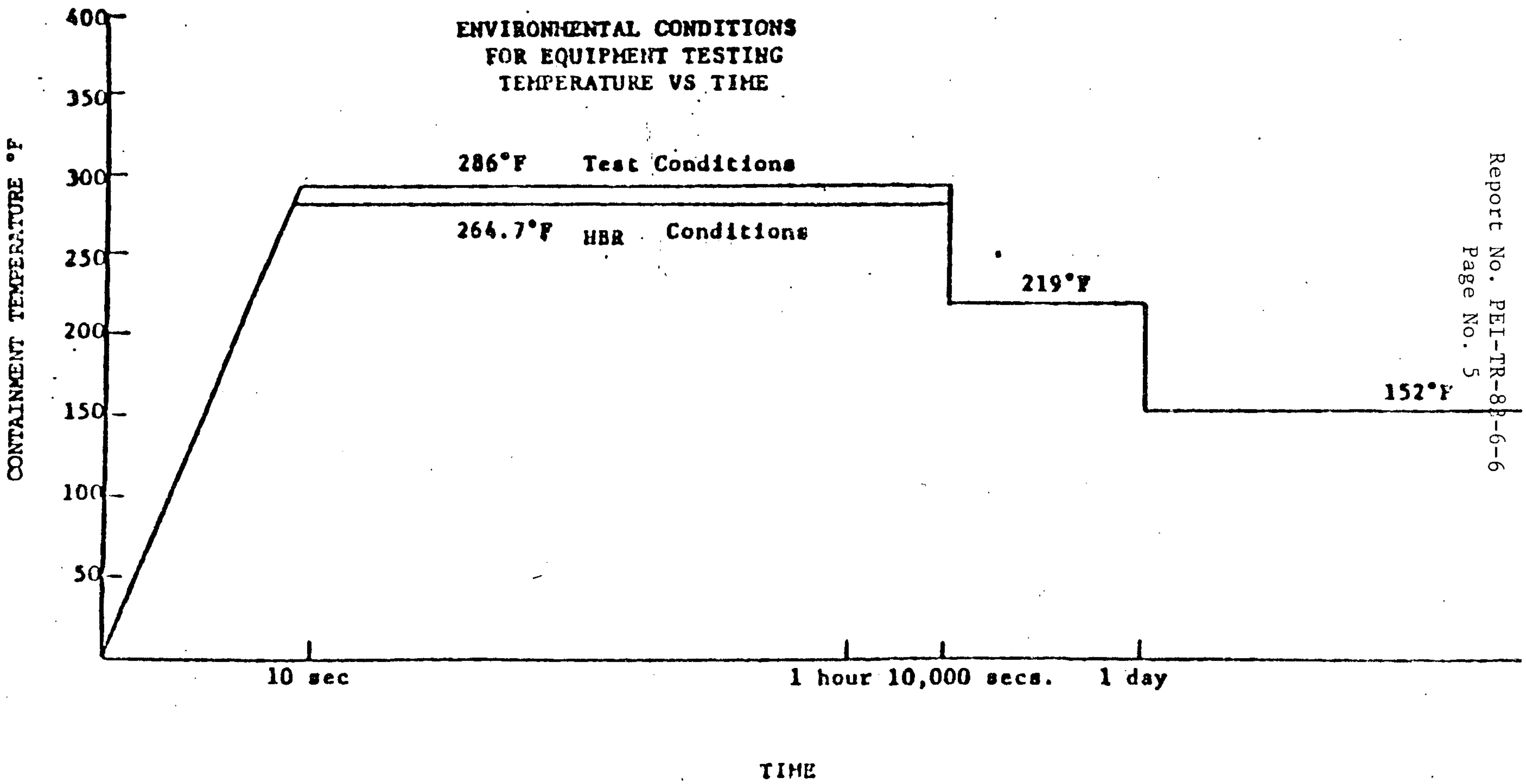

Figure 2: Containment Temperature vs. Time Following LOCA/MSLB [17]

SECTION II. QUALIFICATION ASSESSMENT

1. **QUALIFICATION DOCUMENTATION**

a. Title: Environmental Qualification of Safety-Related Class 1E Process Instrumentation

Report No.: WCAP-9157 Date: September, 1977

Source: Westinghouse Electric Corporation

2. **QUALIFICATION DOCUMENTATION ANALYSIS**

a. **Design Basis Event Analysis**

LOCA Simulation Profile: See Figure 3

	Yes	No*	N/A
1) Are all peak temperature/pressure and time requirements during the transient phase enveloped?		X	
2) Are all temperature/pressure and time requirements during the post-accident phase enveloped?			X
3) Are margins as applied consistent with those defined in NUREG-0588, IEEE 323-1974, and/or the DOR Guidelines, as applicable?	X		
4) Are the functional tests as performed adequate to demonstrate that the functional requirements (accuracy, repeatability, insulation resistance, etc.) for the equipment can be met?	X		
5) Was the normal and accident radiation applied prior to and/or simultaneously with the accident simulation? If yes, to what level? $1x10^8$ rads gamma	X		

		Yes	No*	N/A
6)	If submergence is a requirement, does the test demonstrate acceptable operation?			X
7)	Was the requirement for chemical spray enveloped?	X		
8)	Were all known synergisms accounted for in the test sequence?	X		
9)	If failures occurred during the test program, are adequate justifications provided in the form of a failure analysis such that the qualification is not negated?			X

b. **Normal Service Conditions Analysis**

		Yes	No*	N/A
1)	Does the aging analysis provided in the supporting documentation provide for a 40-year qualified life at the HBR-2 defined service temperature?	X		
2)	Was the aging analysis performed using Arrhenius techniques?		X	
3)	Is the aging analysis auditable?		X	
4)	Was the radiation requirement accomplished by the radiation test?	X		
5)	If any radiation exemptions were utilized, are they auditable?			X
6)	Did the equipment perform successfully at the extremes of its normal service conditions (temperature, radiation, pressure, voltage, current, humidity, etc.) as required by IEEE 323-1974 and NUREG-0588?	X		

	Yes	No*	N/A
7) Were the functional tests performed adequate to demonstrate operability parameters as seen in service?	X		
8) Are the acceptance/failure criteria clearly defined?	X		
9) If failures occurred during the test program, are adequate justifications provided in the form of a failure analysis such that the qualification is not negated?	X		
10) Are all known synergisms accounted for in the test program?			X

* All questions marked "No" require additional analysis to justify qualification. Section III of this report contains the additional analysis to resolve the qualification deficiencies and justify qualification.

3. CONCLUSIONS AND RECOMMENDATIONS

Reference 1.a fulfills all the requirements of the DOR Guidelines except for those items listed in Paragraph 4.

4. OUTSTANDING ITEMS REQUIRING RESOLUTION

- Time-Temperature Effects
- Degradation Equivalency (Peak Transient)
- Reference Auditability

Section III of this document contains analyses to resolve these outstanding items.

WESTINGHOUSE PROPRIETARY CLASS 2

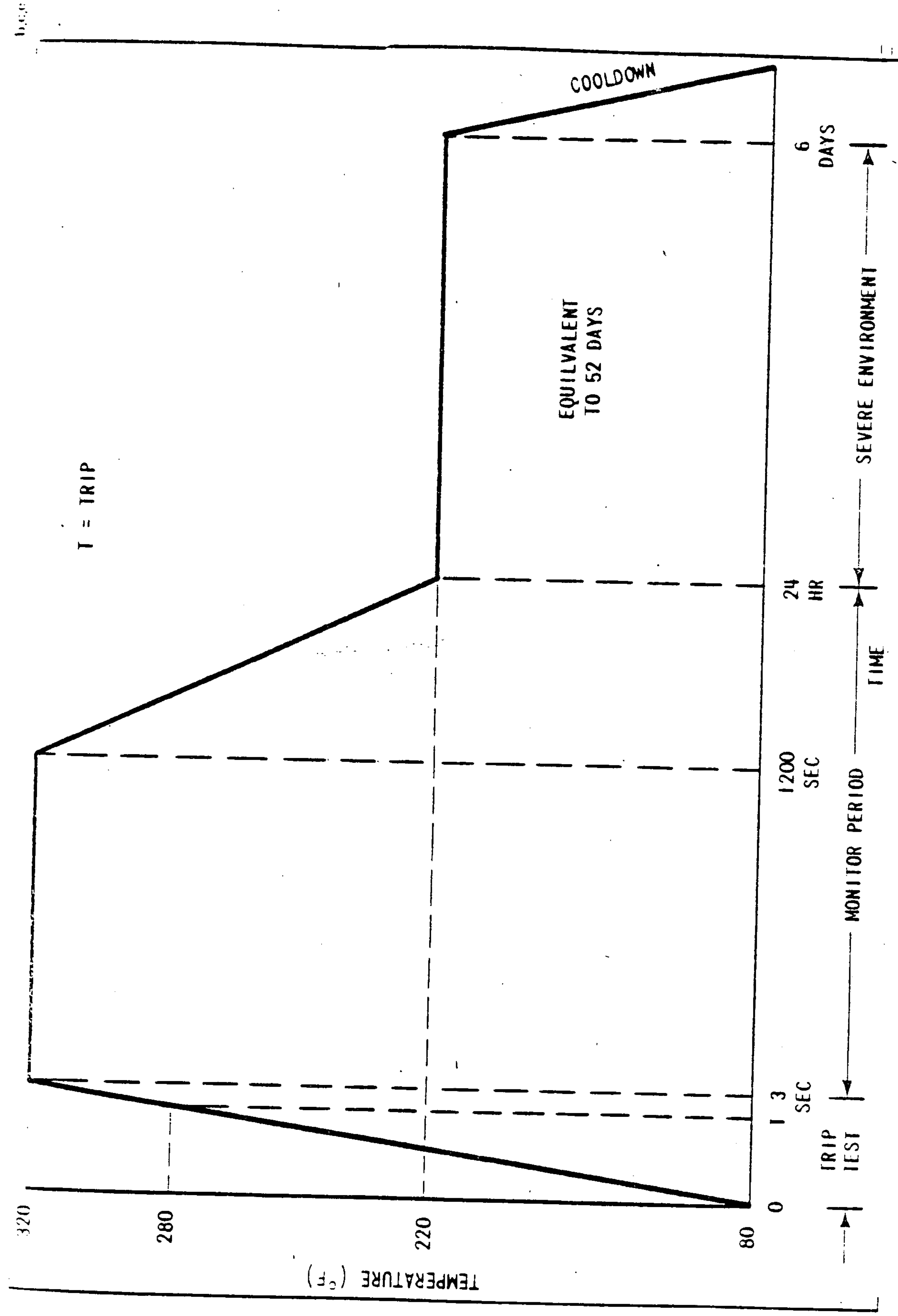

Figure 3. Sensor Environmental Qualification Program Temperature Profile - RTDs

SECTION III. QUALIFICATION JUSTIFICATION ANALYSIS

Where qualification parameters are not clearly defined, when new research highlights potential problem areas, or when the plant requirements are not met, analysis must be performed to augment the existing qualification documentation. The intent of this section is to summarize the results of this analysis. From these results, a specific program is recommended, if required, to maintain the qualification status of the Class 1E equipment.

For the Rosemount 176KF RTD's, the following areas were analyzed:

- o 1.0 Time-Temperature Effects
- o 2.0 Degradation Equivalency
- o 3.0 Reference Auditability

1.0 TIME-TEMPERATURE EFFECTS

Aging effects on all Class 1E equipment must be considered and included in the qualification program. For time-temperature effects, the present state-of-the-art allows artificial acceleration of these effects associated with organic materials by increasing the temperature. The deterioration due to these effects is judged to be insignificant for metallic materials. Therefore, the aging of the Class 1E equipment will be based on its nonmetallic materials.

For many organic materials, it is known that the degradation process can be defined by a single temperature-dependent reaction that follows the Arrhenius equation (References 1 and 2):

$$k = A \exp(-Ea/k_B T) \qquad (1)$$

where,

k = reaction rate

A = frequency factor

exp = exponent to base e

Ea = activation energy

k_B = Boltzmann's Constant

T = absolute temperature

It is further noted that, for many reactions, the activation energy can be considered to be constant over the applicable temperature range. Equation (1) can be transformed into a form which yields an acceleration factor.

The acceleration factor is defined as t_2/t_1.

The equation is:

$$t_2/t_1 = \exp\left(-(Ea/k_B)(1/T_1 - 1/T_2)\right) \qquad (2)$$

where,

t_1 = accelerated aging time at temperature T_1

t_2 = normal service time at temperature T_2

exp = exponent to base e

Ea = activation energy (eV)

k_B = Boltzmann's Constant (8.617×10^{-5} eV/^{o}K)

T_1 = accelerated aging temperature (^{o}K)

T_2 = normal service temperature (^{o}K)

The transformation of the reaction rate form of the Arrhenius equation to an acceleration form is accomplished as follows:

Life is assumed to be inversely proportional to the chemical reaction rate (References 1 and 2). In terms of life, and after converting to Napierian base logarithm, Equation (1) becomes:

$$\ln(\text{life}) = (Ea/k_B)(1/T) + \text{Constant} \qquad (3)$$

Equation (3) has the algebraic form:

$$y = mx + b \qquad (4)$$

where,

y = ln (life)

x = 1/T

m = Ea/k_B, constant for single dominant reactions

b = constant

The constants, m and b, can be estimated by fitting experimental data in the form of ln (life) versus 1/T into the above simple linear relationship.

The derivation of an acceleration factor is accomplished by taking the difference between any two points of the linear relationship.

Thus, if we substitute t for life into Equation (3), we obtain:

$$\ln t = (Ea/k_B)(1/T) + \text{Constant} \qquad (5)$$

For the set of points (t_1, T_1), Equation (5) becomes:

$$\ln t_1 = (Ea/k_B)(1/T_1) + \text{Constant} \qquad (6)$$

For the set of points (t_2, T_2), Equation (5) becomes:

$$\ln t_2 = (Ea/k_B)(1/T_2) + \text{Constant} \qquad (7)$$

Subtracting Equation (6) from Equation (7) yields:

$$\ln t_2 - \ln t_1 = (Ea/k_B)(1/T_2) + \text{Constant} - (Ea/k_B)(1/T_1) - \text{Constant} \qquad (8)$$

Simplifying and rearranging Equation (8) yields:

$$\ln (t_2/t_1) = -(Ea/k_B)(1/T_1 - 1/T_2) \qquad (9)$$

Taking antilogarithm yields:

$$t_2/t_1 = \exp(-(Ea/k_B)(1/T_1 - 1/T_2)) \qquad (10)$$

Equation (10) is the same as Equation (2).

The qualified life of the nonmetallics in the equipment is determined by solving Equation (10) for t_2.

$$t_2 = t_1/\exp((Ea/k_B)(1/T_1 - 1/T_2)) \qquad (11)$$

The Containment has two (2) postulated service temperatures during the 40-year service life (see Section I, 2.b., of this report). Therefore, the above equation is modified to:

$$Q.L. = t_1 / \sum_{x=2}^{n+1} P_x \exp((Ea/k_B)(1/T_1 - 1/T_x)) \qquad (12)$$

where,

t_1	=	aging time
T_1	=	aging temperature
T_x	=	service temperature
P_x	=	fraction of 40-year life at T_x
exp	=	exponent to base e
Ea/k_B	=	activation energy/Boltzmann's Constant

Since, in most cases, it is not practical to independently accelerate the time-temperature effects of each nonmetallic material, a determination is made as to which material has the lowest activation energy. The time-temperature effects are then accelerated based upon the lowest activation energy for conservatism. This assures that the degradation of each age-sensitive component is accelerated to at least the equivalent degradation as that to be encountered during the operating life.

1.1 Specific Analysis of Time-Temperature Effects

For Rosemount 176KF RTD's, auditable thermal age conditioning documentation is unavailable to substantiate a 40-year qualified life based on expected normal service conditions. However, it can be shown through use of Arrhenius Equation (3) that the equipment is insensitive to time-temperature effects for this application.

$$\ln(\text{life}) = (Ea/k_B)(1/T) + \text{Constant} \qquad (3)$$

A substitution shall be made for the slope and constant to determine the expected life of the equipment at the worst-case service temperature, 120°F.

The calculation of expected life is as follows:

For silicone rubber (wire/cable insulation), the slope and constant values are 19445.15602 and -29.40914683, respectively. Therefore,

$$\ln(\text{life}) = 19445.15602\,(1/T) - 29.40914683 \text{ (Ref. 3)} \quad (13)$$

Substituting the worst-case service temperature, 321.89°K (120°F), results in:

$$\ln(\text{life}) = 31.00038169, \text{ or}$$

$$\text{life} = 2.9\text{x}10^{13} \text{ hours, or}$$

$$\text{life} = 3.3\text{x}10^{9} \text{ years}$$

Based on the wire calculated expected life, the silicone rubber-insulated wire is considered insensitive to time-temperature effects for a 40-year qualified life at 120°F. The expected lives of the other materials of construction are shown in Table I.

2.0 DEGRADATION EQUIVALENCY ANALYSIS

A comparison of the test profile (see Figure 3) and the HBR-2 accident profiles shows that the peak transients are enveloped for temperature. The accident phase is not enveloped by the test conditions. Since the materials follow an Arrhenius relationship, the requirements at one time and temperature can be transferred to another set of time-temperature coordinates using the relationship:

$$t_1 = \sum_{x=2}^{n+1} t_x / \exp\left((Ea/k_B)(1/T_x - 1/T_1)\right) \quad (13)$$

where,

t_1 = equivalent time at T_1

t_x = time at temperature T_x

T_x = accident temperature above T_1

exp = exponent to base e

Ea = activation energy (eV)

k_B = Boltzmann's Constant ($8.617\text{x}10^{-5}$)

2.1 Specific Degradation Equivalency Analysis

For the subject equipment, the test conditions exceed the worst-case accident conditions (Figure 1) for the initial 20 minutes, but do not envelop the entire postulated plant accident phase in duration. A time-temperature equivalency can be derived to verify that the test conditions, after 20 minutes, exceed the plant postulated post-accident phase by using Equation (13) and the following parameters for t_x and T_x (see Figure 2):

t_2 = 120 hours

T_2 = $220^{o}F$

The equivalent time at an ambient temperature of $286^{o}F$ is greater than 9 hours. Therefore, the Rosemount 176KF RTD is considered qualified for the postulated HBR-2 accident and post-accident phases.

Thus, using the lowest activation energy method, it is demonstrated that the accident test exposed the nonmetallic materials to a greater thermal degradation than the postulated plant accident.

3.0 REFERENCE AUDITABILITY

In accordance with IEEE 323-1974, all references listed below, including those with Arrhenius or radiation data, are auditable at Patel Engineers.

1. "IEEE Guide for the Statistical Analysis of Thermal Life Test Data," IEEE 101-1972, Library Code 102-82.

2. Handbook of Engineering Fundamentals, Wiley, 1975, Library Code 103-82.

3. "Heat Aging Study of WCSF Compound," Raychem Energy Division, Report No. EDR 2001, Library Code 124-82.

4. "Qualification Report, Westinghouse Electric Corporation Type AB Circuit Breaker," Revision 2, Westinghouse, Library Code 039-82.

5. "Qualification of Okonite Ethylene Propylene Rubber Insulation for Nuclear Plant Service," The Okonite Company, Report No. NQRN-1, Appendix 2, Library Code 011-82A.

6. Kapton Arrhenius Data, Conax Report No. 325 in Reference to L.L. Lewis of DuPont, IPS-325, Library Code 134-82.

7. "Wires and Cords for Original Equipment Manufacturers," General Electric Company, No. WCC-2, Library Code 137-82.

SECTION IV. CONCLUSIONS

Based on the comparison of the qualification test documentation to the normal and accident service conditions postulated for HBR-2, the Rosemount 176KF is judged to possess a 40-year qualified life at HBR-2.

This conclusion is based on analyses performed in the following areas:

- Time-Temperature Effects - Based on the expected life analysis performed, the Rosemount 176KF RTD can be considered insensitive to time-temperature aging effects over a 40-year period.

- Accident Degradation Equivalency - A time-temperature equivalence was derived to verify that the test conditions (described in Section II) exceed the HBR-2 worst-case accident conditions. It was shown that the test conditions equate to a period of 9 hours at 286°F in comparison with the required 1 hour.

TABLE I. LIST OF NONMETALLIC MATERIALS AND THEIR AGING MECHANISMS

Item No.	Item/Manufacturer	Mfg. Rating	Service Environmental Conditions	Materials	Aging Mechanisms			Expected Life
					Radiation Threshold (Rads Gamma)	Activation Energy (eV)	Cycling	
1.0	Rosemount 176KF RTD		See Sect. I		$1x10^8$ (Test)		N/A	
1.1	Lead Wrapping			Vinyl		1.15 (Ref 4)		4,766 Years
1.2	Insulating Tube			Polyolefin		1.29 (Ref 3)		$1.0x10^4$ Years
1.3	Packing			Mica Quartz		NAS*		NAS*
1.4	Sealant			Epoxy		1.0 (Ref 4)		2,363 Years
1.5	Swaged Insulation			Ethylene-Propylene		1.09 (Ref 5)		598 Years
1.6	Ground Wire Insulation			Kapton		0.91 (Ref 6)		$8.0x10^4$ Years
1.7	Lead Wire Insulation			Silicone Rubber		1.68 (Ref 7)		$3.3x10^9$ Years
1.8	Insulation Seal			Silica Glass		NAS*		NAS*

*NAS = Not Age Sensitive

TECHNICAL REPORT
PEI-TR-83-6-8

Final Report in the Evaluation of the Qualification of Westinghouse Motors

TO BE SUPPLIED LATER

TECHNICAL REPORT
PEI-TR-83-6-10
March 15, 1983

FINAL REPORT ON THE EVALUATION OF THE QUALIFICATION OF THE TYPE CC-2115 CABLE PROVIDED BY CONTINENTAL WIRE AND CABLE FOR USE IN THE H.B. ROBINSON STEAM ELECTRIC PLANT - UNIT 2

by
Michael M. Hall

Prepared for

CAROLINA POWER AND LIGHT COMPANY
Raleigh, North Carolina

Contract No.: 82-NPED-04
PEI Job No.: 8310

patel engineers
huntsville, alabama

REPORT NO.: PEI-TR-83-6-10

PREPARED BY: Michael M. Hall, Sr. Project Engineer

APPROVED BY: David Stinson, Director

Q.A. REVIEW: M.J. Kimbrell, Director, Product Assurance

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TABLE OF CONTENTS

INTRODUCTION AND SUMMARY

This document is designed to assess qualification documentation of Class 1E equipment to the H.B. Robinson Steam Electric Plant, Unit 2 (HBR-2), specific requirements. It is divided into four (4) sections. They are as follow:

SECTION I. EQUIPMENT IDENTIFICATION/QUALIFICATION REQUIREMENTS

SECTION II. QUALIFICATION DOCUMENTATION ASSESSMENT

SECTION III. QUALIFICATION JUSTIFICATION ANALYSIS

SECTION IV. CONCLUSIONS

Continental Wire and Cable Type CC-2115 instrumentation cable (4/C #16, 2/C #16, shielded) assessed in this report is judged qualified to the DOR Guidelines requirements for all postulated normal and extreme service conditions within containment at HBR-2. The analysis performed shows full qualification for a full 40-year life.

SECTION I. EQUIPMENT IDENTIFICATION/QUALIFICATION REQUIREMENTS

1. **EQUIPMENT DESCRIPTION**

System: Various — **Component I.D.:** N/A

Manufacturer: Continental Wire and Cable

Equipment Type: Shielded #16 AWG (2/C, 4/C) Instrumentation Cable

Serial No.: N/A — **Model No.:** CC-2115

Location: Containment

Safety-Related Function: Provides signal path for Class 1E Equipment.

2. **QUALIFICATION SPECIFICATIONS**

a. **Applicable Standards**

DOR Guidelines	X
NUREG-0588, Cat. I	
NUREG-0588, Cat. II	

b. **Normal Service Conditions**

Temperature: $120^{\circ}F$ for 84% of qualified life
$88^{\circ}F$ for 16% of qualified life

Pressure: Atmospheric

Radiation: $3.5x10^4$ rads gamma (air equivalent) TID

Relative Humidity: 20% to 90%

c. **Design Basis Events**

Accident Profile: See Figures 1 and 2

Source:

MSLB	X
HELB	
LOCA	X

Operating Time: 30 days

Radiation: 1.4×10^{7} rads gamma
$<1.4\times10^{6}$ rads beta* (assumed)

Relative Humidity: 100%

Submergence: Yes ____ No X

Chemical Spray: Yes X No ____

Mode:

Active	X
Passive	
Fail-Safe	

* Per the utility, beta contributions are considered to amount to less than 10% of the postulated gamma dose, in rads, due to ". . . time of operation, equipment location, shield wall absorption, compartment wall absorption, insulation thickness, instrumentation housing absorption, motor case shielding, et. al. . . ."

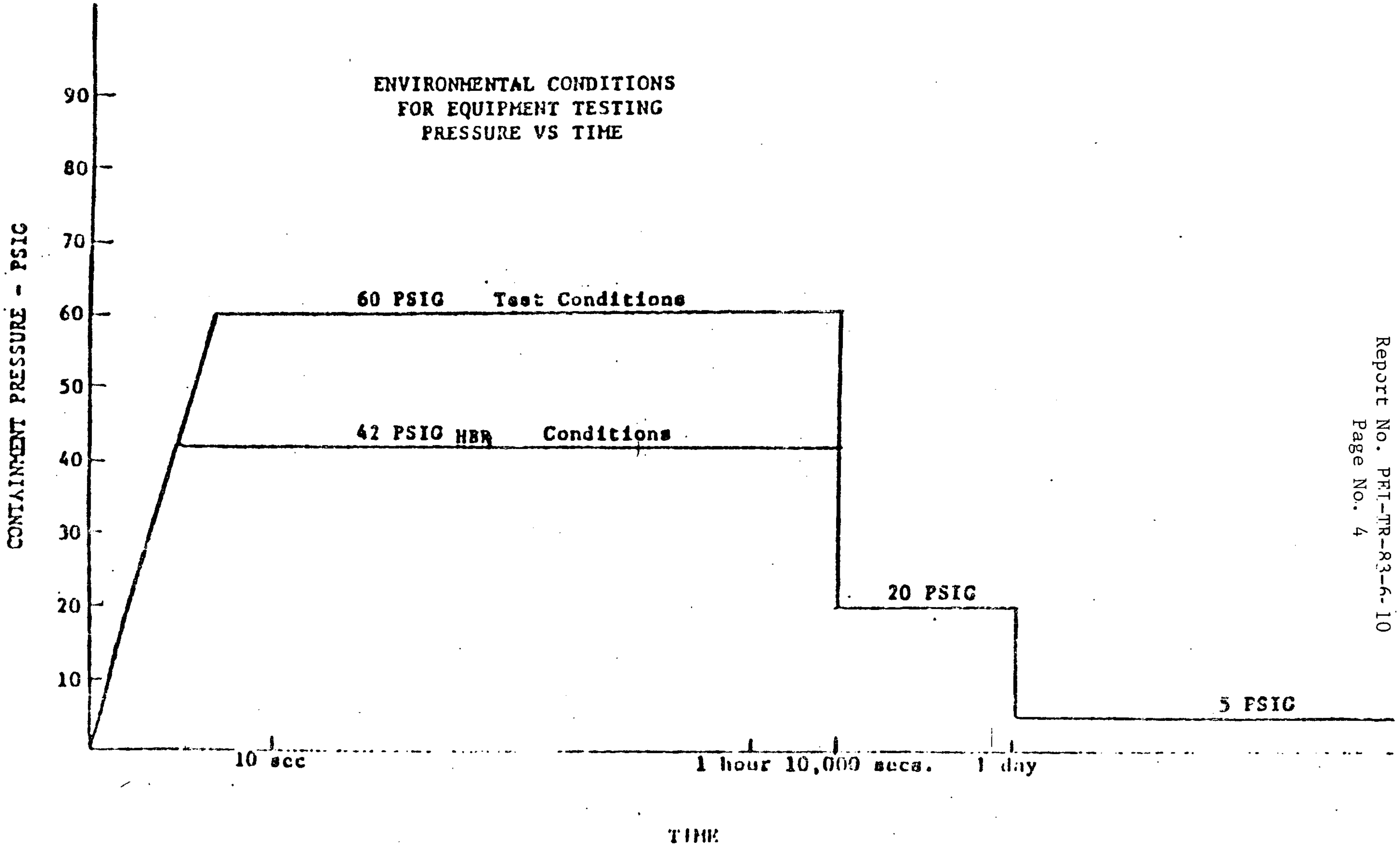

Figure 1: Containment Pressure vs. Time Following LOCA/MSLB [17]

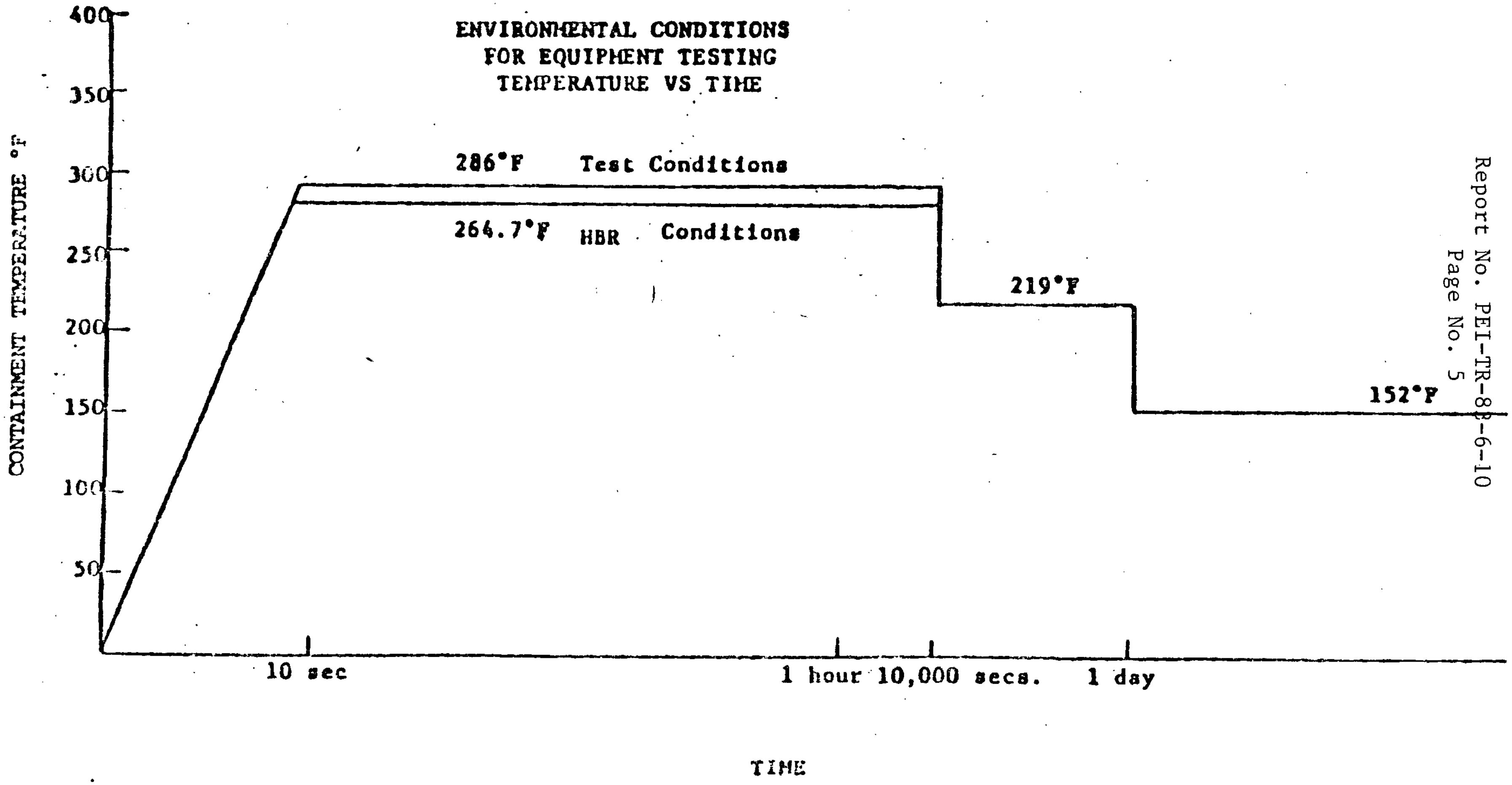

Figure 2: Containment Temperature vs. Time Following LOCA/MSLB [17]

SECTION II. QUALIFICATION ASSESSMENT

1. **QUALIFICATION DOCUMENTATION**

a. **Title:** Test of Electrical Cables Under Simulated Post-Accident Reactor Containment Service

Report No.: F-C2935 **Date:** October, 1970

Source: Franklin Institute Research Laboratories (FIRL)

b. **Title:** Test of Electrical Cables Under Simulated Post-Accident Reactor Containment Service

Report No.: F-C2935, Addendum **Date:** November, 1970

Source: Franklin Institute Research Laboratories (FIRL)

c. **Title:** Physical Properties of CC-2115 Silicone Rubber After Conditioning Simulating a LOCA Condition, Revision 1

Report No.: N/A **Date:** March 28, 1980

Source: Anaconda Wire and Cable Division, Continental Wire and Cable

2. **QUALIFICATION DOCUMENTATION ANALYSIS**

a. **Design Basis Event Analysis**

LOCA Simulation Profile: See Figure 3

	Yes	No*	N/A
1) Are all peak temperature/pressure and time requirements during the transient phase enveloped?		X	
2) Are all temperature/pressure and time requirements during the post-accident phase enveloped?		X	

	Yes	No*	N/A
3) Are margins as applied consistent with those defined in NUREG-0588, IEEE 323-1974, and/or the DOR Guidelines, as applicable?	X		
4) Are the functional tests as performed adequate to demonstrate that the functional requirements (accuracy, repeatability, insulation resistance, etc.) for the equipment can be met?	X		
5) Was the normal and accident radiation applied prior to and/or simultaneously with the accident simulation sufficient to envelop the requirements?		X	
6) If submergence is a requirement, does the test demonstrate acceptable operation?			X
7) Was the requirement for chemical spray spray enveloped?		X	
8) Were all known synergisms accounted for in the test sequence?			X
9) If failures occurred during the test program, are adequate justifications provided in the form of a failure analysis such that the qualification is not negated?			X

b. Normal Service Conditions Analysis

	Yes	No*	N/A
1) Does the aging analysis provided in the supporting documentation provide for a 40-year qualified life at the HBR-2 defined service temperature?		X	
2) Was the aging analysis performed using Arrhenius techniques?		X	

		Yes	No*	N/A
3)	Is the aging analysis auditable?		X	
4)	Was the radiation requirement accomplished by the radiation test?	X		
5)	If any radiation exemptions were utilized, are they auditable?			X
6)	Did the equipment perform successfully at the extremes of its normal service conditions (temperature, radiation, pressure, voltage, current, humidity, etc.) as required by IEEE 323-1974 and NUREG-0588?			X
7)	Were the functional tests performed adequate to demonstrate operability parameters as seen in service?	X		
8)	Are the acceptance/failure criteria clearly defined?	X		
9)	If failures occurred during the test program, are adequate justifications provided in the form of a failure analysis such that the qualification is not negated?			X
10)	Are all known synergisms accounted for in the test program?			X

* All questions marked "No" require additional analysis to justify qualification. Section III of this report contains the additional analysis to resolve the qualification deficiencies and justify qualification.

3. CONCLUSIONS AND RECOMMENDATIONS

References l.a, l.b, and l.c fulfill all the requirements of the DOR Guidelines, except for those items listed in Paragraph 4, below.

4. OUTSTANDING ITEMS REQUIRING RESOLUTION

- Time-Temperature Effects
- Degradation Equivalency
- Accident Radiation
- Chemical Spray
- Reference Auditability

Section III of this report provides additional analyses to resolve these outstanding items.

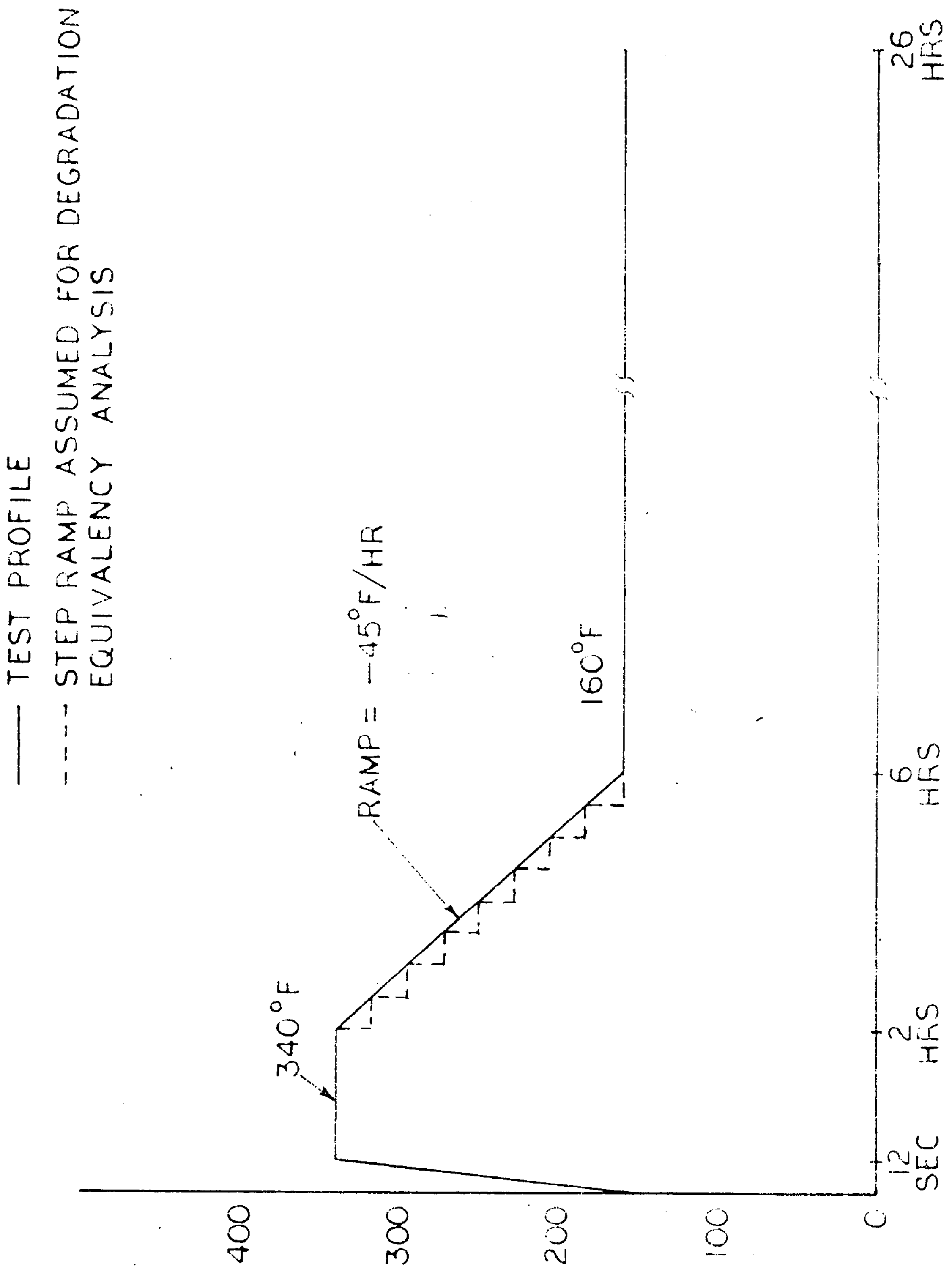

FIGURE 3. ACCIDENT TEST PROFILE

SECTION III. QUALIFICATION JUSTIFICATION ANALYSIS

Where qualification parameters are not clearly defined, when new research highlights potential problem areas, or when the plant requirements are not met, analysis must be performed to augment the existing qualification documentation. The intent of this section is to summarize the results of this analysis. From these results, a specific program is recommended, if required, to maintain the qualification status of the Class 1E equipment.

For the Type CC-2115 cable, the following areas were analyzed:

- 1.0 Time-Temperature Effects
- 2.0 Degradation Equivalency
- 3.0 Accident Radiation
- 4.0 Chemical Spray
- 5.0 Reference Auditability

1.0 TIME-TEMPERATURE EFFECTS

Aging effects on all Class 1E equipment must be considered and included in the qualification program. For time-temperature effects, the present state-of-the-art allows artificial acceleration of these effects associated with organic materials by increasing the temperature. The deterioration due to these effects is judged to be insignificant for metallic materials. Therefore, the aging of the Class 1E equipment will be based on its nonmetallic materials.

For many organic materials, it is known that the degradation process can be defined by a single temperature-dependent reaction that follows the Arrhenius equation (References 1 and 2):

$$k = A \exp(-Ea/k_B T) \qquad (1)$$

where,

k = reaction rate

A = frequency factor

exp = exponent to base e

Ea = activation energy

k_B = Boltzmann's Constant

T = absolute temperature

It is further noted that, for many reactions, the activation energy can be considered to be constant over the applicable temperature range. Equation (1) can be transformed into a form which yields an acceleration factor.

The acceleration factor is defined as t_2/t_1.

The equation is:

$$t_2/t_1 = \exp\left(-(Ea/k_B)(1/T_1 - 1/T_2)\right) \quad (2)$$

where,

t_1 = accelerated aging time at temperature T_1

t_2 = normal service time at temperature T_2

exp = exponent to base e

Ea = activation energy (eV)

k_B = Boltzmann's Constant (8.617×10^{-5} eV/°K)

T_1 = accelerated aging temperature (°K)

T_2 = normal service temperature (°K)

The transformation of the reaction rate form of the Arrhenius equation to an acceleration form is accomplished as follows:

Life is assumed to be inversely proportional to the chemical reaction rate (References 1 and 2). In terms of life, and after converting to Napierian base logarithm, Equation (1) becomes:

$$\ln(\text{life}) = (Ea/k_B)(1/T) + \text{Constant} \quad (3)$$

Equation (3) has the algebraic form:

$$y = mx + b \quad (4)$$

where,

y = ln (life)

x = $1/T$

m = Ea/k_B, constant for single dominant reactions

b = constant

The constants, m and b, can be estimated by fitting the experimental data in the form of ln (life) versus 1/T into the above simple linear relationship.

The derivation of an acceleration factor is accomplished by taking the difference between any two points of the linear relationship.

Thus, if we substitute t for life into Equation (3), we obtain:

$$\ln t = (Ea/k_B)(1/T) + \text{Constant} \qquad (5)$$

For the set of points (t_1, T_1), Equation (5) becomes:

$$\ln t_1 = (Ea/k_B)(1/T_1) + \text{Constant} \qquad (6)$$

For the set of points (t_2, T_2), Equation (5) becomes:

$$\ln t_2 = (Ea/k_B)(1/T_2) + \text{Constant} \qquad (7)$$

Subtracting Equation (6) from Equation (7) yields:

$$\ln t_2 - \ln t_1 = (Ea/k_B)(1/T_2) + \text{Constant} - (Ea/k_B)(1/T_1) - \text{Constant} \qquad (8)$$

Simplifying and rearranging Equation (8) yields:

$$\ln (t_2/t_1) = -(Ea/k_B)(1/T_1 - 1/T_2) \qquad (9)$$

Taking antilogarithm yields:

$$t_2/t_1 = \exp(-(Ea/k_B)(1/T_1 - 1/T_2)) \qquad (10)$$

Equation (10) is the same as Equation (2).

The qualified life of the nonmetallics in the equipment is determined by solving Equation (10) for t_2.

$$t_2 = t_1/\exp\left((Ea/k_B)(1/T_1 - 1/T_2)\right) \qquad (11)$$

The Type CC-2115 cable has two (2) postulated service temperatures during the 40-year service life (see Section I, 2.b., of this report). Therefore, the above equation is modified to:

$$Q.L. = t_1/\sum_{x=2}^{n+1} P_x \exp\left((Ea/k_B)(1/T_1 - 1/T_x)\right) \qquad (12)$$

where,

t_1 = aging time

T_1 = aging temperature

T_x = service temperature

P_x = fraction of 40-year life at T_x

Ea/k_B = activation energy/Boltzmann's Constant

Since, in most cases, it is not practical to independently accelerate the time-temperature effects of each nonmetallic material, a determination is made as to which material has the lowest activation energy. The time-temperature effects are then accelerated based upon the lowest activation energy for conservatism. This assures that the degradation of each age-sensitive component is accelerated to at least the equivalent degradation as that to be encountered during the operating life.

1.1 Specific Analysis of Time-Temperature Effects

For Type CC-2115 cable, auditable thermal age conditioning documentation is unavailable to substantiate a 40-year qualified life based on expected normal service conditions. However, it can be shown through use of Arrhenius Equation (3) that the equipment is insensitive to time-temperature effects for this application.

Arrhenius Equation (3) is repeated:

$$\ln(\text{life}) = (Ea/k_B)(1/T) + \text{Constant} \qquad (3)$$

A substitution shall be made for the slope and constant to determine the expected life of the equipment at the worst-case service temperature, $120^{o}F$.

In this application (instrumentation cable), the equipment must carry analog signal currents on the order of 1 ampere or less. For #16 AWG stranded copper conductors, heat rise due to resistance heating effects was judged to be negligible.

The calculation of expected life is as follows:

For silicone rubber (wire/cable insulation), the slope and constant values are 19445.15602 and -29.40914683, respectively. Therefore:

$$\ln(\text{life}) = 19445.15602\,(1/T) - 29.40914685 \quad \text{(Ref. 3)} \qquad (13)$$

Substituting the worst-case service temperature 321.89°K (120°F) results in:

$$\ln(\text{life}) = 31.00038169$$

or $\text{life} = 2.9 \times 10^{13}$ hours

or $\text{life} = 3.3 \times 10^{9}$ years

Based on the calculated expected life, Type CC-2115 silicone rubber-insulated cable is considered insensitive to time-temperature effects for a 40-year qualified life at 120°F.

Note: Reference 1.a reported that a "preconditioning" test was performed prior to the accident simulation. The test consisted of exposing the test cables to 151°F ($\pm$6°F) for 6 hours while loaded at 12-14 amperes per conductor. This test was not intended to establish a qualified life for the equipment although a minimal qualified life could be demonstrated through use of Equation (12).

2.0 DEGRADATION EQUIVALENCY ANALYSIS

A comparison of the test profile (see Figure 3) and the HBR-2 accident profiles shows that the initial transient (286°F) is enveloped for time and temperature. However, the second plateau (219°F) and the post-accident phase (152°F) are not enveloped by the test conditions. Since silicone rubber follows an Arrhenius relationship, the requirements at one time and temperature can be transferred to another set of time-temperature coordinates using the relationship:

$$t_1 = \sum_{x=2}^{n+1} t_x / \exp\left((Ea/k_B)(1/T_x - 1/T_1)\right) \qquad (14)$$

where,

t_1 = equivalent time at T_1

t_x = time at temperature T_x

T_x = accident temperature above T_1

Ea = activation energy (eV)

k_B = Boltzmann's Constant (8.617×10^{-5})

2.1 Specific Degradation Equivalency Analysis

For the subject equipment, a time-temperature equivalency can be derived to verify that the test conditions, after 1×10^4 seconds, exceed the plant postulated requirements.

Using Equation (14), the time-temperature parameters given for the plant accident (after 1×10^4 seconds) can be transferred to an equivalent time at 150°F.

Calculation Parameters

Ea/k_B = 19445.15602

T_1 = 150°F (338.56°K)

T_2 = 152°F (339.67°K)

T_3 = 219°F (376.89°K)

t_2 = 696 hours (29 days)

t_3 = 21.22 hours (1 day - 10^4 seconds)

The calculated equivalent time at 150°F is 339.5 days.

Similarly, Equation (14) is used to calculate a time equivalency at 150°F for the time-temperature conditions shown in Figure 3 (after 1×10^4 seconds). Since distinct sets of time-temperature parameters must be input to the equation, the ramp shown in Figure 3 has been conservatively transformed into a step ramp (eight (8) intervals) to facilitate the analysis. Each interval is assumed to be 0.5 hour in duration and adjacent plateaus are 22.5°F apart. During the calculation, credit has been taken for only those intervals (or part thereof) which exceed 1×10^4 seconds.

Calculation Parameters

T_1 = 150^oF (338.56^oK)

T_2 = 160^oF (344.11^oK)

T_3 = 182.5^oF (356.61^oK)

T_4 = 205^oF (369.11^oK)

T_5 = 227.5^oF (381.61^oK)

T_6 = 250^oF (394.11^oK)

T_7 = 272.5^oF (406.61^oK)

T_8 = 295^oF (419.11^oK)

t_2 = 20.5 hours

t_3 = 0.5 hour

t_4 = 0.5 hour

t_5 = 0.5 hour

t_6 = 0.5 hour

t_7 = 0.5 hour

t_8 = 0.22 hour (3 hours - $1x10^4$ seconds)

The calculated equivalent time at 150^oF is greater than 975 days (2.67 years).

Based on these calculations, it has been demonstrated that, after $1x10^4$ seconds, the documented test conditions are equivalently more severe than the plant requirements (975 days vs. 339.5 days at 150^oF, respectively).

Conclusions drawn from the preceding calculations are predicated upon the fact that isothermal test data from which the slope and constant values were obtained indicates that no phase changes occur for silicone rubber wire insulation over the temperature range under consideration. This is evidenced by the linearity of the Arrhenius plot, even at temperatures exceeding 200^oC.

It should be noted that substantial margin exists in the documented test profile which was not factored into the preceding discussion:

1. In terms of equivalent degradation, the 2-hour plateau at 340°F (test) is considered significantly more severe than the required 286°F peak temperature plateau.

2. Transformation of the 4-hour ramp (340°F to 160°F) into an 8-interval step ramp imparted a considerable measure of conservatism into the degradation equivalency analysis.

3. During the test program, the #16 AWG cable specimens were loaded at 600 VAC, 12 amperes per conductor. This loading level is significantly higher than expected service conditions. Also, resistance heating effects during the test undoubtedly resulted in insulation bulk temperatures in excess of 340°F, providing additional margin.

3.0 ACCIDENT RADIATION ANALYSIS

As stated in Reference 1.a, the equipment was subjected to 1.0×10^7 rads gamma prior to accident simulation. Per Paragraph I.2.c, the total postulated accident dose requirement is 1.54×10^7 rads, assuming a one-to-one correspondence between the gamma and beta doses. Therefore, irradiation performed prior to or simultaneously with the accident simulation did not encompass the requirement.

As stated in Reference 1.b, the same equipment was subjected to additional radiation conditioning subsequent to the accident simulation. Samples designated A-1 and B-1 (Type CC-2115 cable) were subjected to an additional 9.0×10^7 rads during the second exposure, bringing the total for these specimens to 1.0×10^8 rads. Insulation resistance and leakage current measurements taken before and after final irradiation were comparable, indicating that the effects of irradiation were minimal.

Therefore, since samples of Type CC-2115 cable were subjected to gamma irradiation to levels far in excess of the requirements with minimal effect on insulation properties, it is concluded that the equipment is qualified for the postulated HBR-2 radiation environment.

4.0 CHEMICAL SPRAY ANALYSIS

As stated in Reference 1.c, samples of #12 AWG CC-2115 silicone rubber cable were subjected to 120 hours of 50 psi steam, followed by 120 hours of chemical spray (.5% boric acid) at 150°F.

Subsequent to testing, tube specimens were taken from the cable and tested for tensile strength and absolute elongation. Compared to similar tests conducted prior to testing, tensile strength and elongation were reduced by 39% and 38%, respectively.

It should be noted that radiation testing reported in the same reference shows that, after exposure to $1x10^8$ rads gamma, tensile strength and elongation were reduced by 50% and 94%, respectively. However, as noted in Paragraph III.3.0, the reduction in tensile strength and elongation did not significantly effect the electrical performance of the equipment.

Therefore, it is concluded that the reductions in properties caused by steam/chemical spray exposure should not significantly affect the electrical integrity of the equipment.

5.0 REFERENCES

In accordance with IEEE 323-1974, all references listed below, including those with Arrhenius or radiation data, are auditable at Patel Engineers.

1. "IEEE Guide for the Statistical Analysis of Thermal Life Test Data," IEEE 101-1972, Library Code 102-82.

2. Handbook of Engineering Fundamentals, Wiley, 1975, Library Code 103-82.

3. "Wires and Cords for Original Equipment Manufacturers," General Electric Company, No. WCC-2, Library Code 137-82.

SECTION IV. CONCLUSIONS

Based on the comparison of the qualification test documentation to the normal and accident service conditions postulated for the Type CC-2115 cable, the cable is judged to possess a 40-year qualified life at the HBR-2.

This conclusion is based on analyses performed in the following areas:

- Time-Temperature Effects - Based on an expected life of 3.3×10^{9} years at 120°F, the equipment is judged to possess a qualified life of greater than 40 years.

- Post-Accident Degradation Equivalency - A time-temperature equivalence was derived to verify that the test conditions (described in Section II) exceed the HBR-2 worst-case accident conditions, including the post-accident phase.

- Accident Radiation Analysis - A review of cited test documentation provided assurance that the equipment will continue to maintain electrical integrity after exposure to gamma radiation levels far in excess of plant postulated radiation environments.

- Chemical Spray Analysis - It has been shown that the effects of the postulated chemical spray environment will not adversely affect the electrical integrity of Type CC-2115 cable.

TECHNICAL REPORT
PEI-TR-83-6-11
February 10, 1983

FINAL REPORT ON THE EVALUATION OF THE QUALIFICATION OF THE THERMOCOUPLE EXTENSION CABLE PROVIDED BY SAMUEL MOORE AND COMPANY FOR USE IN THE H.B. ROBINSON STEAM ELECTRIC PLANT - UNIT 2

by
Fredrick L. Roy

Prepared for

CAROLINA POWER AND LIGHT COMPANY
Raleigh, North Carolina

Contract: 83-NPED-04
PEI Job No. 8310

patel engineers
huntsville, alabama

REPORT NO.: PEI-TR-83-6-11

PREPARED BY: Fredrick L. Roy, Program Manager

APPROVED BY: David Stinson, Director

Q.A. REVIEW: M. J. Kimbrell, Director, Product Assurance

ORIGINAL ISSUE: February 10, 1983

REVISIONS

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TABLE OF CONTENTS

INTRODUCTION AND SUMMARY

This document, designed to assess qualification documentation of Class 1E equipment to the H.B. Robinson Steam Electric Plant, Unit 2 (HBR-2), specific requirements, is divided into four (4) sections. They are as follow:

SECTION I. EQUIPMENT IDENTIFICATION/QUALIFICATION REQUIREMENTS

SECTION II. QUALIFICATION ASSESSMENT

SECTION III. QUALIFICATION JUSTIFICATION ANALYSIS

SECTION IV. CONCLUSIONS

The thermocouple extension cable assessed is fully qualified to NUREG-0588, Category I, requirements for use in HBR-2, and has a qualified life of 40 years at the plant worst-case ambient conditions.

SECTION I. EQUIPMENT IDENTIFICATION/QUALIFICATION REQUIREMENTS

1. **EQUIPMENT DESCRIPTION**

System: Various

Component I.D.: N/A

Manufacturer: Samuel Moore & Co.

Equipment Type: Thermocouple Extension Cable

Serial No.: N/A

Model No.: 2C #16 Dekoron

Location: Containment

Safety-Related Function: Electrical connection of TMI equipment.

2. **QUALIFICATION SPECIFICATIONS**

a. Applicable Standards

DOR Guidelines	
NUREG-0588, Cat. I	X
NUREG-0588, Cat. II	

b. Normal Service Conditions

Temperature: 120°F for 84% of qualified life
88°F for 16% of qualified life

Pressure: Atmospheric

Radiation: 3.5×10^4 rads gamma (air equivalent) TID

Relative Humidity: 20% to 90%

c. Design Basis Events

Accident Profile: See Figures 1 and 2.

Source:

MSLB	X
HELB	
LOCA	X

Operating Time:	30 days			
Radiation:	1.4×10^7 rads gamma			
Relative Humidity:	100%			
Submergence:	Yes		No	X
Chemical Spray:	Yes	X	No	
Mode:	Active	X		
	Passive			
	Fail-Safe			

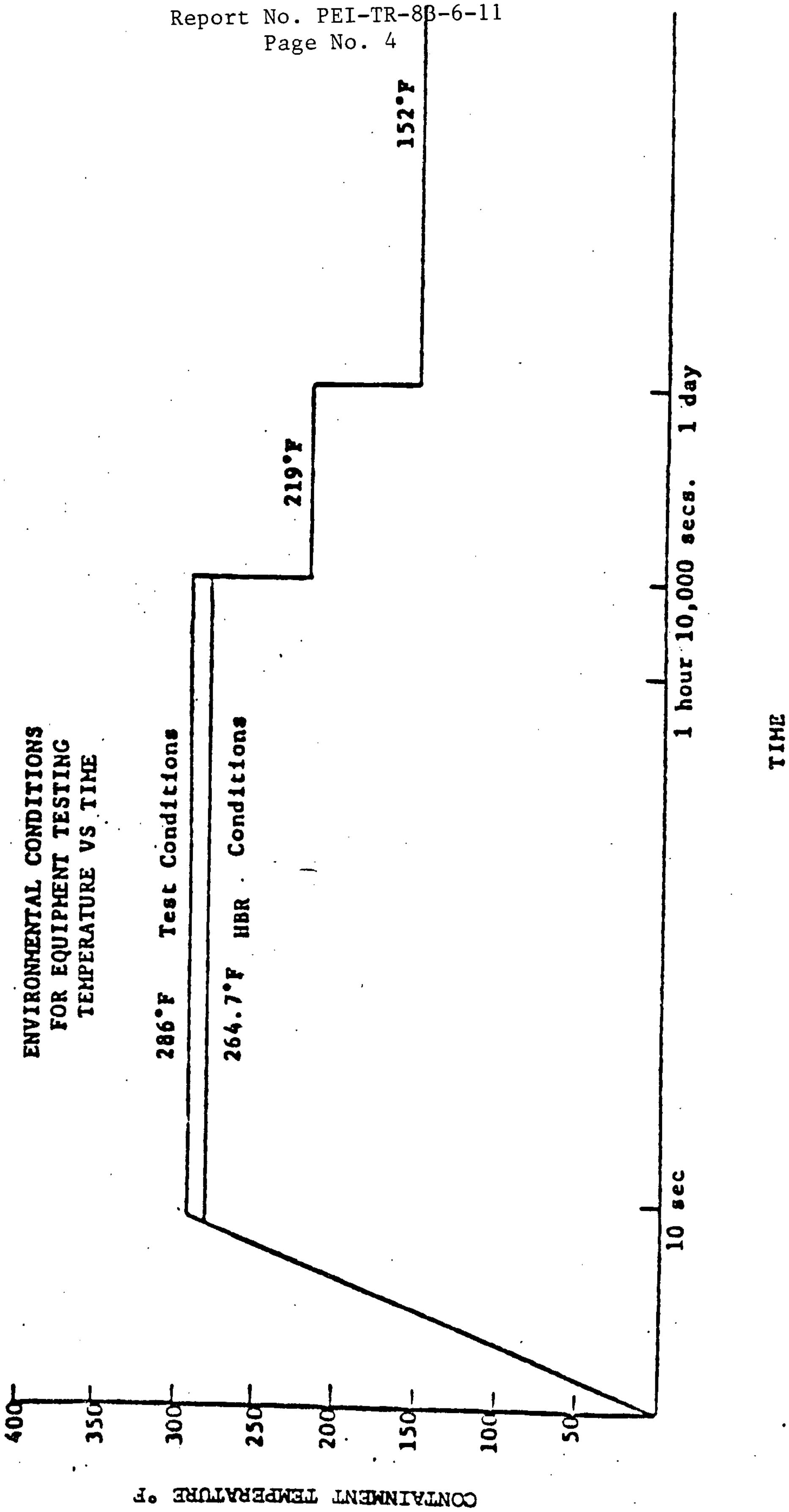

FIGURE 1. Containment Temperature vs. Time Following LOCA/MSLB [17]

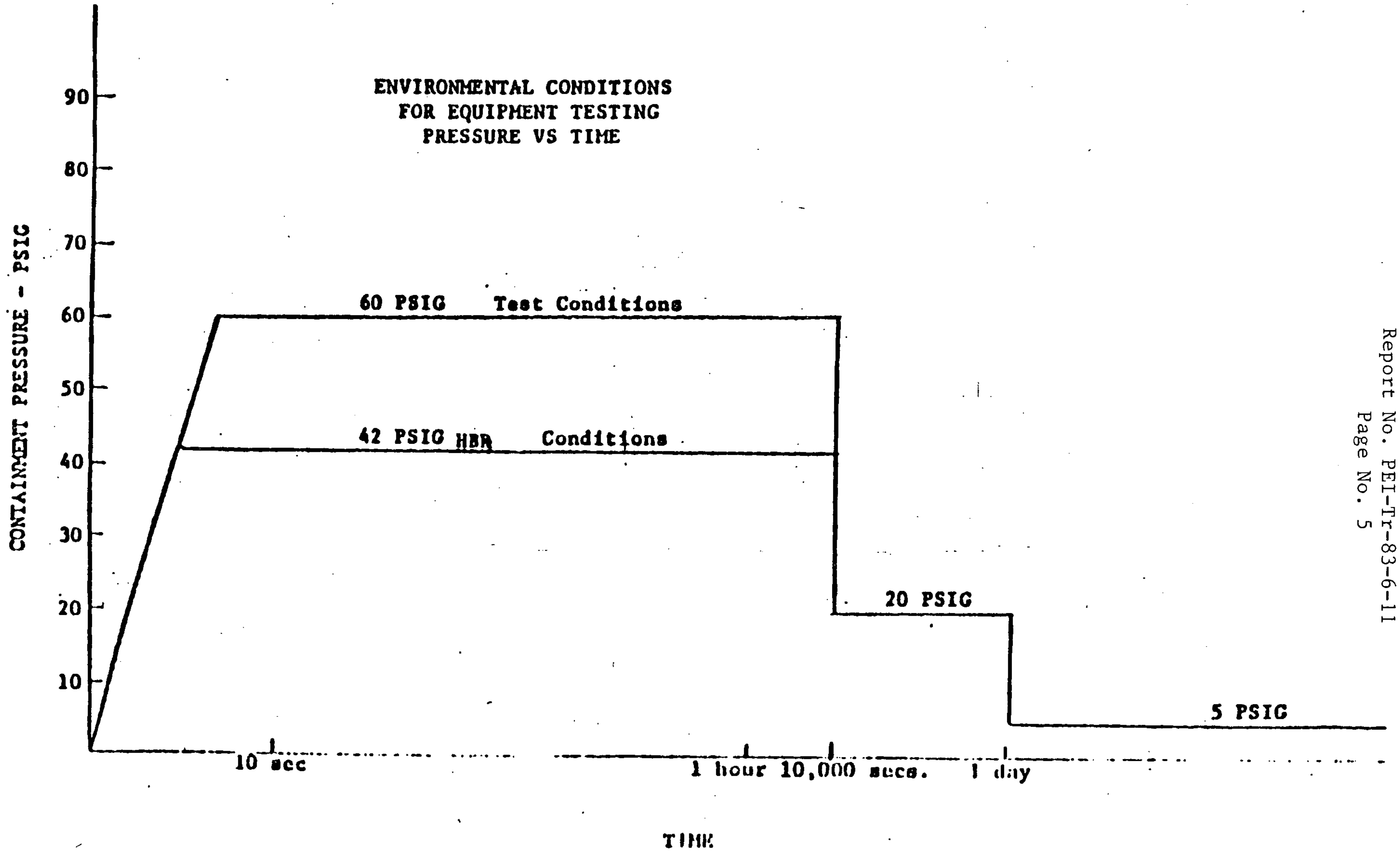

FIGURE 2. Containment Pressure vs. Time Following LOCA/MSLB [17]

SECTION II. QUALIFICATION ASSESSMENT

1. QUALIFICATION DOCUMENTATION

a. **Title:** Qualification Tests of Electric Cables Under Conditions Simulating Normal Reactor Containment Service and a Loss-of-Coolant Accident

Report No.: F-C3683 **Date:** November, 1973

Source: Samuel Moore and Company

2. QUALIFICATION DOCUMENTATION ANALYSIS

a. **Design Basis Event Analysis**

LOCA Simulation Profile: See Figure 3.

	Yes	No*	N/A
1) Are all peak temperature/pressure and time requirements during the transient phase enveloped?	X		
2) Are all temperature/pressure and time requirements during the post-accident phase enveloped?		X	
3) Are margins as applied consistent with those defined in NUREG-0588, IEEE 323-1974, and/or the DOR Guidelines, as applicable?	X		
4) Are the functional tests as performed adequate to demonstrate that the functional requirements (accuracy, repeatability, insulation resistance, etc.) for the equipment can be met?	X		
5) Was the normal and accident radiation applied prior to and/or simultaneously with the accident simulation? If yes, to what level? $1x10^8$ rads gamma	X		

		Yes	No*	N/A
6)	If submergence is a requirement, does the test demonstrate acceptable operation?			X
7)	Was the requirement for chemical spray enveloped?	X		
8)	Were all known synergisms accounted for in the test sequence?	X		
9)	If failures occurred during the test program, are adequate justifications provided in the form of a failure analysis such that the qualification is not negated?	X		

b. **Normal Service Conditions Analysis**

		Yes	No*	N/A
1)	Does the aging analysis provided in the supporting documentation provide for a 40-year qualified life at the HBR-2 defined service temperature?		X	
2)	Was the aging analysis performed using Arrhenius techniques?		X	
3)	Is the aging analysis auditable?		X	
4)	Was the radiation requirement accomplished by the radiation test?	X		
5)	If any radiation exemptions were utilized, are they auditable?			X
6)	Did the equipment perform successfully at the extremes of its normal service conditions (temperature, radiation, pressure, voltage, current, humidity, etc.) as required by IEEE 323-1974 and NUREG-0588?	X		

	Yes	No*	N/A
7) Were the functional tests performed adequate to demonstrate operability parameters as seen in service?	X		
8) Are the acceptance/failure criteria clearly defined?	X		
9) If failures occurred during the test program, are adequate justifications provided in the form of a failure analysis such that the qualification is not negated?	X		
10) Are all known synergisms accounted for in the test program?		X	

* All questions which were marked "No" will require additional analysis to justify qualification.

3. CONCLUSIONS AND RECOMMENDATIONS

Reference 1.a fulfills all the requirements of NUREG-0588, Category I, except for those items listed in Paragraph 4 below.

4. OUTSTANDING ITEMS REQUIRING RESOLUTION

- Time-Temperature Effects
- Degradation Equivalency
- Known Synergisms
- Reference Auditability

Section III of this report provides additional analysis to resolve these outstanding items.

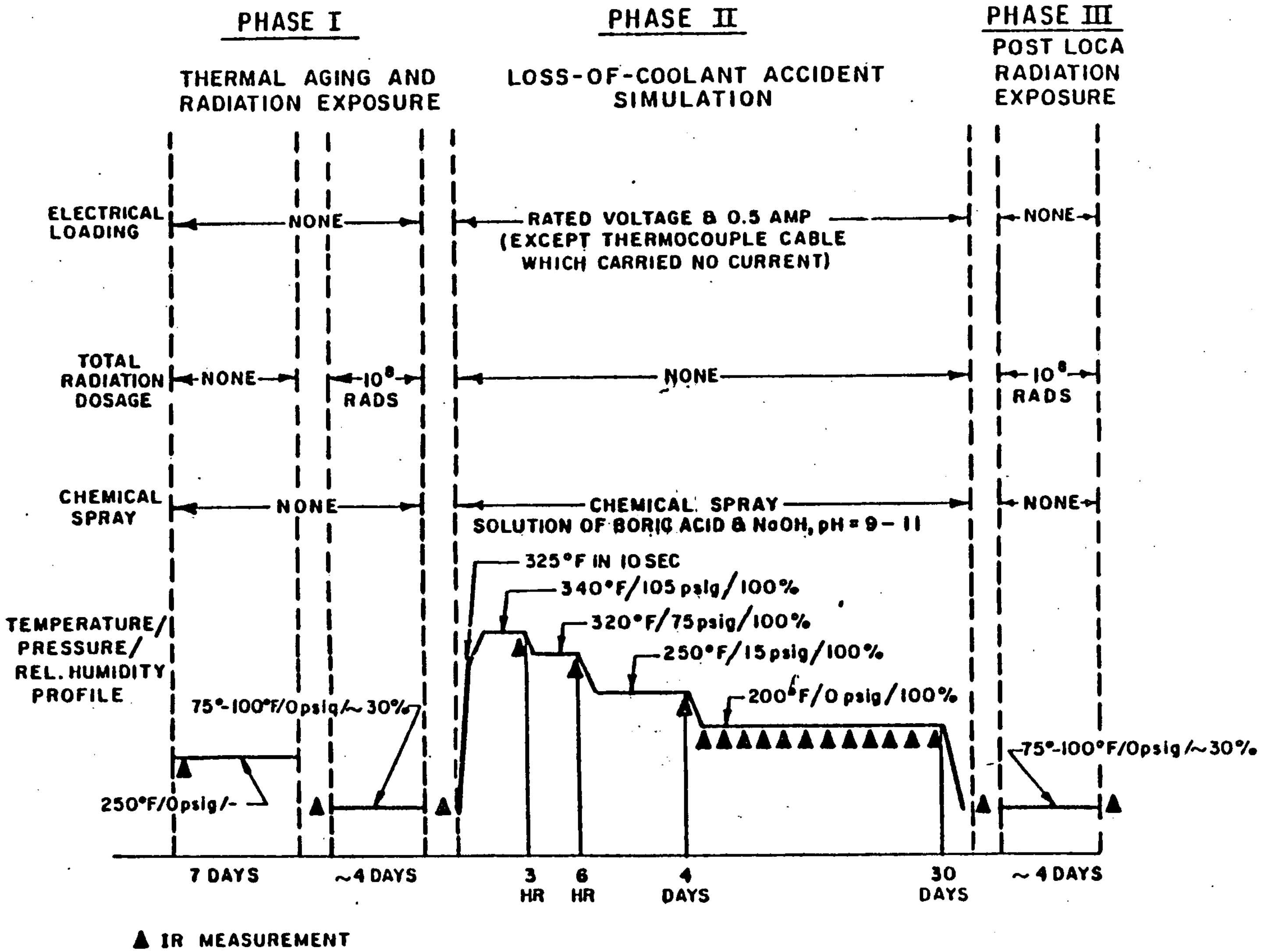

FIGURE 3. PROFILE OF TEST PHASES

SECTION III. QUALIFICATION JUSTIFICATION ANALYSIS

Where qualification parameters are not clearly defined, when new research highlights potential problem areas, or when the plant requirements are not met, analysis must be performed to augment the existing qualification documentation. The intent of this section is to summarize the results of this analysis. From these results, a specific program, if required, to maintain the qualification status of the Class 1E equipment is recommended.

For the Samuel Moore thermocouple extension cable, the following areas were analyzed:

- o 1.0 Time-Temperature Effects
- o 2.0 Degradation Equivalency
- o 3.0 Known Synergisms
- o 4.0 Reference Auditability

1.0 TIME-TEMPERATURE EFFECTS

Aging effects on all Class 1E equipment must be considered and included in the qualification program. For time-temperature effects, the present state-of-the-art allows artificial acceleration of these effects associated with organic materials by increasing the temperature. The deterioration due to these effects is judged to be insignificant for metallic materials. Therefore, the aging of the Class 1E equipment will be based on its nonmetallic materials.

For many organic materials, it is known that the degradation process can be defined by a single temperature-dependent reaction that follows the Arrhenius equation (References 1 and 2):

$$k = A \exp (-Ea/k_B T) \qquad (1)$$

where,

k = reaction rate

A = frequency factor

exp = exponent to base e

Ea = activation energy

k_B = Boltzmann's Constant

T = absolute temperature

It is further noted that, for many reactions, the activation energy can be considered to be constant over the applicable temperature range. Equation (1) can be transformed into a form which yields an acceleration factor.

The acceleration factor is defined as t_2/t_1.

The equation is:

$$t_2/t_1 = \exp\left(-(Ea/k_B)(1/T_1 - 1/T_2)\right) \qquad (2)$$

where,

t_1 = accelerated aging time at temperature T_1

t_2 = normal service time at temperature T_2

exp = exponent to base e

Ea = activation energy (eV)

k_B = Boltzmann's Constant (8.617×10^{-5} eV/^{o}K)

T_1 = accelerated aging temperature (^{o}K)

T_2 = normal service temperature (^{o}K)

The transformation of the reaction rate form of the Arrhenius equation to an acceleration form is accomplished as follows:

Life is assumed to be inversely proportional to the chemical reaction rate (References 1 and 2). In terms of life, and after converting to Napierian base logarithm, Equation (1) becomes:

$$\ln(\text{life}) = (Ea/k_B)(1/T) + \text{Constant} \qquad (3)$$

Equation (3) has the algebraic form:

$$y = mx + b \qquad (4)$$

where,

y = ln (life)

x = 1/T

m = Ea/k_B, constant for single dominant reactions

b = constant

The constants, m and b, can be estimated by fitting the experimental data in the form of ln (life) versus 1/T into the above simple linear relationship.

The derivation of an acceleration factor is accomplished by taking the difference between any two points of the linear relationship.

Thus, if we substitute t for life into Equation (3), we obtain:

$$\ln t = (Ea/k_B)(1/T) + \text{Constant} \quad (5)$$

For the set of points (t_1, T_1), Equation (5) becomes:

$$\ln t_1 = (Ea/k_B)(1/T_1) + \text{Constant} \quad (6)$$

For the set of points (t_2, T_2), Equation (5) becomes:

$$\ln t_2 = (Ea/k_B)(1/T_2) + \text{Constant} \quad (7)$$

Subtracting Equation (6) from Equation (7) yields:

$$\ln t_2 - \ln t_1 = (Ea/k_B)(1/T_2) + \text{Constant} - (Ea/k_B)(1/T_1) - \text{Constant} \quad (8)$$

Simplifying and rearranging Equation (8) yields:

$$\ln (t_2/t_1) = -(Ea/k_B)(1/T_1 - 1/T_2) \quad (9)$$

Taking antilogarithm yields:

$$t_2/t_1 = \exp(-(Ea/k_B)(1/T_1 - 1/T_2)) \quad (10)$$

Equation (10) is the same as Equation (2).

The qualified life of the nonmetallics in the equipment is determined by solving Equation (10) for t_2.

$$t_2 = t_1/\exp((Ea/k_B)(1/T_1 - 1/T_2)) \quad (11)$$

The thermocouple extension cable has two (2) postulated service temperatures during the 40-year service life (see Section I, 2.b., of this report). Therefore, the above equation is modified to:

$$Q.L. = t_1 / \sum_{x=2}^{n+1} P_x \exp((Ea/k_B)(1/T_1 - 1/T_x)) \quad (12)$$

where,

t_1 = aging time

T_1 = aging temperature

T_x = service temperature

P_x = fraction of 40-year life at T_x

Ea/k_B = activation energy/Boltzmann's Constant

Since, in most cases, it is not practical to independently accelerate the time-temperature effects of each nonmetallic material, a determination is made as to which material has the lowest activation energy. The time-temperature effects are then accelerated based upon the lowest activation energy for conservatism. This assures that the degradation of each age-sensitive component is accelerated to at least the equivalent degradation as that to be encountered during the operating life.

1.1 Specific Analysis of Time-Temperature Effects

The subject equipment was aged prior to the design basis event for 168 hours at 121°C. The nonmetallic materials are EPDM and Hypalon. Using Equation (12):

$$\text{Qualified Life} = t_1 / \sum_{x=2}^{n+1} P_x \exp((Ea/k_B)(1/T_1 - 1/T_x))$$

where,

t_1 = 168 hours

P_x = fraction of 40-year life at T_x

exp = exponent to base e

Ea = 1.14 eV (Reference 6 - See Note 1)

k_B = 8.617×10^{-5} (Boltzmann's Constant)

T_1 = 121°C (aging temperature)

T_x = service temperature (See Note 2)

Note 1: Generically similar system aging data was used. System data is preferred to account for any synergisms during thermal aging.

Note 2: Heat rise due to current loading is minimal for thermocouple cabling; hence, the use of the normal ambient temperatures.

Solving the equation gives a qualified life of greater than 41 years at the service temperatures specified in Section I, 2.b.

2.0 DEGRADATION EQUIVALENCY ANALYSIS

A comparison of the test profile (see Figure 3) and the HBR-2 accident profiles shows that the peak transients are enveloped for time and temperature. The post-accident phase is not enveloped by the test conditions due to the requirement for 10% margin on operating time. Since the materials follow an Arrhenius relationship, the requirements at one time and temperature can be transferred to another set of time-temperature coordinates using the relationship:

$$t_1 = \sum_{x=2}^{n+1} t_x / \exp\left((Ea/k_B)(1/T_x - 1/T_1)\right) \qquad (13)$$

where,

t_1 = equivalent time at T_1

t_x = time at temperature T_x

T_x = accident temperature above T_1

Ea = activation energy (eV)

k_B = Boltzmann's Constant (8.617×10^{-5})

2.1 Specific Degradation Equivalency Analysis

For the subject equipment, the test conditions exceed the worst-case accident conditions (Figure 1) for the initial 30 days, but do not envelop the entire postulated plant post-accident phase in duration. A time-temperature equivalency can be derived to verify that the test conditions, after 5 days, exceed the plant postulated post-accident phase by using Equation (13) and the following parameters for t_x and T_x (see Figure 3):

t_2 = 600 hours

T_2 = $200^{o}F$

The equivalent time at an ambient temperature of $152^{o}F$ is greater than 425 days. Therefore, the thermocouple cable is considered qualified for the postulated HBR-2 accident and post-accident phases.

3.0 KNOWN SYNERGISMS

Two (2) known synergisms were not addressed during the test. They are as follow:

- Radiation prior to thermal aging
- Dose rate effects

An explanation of these known potential synergisms is provided in the following paragraphs.

3.1 Radiation Exposure Prior to Thermal Aging

Testing sponsored by the Nuclear Regulatory Commission (NRC) and reported by Sandia Laboratories (Reference 3) has shown radiation prior to thermal aging to cause some polymers to degrade to a greater extent than when irradiated following thermal aging. The report states that, "The mechanistic postulate is that radiation-cleaved bonds, in the form of radicals, react with oxygen to give degradation products, including peroxides. The peroxides are chemically weak links which are susceptible to thermal cleavage. This thermal peroxide cleavage gives more radicals which, in the presence of oxygen, lead to more degradation and more peroxides. Thermal aging prior to irradiation does not substantially disrupt the polymer's original molecular structure over the normal elevated temperature ranges which, in turn, results in a lesser degree of degradation than may be expected in actual plant applications. Thus, the amplification of the degradation process caused by the thermal peroxide cleavage must be accounted for by performing normal radiation prior to thermal aging.

Subsequent testing by Sandia Laboratories, as reported in SAND 80-21496 (Reference 4), established performing thermal aging after irradiation as the only method in which to account for the strong synergism due to radiation and high temperature found in some polymers. "The joint effect of gamma radiation and elevated temperature was also found to occur when the two environments were applied in a sequential fashion, but only when the experiments were performed in that order--radiation followed by elevated temperature."

3.2 Dose Rate Effects

Testing sponsored by the NRC and reported by Sandia Laboratories (Reference 5) indicates that for some polymers the mechanical damage present for a given total dose is dependent on the dose rate. Testing was performed at $1x10^3$ rads per hour and $1x10^6$ rads per hour. For the polymers tested, it was found that more degradation occurred at the lower dose rate than at $1x10^6$ rads per hour. Specifically, the report states, "Sufficient data has now been accumulated from the low dose rate experiments to indicate that dose rate effects are present for every material which we have studied and must, therefore, be considered before extrapolating high dose rate accelerated simulations to low dose rate ambient conditions." Ethylene propylene was specifically mentioned by this report as being susceptible to dose rate effects.

3.3 Effect on Qualification

The intent of the research documented was to highlight potential aging problem areas between real time and artificially accelerated radiation aging. For Class 1E equipment located in a harsh environment, qualification testing to the postulated normal and accident radiation levels may not degrade the equipment to a level which is indicative of actual degradation experienced in its proposed service life. Surveillance programs or "overtesting" are two (2) methods to account for this effect.

Performing qualification testing at levels in excess of the required level, plus margin, is a common method to account for this synergistic effect. The amount of conservatism normally used is 10%. For the thermocouple cable used at HBR-2, the test specimens were radiation aged to a level 7.1 times (610% above) the requirement. Therefore, it is judged the thermocouple cable was degraded to a level much greater than would be seen in service and no surveillance program would be required.

4.0 REFERENCES

In accordance with IEEE 323-1974, all references listed below, including those with Arrhenius or radiation data, are auditable at Patel Engineers.

1. "IEEE Guide for the Statistical Analysis of Thermal Life Test Data," IEEE 101-1972, Library Code 102-82.

2. Handbook of Engineering Fundamentals, Wiley, 1975, Library Code 103-82.

3. "A Study of Strong Synergisms in Polymer Degradation," Clough, Gillen, and Salazar, Sandia National Laboratories, SAND 79-092CK, Library Code 104-82.

4. "Radiation - Thermal Degradation of PE and PVC: Mechanism of Synergisms and Dose Rate Effects," R.L. Clough and K.T. Gillen, Sandia National Laboratories, SAND 80-2149C, Library Code 093-82.

5. "Occurrence and Implication of Radiation Dose Rate Effects for Material Aging Studies," K.T. Gillen and R.L. Clough, Sandia National Laboratories, SAND 80-1796C, Library Code 092-82.

6. Arrhenius Plots for BIW Cables from Various BIW Reports, Boston Insulated Wire and Cable Company, BIW Reports B912, B915, B916, and B921, Library Code 060-82.

SECTION IV. CONCLUSIONS

Based on the comparison of the qualification test documentation to the normal and accident service conditions postulated for containment, the Samuel Moore thermocouple extension cable is judged to possess a 40-year qualified life at HBR-2.

This conclusion is based on analyses performed in the following areas:

- Time-Temperature Effects - Based on the lowest activation energy obtained, 1.14 eV, and using the temperatures specified in Paragraph 1.1, Section III, the equipment possesses a qualified life of greater than 41 years.

- Post-Accident Degradation Equivalency - A time-temperature equivalence was derived to verify that the test conditions (described in Section II) exceed the HBR-2 worst-case accident conditions, including the post-accident phase. It was shown that the test conditions equate to a period of 425 days at 152^{o}F in comparison with the required 33 days (30 days plus 10% margin).

- Known Synergisms - The test specimen was subjected to radiation after the thermal aging simulation. The two known synergistic effects--radiation prior to thermal aging and dose rate effects--were overcome by a greater than 6.1% margin with a total exposure of $1x10^8$ rads gamma*, as compared with a requirement of $1.4x10^7$ rads gamma.

*Only the 100 megarads performed prior to the accident simulation were included.

TECHNICAL REPORT
PEI-TR-83-6-12
February 4, 1983

FINAL REPORT ON THE EVALUATION OF THE QUALIFICATION OF THE THERMOFIT CABLE SPLICES PROVIDED BY RAYCHEM CORPORATION FOR USE IN THE H.B. ROBINSON STEAM ELECTRIC PLANT - UNIT 2

by
Fredrick L. Roy

Prepared for

CAROLINA POWER AND LIGHT COMPANY
Raleigh, North Carolina

Contract No.: 82-NPED-04
PEI Job No. 8310

patel engineers
huntsville, alabama

REPORT NO.: PEI-TR-83-6-12

PREPARED BY: Fredrick L. Roy TWH
Fredrick L. Roy, Program Manager

APPROVED BY: David Stinson
David Stinson, Director

Q.A. REVIEW: M J Kimbrell
M. J. Kimbrell, Director, Product Assurance

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TABLE OF CONTENTS

SECTION I. EQUIPMENT IDENTIFICATION/QUALIFICATION REQUIREMENTS

1. EQUIPMENT DESCRIPTION

System:	Various	**Component I.D.:**	N/A
Manufacturer:	Raychem Corporation	**Equipment Type:**	Cable Splices
Serial No.:	N/A	**Model No.:**	Thermofit WCSF-N (See Introduction & Summary)

Location: Various

Safety-Related Function: Protects Class 1E electrical circuits

2. QUALIFICATION SPECIFICATIONS

a. **Applicable Standards**

DOR Guidelines	X
NUREG-0588, Cat. I	X
NUREG-0588, Cat. II	

b. **Normal Service Conditions**

Temperature: $120^{\circ}F$ for 84% of qualified life
$88^{\circ}F$ for 16% of qualified life

Pressure: Atmospheric

Radiation: 3.5×10^{4} rads gamma (air equivalent) TID

Relative Humidity: 20% to 90%

c. **Design Basis Events**

Accident Profile: See Figures 1 and 2

Source:

MSLB	X
HELB	
LOCA	X

Operating Time:	30 days			
Radiation:	$1.4x10^7$ rads gamma			
Relative Humidity:	100%			
Submergence:	Yes		No	X
Chemical Spray:	Yes	X	No	
Mode:	Active	X		
	Passive			
	Fail-Safe			

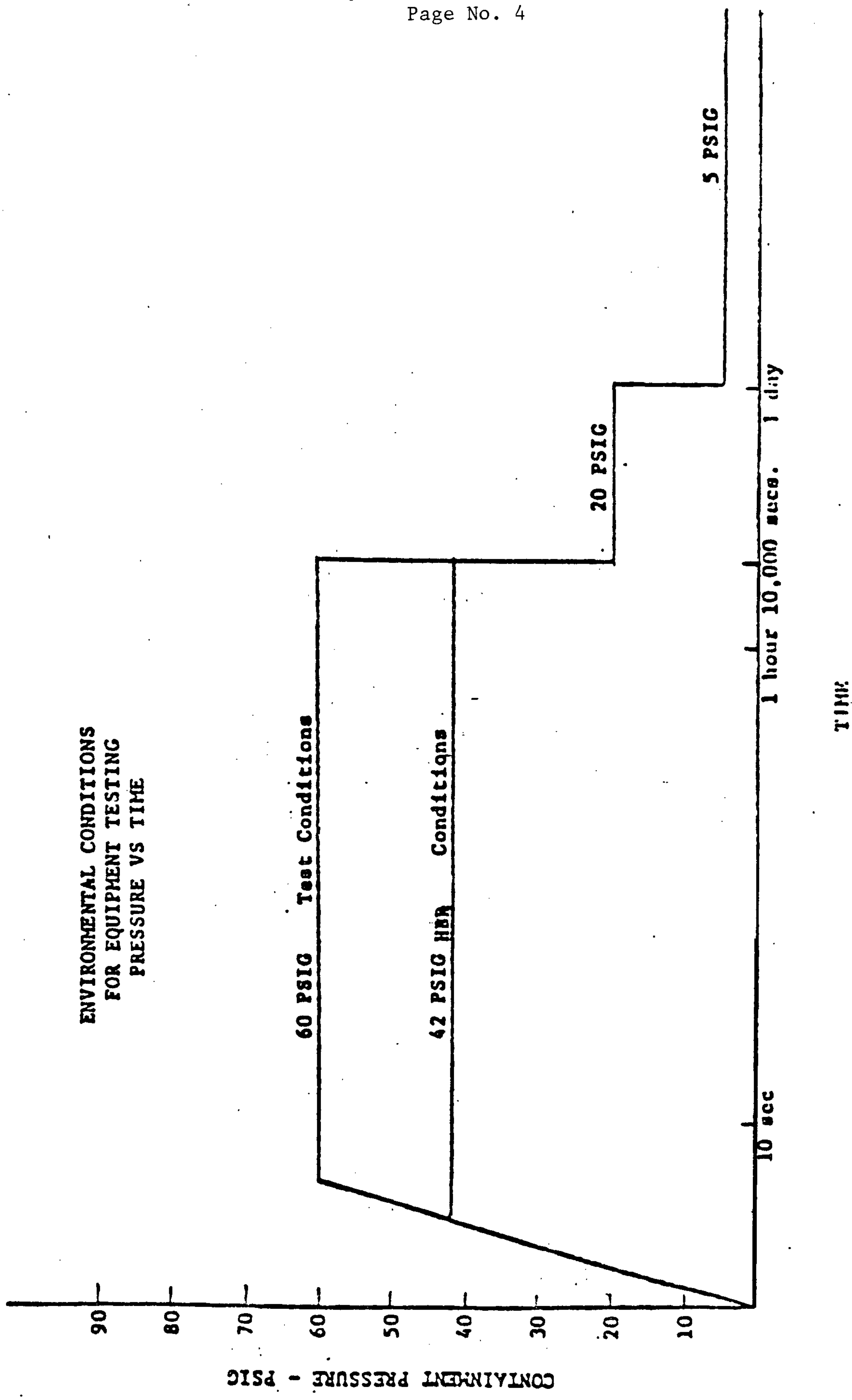

Figure 1: Containment Pressure vs. Time Following LOCA/MSLB [17]

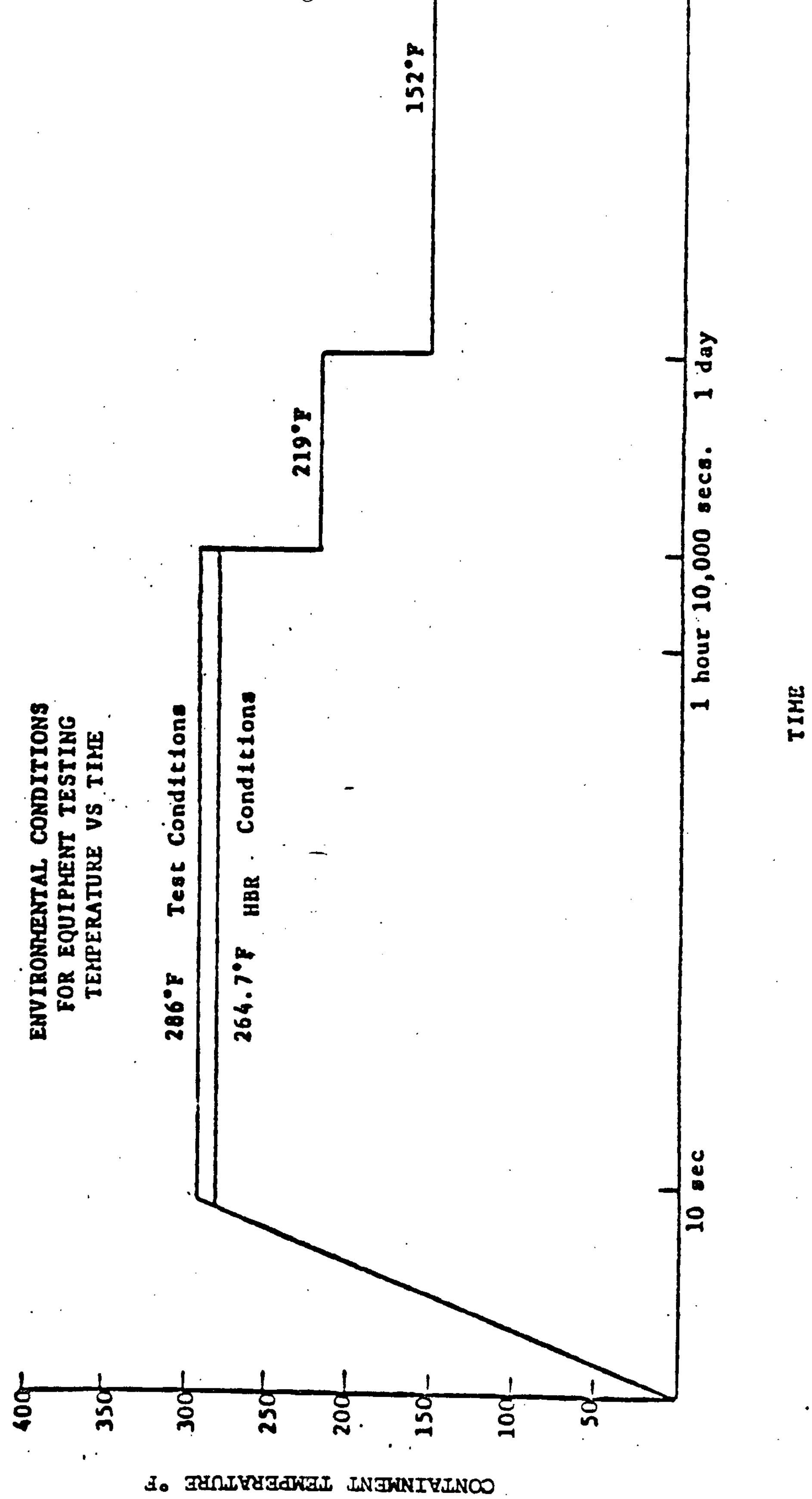

Figure 2: Containment Temperature vs. Time Following LOCA/MSLB [17]

SECTION II. QUALIFICATION ASSESSMENT

1. QUALIFICATION DOCUMENTATION

a. **Title:** Tests of Raychem Thermofit Insulation Systems Under Simultaneous Exposure to Heat, Gamma Radiation, Steam, and Chemical Spray While Electrically Energized

Report No.: F-C4033-3 **Date:** January, 1975

Source: Raychem Corporation

2. QUALIFICATION DOCUMENTATION ANALYSIS

a. **Design Basis Event Analysis**

LOCA Simulation Profile: See Figure 3.

	Yes	No*	N/A
1) Are all peak temperature/pressure and time requirements during the transient phase enveloped?	X		
2) Are all temperature/pressure and time requirements during the post-accident phase enveloped?		X	
3) Are margins as applied consistent with those defined in NUREG-0588, IEEE 323-1974, and/or the DOR Guidelines, as applicable?	X		
4) Are the functional tests as performed adequate to demonstrate that the functional requirements (accuracy, repeatability, insulation resistance, etc.) for the equipment can be met?	X		
5) Was the normal and accident radiation applied prior to and/or simultaneously with the accident simulation? If yes, to what level? 2.0×10^8 rads gamma	X		

	Yes	No*	N/A
6) If submergence is a requirement, does the test demonstrate acceptable operation?			X
7) Was the requirement for chemical spray enveloped?	X		
8) Were all known synergisms accounted for in the test sequence?	X		
9) If failures occurred during the test program, are adequate justifications provided in the form of a failure analysis such that the qualification is not negated?			X

b. <u>Normal Service Conditions Analysis</u>

	Yes	No*	N/A
1) Does the aging analysis provided in the supporting documentation provide for a 40-year qualified life at the HBR-2 defined service temperature?		X	
2) Was the aging analysis performed using Arrhenius techniques?		X	
3) Is the aging analysis auditable?		X	
4) Was the radiation requirement accomplished by the radiation test?	X		
5) If any radiation exemptions were utilized, are they auditable?			X
6) Did the equipment perform successfully at the extremes of its normal service conditions (temperature, radiation, pressure, voltage, current, humidity, etc.) as required by IEEE 323-1974 and NUREG-0588?	X		

	Yes	No*	N/A
7) Were the functional tests performed adequate to demonstrate operability parameters as seen in service?	X		
8) Are the acceptance/failure criteria clearly defined?	X		
9) If failures occurred during the test program, are adequate justifications provided in the form of a failure analysis such that the qualification is not negated?			X
10) Are all known synergisms accounted for in the test program?		X	

* All questions which were marked "No" will require additional analysis to justify qualification.

3. CONCLUSIONS AND RECOMMENDATIONS

Reference 1.a fulfills all the requirements of the DOR Guidelines and NUREG-0588, Category I, except for those items listed in Paragraph 4, below.

4. OUTSTANDING ITEMS REQUIRING RESOLUTION

- Time-Temperature Effects
- Degradation Equivalency
- Known Synergisms
- Reference Auditability

Section III of this report provides additional analyses to resolve these outstanding items.

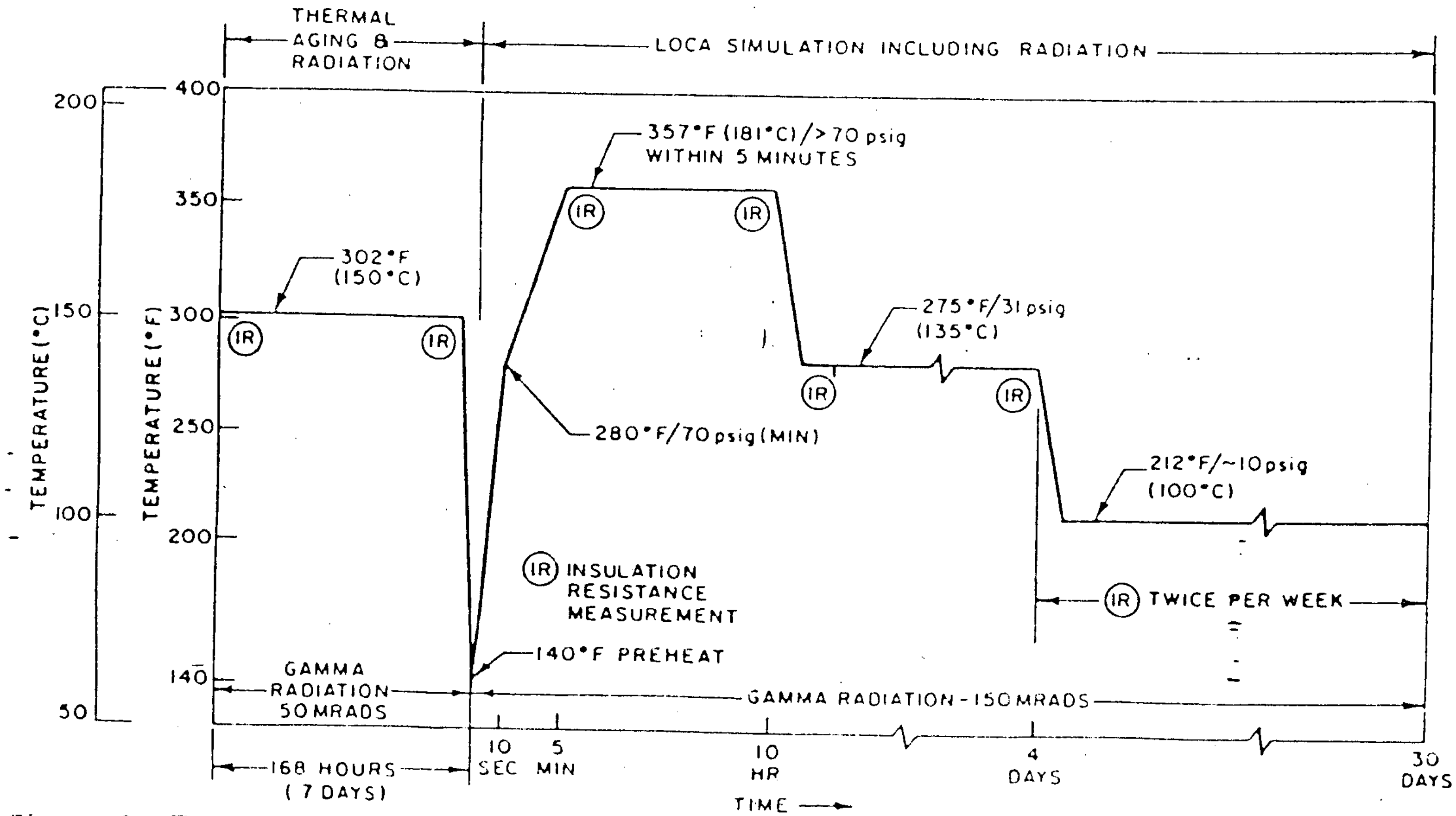

Figure 3. Temperature/pressure profile for simulation of Loss-Of-Coolant Accident environment.

SECTION III. QUALIFICATION JUSTIFICATION ANALYSIS

Where qualification parameters are not clearly defined, when new research highlights potential problem areas, or when the plant requirements are not met, analysis must be performed to augment the existing qualification documentation. The intent of this section is to summarize the results of this analysis. From these results, a specific program, if required, to maintain the qualification status of the Class 1E equipment is recommended.

For the Raychem Thermofit WCSF-N splices, the following areas were analyzed:

- o 1.0 Time-Temperature Effects
- o 2.0 Degradation Equivalency
- o 3.0 Known Synergisms
- o 4.0 Reference Auditability

1.0 TIME-TEMPERATURE EFFECTS

Aging effects on all Class 1E equipment must be considered and included in the qualification program. For time-temperature effects, the present state-of-the-art allows artificial acceleration of these effects associated with organic materials by increasing the temperature. The deterioration due to these effects is judged to be insignificant for metallic materials. Therefore, the aging of the Class 1E equipment will be based on its nonmetallic materials.

For many organic materials, it is known that the degradation process can be defined by a single temperature-dependent reaction that follows the Arrhenius equation (References 1 and 2):

$$k = A \exp(-Ea/k_B T) \qquad (1)$$

where,

k = reaction rate

A = frequency factor

exp = exponent to base e

Ea = activation energy

k_B = Boltzmann's Constant

T = absolute temperature

It is further noted that, for many reactions, the activation energy can be considered to be constant over the applicable temperature range. Equation (1) can be transformed into a form which yields an acceleration factor.

The acceleration factor is defined as t_2/t_1.

The equation is:

$$t_2/t_1 = \exp\left(-(Ea/k_B)(1/T_1 - 1/T_2)\right) \qquad (2)$$

where,

t_1 = accelerated aging time at temperature T_1

t_2 = normal service time at temperature T_2

exp = exponent to base $\bar{e}$

Ea = activation energy (eV)

k_B = Boltzmann's Constant (8.617×10^{-5} eV/^{o}K)

T_1 = accelerated aging temperature (^{o}K)

T_2 = normal service temperature (^{o}K)

The transformation of the reaction rate form of the Arrhenius equation to an acceleration form is accomplished as follows:

Life is assumed to be inversely proportional to the chemical reaction rate (References 1 and 2). In terms of life, and after converting to Napierian base logarithm, Equation (1) becomes:

$$\ln(\text{life}) = (Ea/k_B)(1/T) + \text{Constant} \qquad (3)$$

Equation (3) has the algebraic form:

$$y = mx + b \qquad (4)$$

where,

y = ln (life)

x = 1/T

m = Ea/k_B, constant for single dominant reactions

b = constant

The constants, m and b, can be estimated by fitting the experimental data in the form of ln (life) versus 1/T into the above simple linear relationship.

The derivation of an acceleration factor is accomplished by taking the difference between any two points of the linear relationship.

Thus, if we substitute t for life into Equation (3), we obtain:

$$\ln t = (Ea/k_B)(1/T) + \text{Constant} \qquad (5)$$

For the set of points (t_1, T_1), Equation (5) becomes:

$$\ln t_1 = (Ea/k_B)(1/T_1) + \text{Constant} \qquad (6)$$

For the set of points (t_2, T_2), Equation (5) becomes:

$$\ln t_2 = (Ea/k_B)(1/T_2) + \text{Constant} \qquad (7)$$

Subtracting Equation (6) from Equation (7) yields:

$$\ln t_2 - \ln t_1 = (Ea/k_B)(1/T_2) + \text{Constant}$$
$$-(Ea/k_B)(1/T_1) - \text{Constant} \qquad (8)$$

Simplifying and rearranging Equation (8) yields:

$$\ln (t_2/t_1) = -(Ea/k_B)(1/T_1 - 1/T_2) \qquad (9)$$

Taking antilogarithm yields:

$$t_2/t_1 = \exp (-(Ea/k_B)(1/T_1 - 1/T_2)) \qquad (10)$$

Equation (10) is the same as Equation (2).

The qualified life of the nonmetallics in the equipment is determined by solving Equation (10) for t_2.

$$t_2 = t_1/\exp ((Ea/k_B)(1/T_1 - 1/T_2)) \qquad (11)$$

The Raychem splices have two (2) postulated service temperatures during the 40-year service life (see Section I, 2.b., of this report). Therefore, the above equation is modified to:

$$Q.L. = t_1 / \sum_{x=2}^{n+1} P_x \exp((Ea/k_B)(1/T_1 - 1/T_x)) \qquad (12)$$

where,

t_1	=	aging time
T_1	=	aging temperature
T_x	=	service temperature
P_x	=	fraction of 40-year life at T_x
Ea/k_B	=	activation energy/Boltzmann's Constant

Since, in most cases, it is not practical to independently accelerate the time-temperature effects of each nonmetallic material, a determination is made as to which material has the lowest activation energy. The time-temperature effects are then accelerated based upon the lowest activation energy for conservatism. This assures that the degradation of each age-sensitive component is accelerated to at least the equivalent degradation as that to be encountered during the operating life.

In determining aging temperatures and service temperatures to be used in calculating qualified life, heat rise must be considered. If the heat rise for each component is known and the device was aged unpowered or aged powered and the temperature of each component measured, a qualified life may be determined directly using these temperatures. If the device is aged while powered and the heat rise for each component was not measured, the qualified life should be determined in a manner which accounts for the heat rise. This is accomplished by adding the worst-case heat rise to both the service temperatures and the aging temperature. This can be shown to be conservative by modifying Equation (10) as follows:

$$t_2/t_1 = \exp\ (-Ea/k_B)(T_2 - T_1/T_1T_2) \qquad (13)$$

Since T_1 is larger than T_2, $T_2 - T_1$ is negative and Equation (13) can be rewritten:

$$t_2/t_1 = \exp\ (-Ea/k_B)(-(T_1 - T_2)/T_1T_2) \qquad (14)$$

Simplifying and rearranging Equation (14) yields:

$$t_2 = t_1 \exp\ (Ea/k_B)((T_1 - T_2)/T_1T_2) \qquad (15)$$

It can be seen from Equation (15) that if heat rise is added to the T_1 and T_2, the value of T_1-T_2 will remain the same, but the product T_1T_2 will increase. This increase causes the overall value of the exponent to decrease and the qualified life, t_2, will decrease accordingly. If the qualified life is determined based just on service temperature and aging temperature, ignoring heat rise because the device was aged powered, the qualified life would be significantly greater and less conservative than if heat rise is used in calculating a qualified life.

The heat rise for any single component cannot be greater than the maximum heat rise in the device. Further, the qualified life determined for any heat rise less than the maximum will be greater than that determined for the maximum heat rise. Using the maximum heat rise in the calculation of the qualified life is, therefore, conservative.

1.1 Specific Analysis of Time-Temperature Effects

The subject equipment was aged prior to the design basis event for 168 hours at 150°C. Using Equation (12):

$$\text{Qualified Life} = t_1 / \sum_{x=2}^{n+1} P_x \exp\left((Ea/k_B)(1/T_1 - 1/T_x)\right)$$

where,

t_1 = 168 hours

P_x = fraction of 40-year life at T_x

exp = exponent to base e

Ea = 1.29 eV (Reference 6)

k_B = 8.617×10^{-5} (Boltzmann's Constant)

T_1 = 200°C (aging temperature - 150°C aging temperature +50°C heat rise)

T_x = service temperature (+50°C heat rise)

Solving the equation gives a qualified life of greater than 121 years at the service temperatures specified in Section I, 2.b, plus 50°C heat rise.

2.0 DEGRADATION EQUIVALENCY ANALYSIS

A comparison of the test profile (see Figure 3) and the HBR-2 accident profiles shows that the peak transients are enveloped for time and temperature. The post-accident phase is not enveloped by the test conditions due to the requirement for 10% margin on operating time. Since the materials follow an Arrhenius relationship, the requirements at one time and temperature can be transferred to another set of time-temperature coordinates using the relationship:

$$t_1 = \sum_{x=2}^{n+1} t_x / \exp\left((Ea/k_B)(1/T_x - 1/T_1)\right) \qquad (13)$$

where,

t_1 = equivalent time at T_1

t_x = time at temperature T_x

T_x = accident temperature above T_1

Ea = activation energy (eV)

k_B = Boltzmann's Constant (8.617×10^{-5})

2.1 Specific Degradation Equivalency Analysis

For the subject equipment, the test conditions exceed the worst-case accident conditions (Figures 1 and 2) for the initial 30 days, but do not envelop the entire postulated plant post-accident phase in duration. A time-temperature equivalency can be derived to verify that the test conditions, after 5 days, exceed the plant postulated post-accident phase by using Equation (13) and the following parameters for t_x and T_x (see Figure 3):

t_2 = 600 hours

T_2 = 212°F

The equivalent time at an ambient temperature of 152°F is greater than 1,283 days. Therefore, the cable splices are considered qualified for the postulated HBR-2 accident and post-accident phases.

3.0 KNOWN SYNERGISMS

One (1) known synergism was not addressed during the test. It is as follows:

- o Dose rate effects

An explanation of this known potential synergism is provided in the following paragraphs.

3.1 Dose Rate Effects

Testing sponsored by the NRC and reported by Sandia Laboratories (Reference 5) indicates that for some polymers the mechanical damage present for a given total dose is dependent on the dose rate. Testing was performed at $1x10^3$ rads per hour and $1x10^6$ rads per hour. For the polymers tested, it was found that more degradation occurred at the lower dose rate than at $1x10^6$ rads per hour. Specifically, the report states, "Sufficient data has now been accumulated from the low dose rate experiments to indicate that dose rate effects are present for every material which we have studied and must, therefore, be considered before extrapolating high dose rate accelerated simulations to low dose rate ambient conditions." Polyolefin was specifically mentioned by this report as being susceptible to dose rate effects.

3.2 Effect on Qualification

The intent of the research documented was to highlight potential aging problem areas between real time and artificially accelerated radiation aging. For Class 1E equipment located in a harsh environment, qualification testing to the postulated normal and accident radiation levels may not degrade the equipment to a level which is indicative of actual degradation experienced in its proposed service life. Surveillance programs or "overtesting" are two (2) methods to account for this effect.

Performing qualification testing at levels in excess of the required level, plus margin, is a common method to account for this synergistic effect. The amount of conservatism normally used is 10%. For the Raychem splices used at HBR-2, the test specimens were radiation aged to a level 13 times (1200% above) the requirement. Therefore, it is judged the splices were degraded to a level much greater than would be seen in service and no surveillance program would be required.

4.0 REFERENCES

In accordance with IEEE 323-1974, all references listed below, including those with Arrhenius or radiation data, are auditable at Patel Engineers.

1. "IEEE Guide for the Statistical Analysis of Thermal Life Test Data," IEEE 101-1972, Library Code 102-82.

2. Handbook of Engineering Fundamentals, Wiley, 1975, Library Code 103-82.

3. "A Study of Strong Synergisms in Polymer Degradation," Clough, Gillen, and Salazar, Sandia National Laboratories, SAND 79-092CK, Library Code 104-82.

4. "Radiation - Thermal Degradation of PE and PVC: Mechanism of Synergisms and Dose Rate Effects," R.L. Clough and K.T. Gillen, Sandia National Laboratories, SAND 80-2149C, Library Code 093-82.

5. "Occurrence and Implication of Radiation Dose Rate Effects for Material Aging Studies," K.T. Gillen and R.L. Clough, Sandia National Laboratories, SAND 80-1796C, Library Code 092-82.

6. "Heat Aging Study of WCSF Compound," Raychem Energy Division, Report No. EDR 2001, Library Code 124-82.

SECTION IV. CONCLUSIONS

Based on the comparison of the qualification test documentation to the normal and accident service conditions postulated for containment, the Raychem Thermofit WCSF-N cable splices are judged to possess a 40-year qualified life at the HBR-2.

This conclusion is based on analyses performed in the following areas:

- Time-Temperature Effects - Based on the lowest activation energy obtained, 1.29 eV, and using the temperatures specified in Paragraph 1.1, Section III, the equipment possesses a qualified life of greater than 121 years.

- Post-Accident Degradation Equivalency - A time-temperature equivalence was derived to verify that the test conditions (described in Section II) exceed the worst-case accident conditions, including post-accident phase. It was shown that the test conditions equate to a period of 1,283 days at 152°F in comparison with the required 33 days (30 days plus 10% margin).

- Known Synergisms - The test specimens were subjected to radiation during the thermal aging simulation. The known synergistic effect--dose rate effects--was overcome by a greater than 1200% margin with a total exposure of 2.0×10^8 rads gamma, as compared with a requirement of 1.5×10^7 rads gamma.

TECHNICAL REPORT
PEI-TR-83-6-13
February 9, 1983

FINAL REPORT ON THE EVALUATION OF THE QUALIFICATION OF THE MODEL 53548-1 CONNECTOR PROVIDED BY AMP, INC. FOR USE IN THE H.B. ROBINSON STEAM ELECTRIC PLANT-UNIT 2

by
Fredrick L. Roy

Prepared for

CAROLINA POWER AND LIGHT COMPANY
Raleigh, North Carolina

Contract No. 82-NPED-04
PEI Job No. 8310

patel engineers
huntsville, alabama

REPORT NO.: PEI-TR-83-6-13

PREPARED BY: Fredrick L. Roy, Program Manager

APPROVED BY: David Stinson, Director

Q.A. REVIEW: M.J. Kimbrell, Director, Product Assurance

ORIGINAL ISSUE: February 9, 1983

REVISIONS

REV NO.	REV DATE	REV BY	CHECKED BY	Q.A. BY	DESCRIPTION OF CHANGES AND PAGES REVISED

TABLE OF CONTENTS

INTRODUCTION AND SUMMARY

This document, designed to assess qualification documentation of Class 1E equipment to the H.B. Robinson Steam Electric Plant-Unit 2 (HBR-2) specific requirements, is divided into three (3) sections. They are as follow:

SECTION I. EQUIPMENT IDENTIFICATION/QUALIFICATION REQUIREMENTS

SECTION II. QUALIFICATION ASSESSMENT

SECTION III. CONCLUSIONS

The AMP 53548-1 butt-splice connector, used as part of Carolina Power and Light Company's approved splice procedure, was judged qualified for all postulated normal and accident conditions within containment at HBR-2. This assessment is based on the comparison of the plant profiles to the test documentation.

The connectors have a qualified life of greater than 40 years in the specified HBR-2 environment.

Note: These connectors were tested as part of a splice and their qualification is predicated on their use as part of the splice.

SECTION I. EQUIPMENT IDENTIFICATION/QUALIFICATION REQUIREMENTS

1. EQUIPMENT DESCRIPTION

System: Various

Component I.D.: N/A

Manufacturer: AMP, Inc.

Equipment Type: Pre-Insulated Butt Connectors

Serial No.: N/A

Model No.: AMP 53548-1

Location: Containment

Safety-Related Function: Electrical connection of safety-related equipment

2. QUALIFICATION SPECIFICATIONS

a. **Applicable Standards**

DOR Guidelines	X
NUREG-0588, Cat. I	
NUREG-0588, Cat. II	

b. **Normal Service Conditions**

Temperature: $120^{o}F$ for 84% of qualified life
$88^{o}F$ for 16% of qualified life

Pressure: Atmospheric

Radiation: $3.5x10^4$ rads gamma (air equivalent) TID

Relative Humidity: 20% to 90%

c. **Design Basis Events**

Accident Profile: See Figures 1 and 2.

Source:

MSLB	X
HELB	
LOCA	X

Operating Time:	30 days			
Radiation:	$1.4x10^7$ rads gamma			
Relative Humidity:	100%			
Submergence:	Yes	____	No	X
Chemical Spray:	Yes	X	No	____
Mode:	Active	X		
	Passive	____		
	Fail-Safe	____		

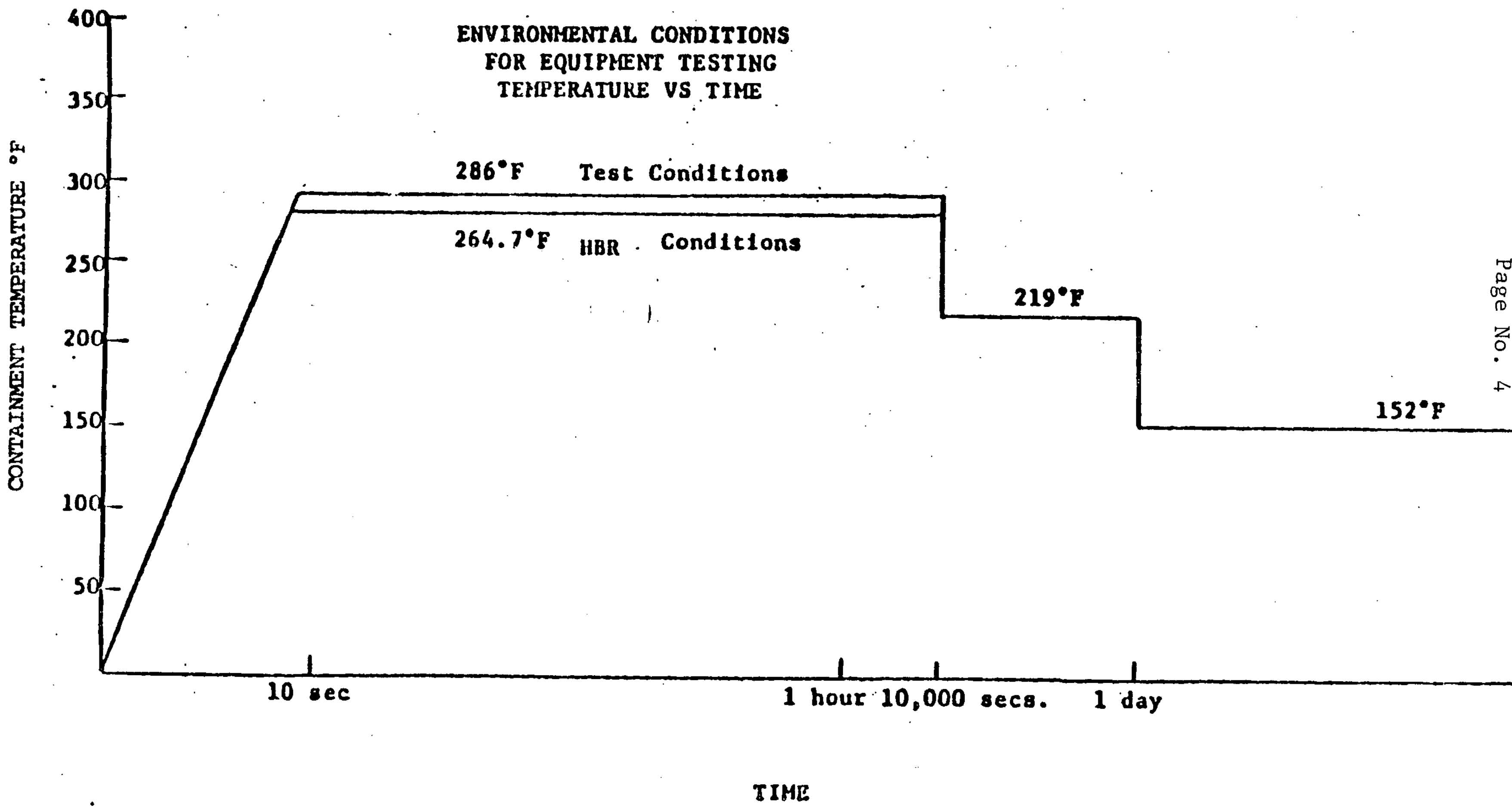

Figure 1. Containment Temperature vs. Time Following LOCA/MSLB [17]

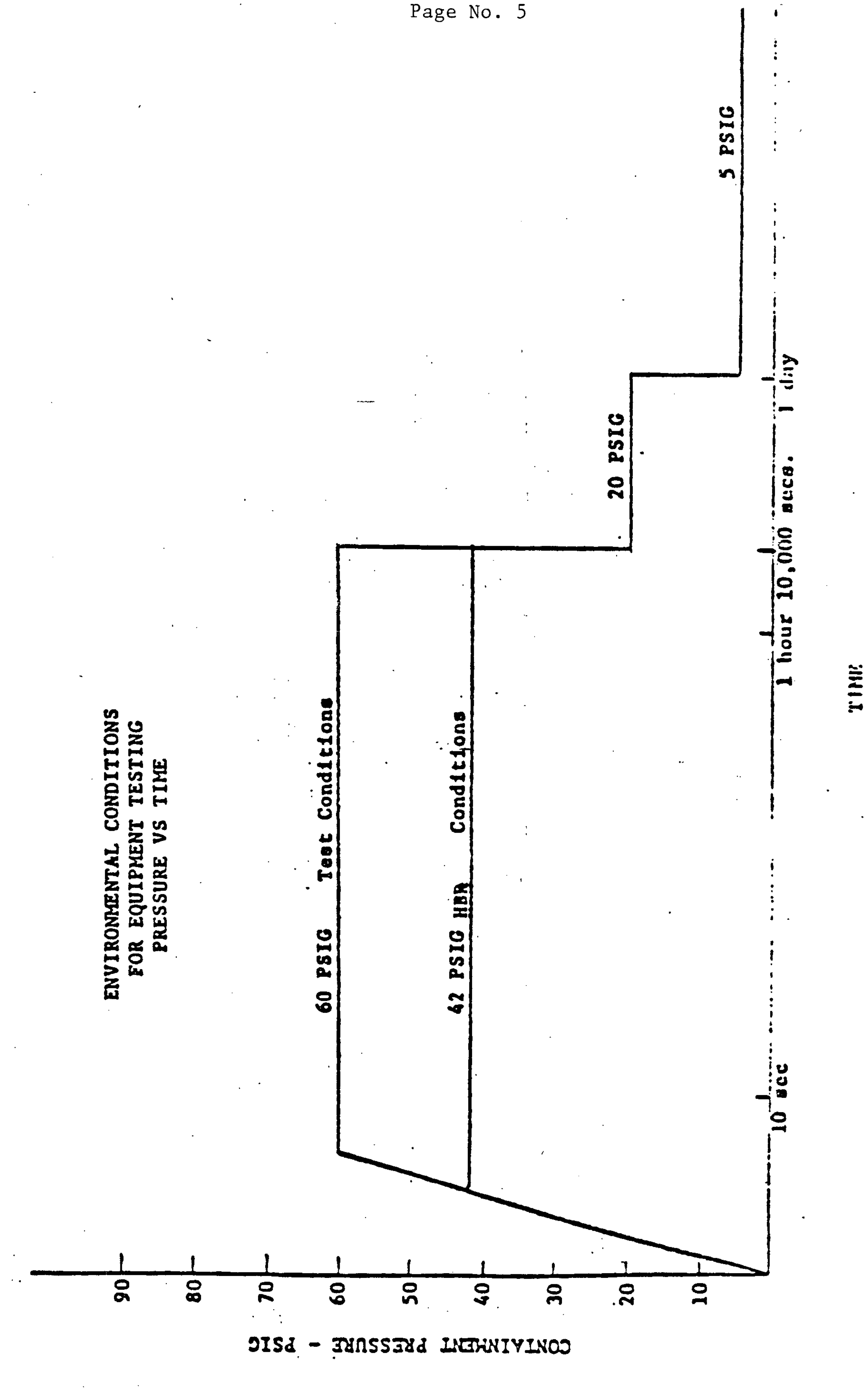

Figure 2. Containment Pressure vs. Time Following LOCA/MSLB [17]

SECTION II. QUALIFICATION ASSESSMENT

1. **QUALIFICATION DOCUMENTATION**

   a. **Title:** Qualification Test Report on In-Containment Cables for Carolina Power and Light Company

   Report No.: 45307-1 **Date:** December 23, 1981

   Source: Carolina Power and Light Company

2. **QUALIFICATION DOCUMENTATION ANALYSIS**

   a. **Design Basis Event Analysis**

   LOCA Simulation Profile: See Figure 3.

	Yes	No*	N/A
1) Are all peak temperature/pressure and time requirements during the transient phase enveloped?	X		
2) Are all temperature/pressure and time requirements during the post-accident phase enveloped?	X		
3) Are margins as applied consistent with those defined in NUREG-0588, IEEE 323-1974, and/or the DOR Guidelines, as applicable?	X		
4) Are the functional tests as performed adequate to demonstrate that the functional requirements (accuracy, repeatability, insulation resistance, etc.) for the equipment can be met?	X		
5) Was the normal and accident radiation applied prior to and/or simultaneously with the accident simulation? If yes, to what level? $1.5X10^7$ rads gamma	X		
6) If submergence is a requirement, does the test demonstrate acceptable operation?			X

	Yes	No*	N/A
7) Was the requirement for chemical spray enveloped?	X		
8) Were all known synergisms accounted for in the test sequence?	X		
9) If failures occurred during the test program, are adequate justifications provided in the form of a failure analysis such that the qualification is not negated?	X		

b. Normal Service Conditions Analysis

	Yes	No*	N/A
1) Does the aging analysis provided in the supporting documentation provide for a 40-year qualified life at the HBR-2 defined service temperature?	X		
2) Was the aging analysis performed using Arrhenius techniques?	X		
3) Is the aging analysis auditable?	X		
4) Was the radiation requirement accomplished by the radiation test?	X		
5) If any radiation exemptions were utilized, are they auditable?			X
6) Did the equipment perform successfully at the extremes of its normal service conditions (temperature, radiation, pressure, voltage, current, humidity, etc.) as required by IEEE 323-1974 and NUREG-0588?	X		
7) Were the functional tests performed adequate to demonstrate operability parameters as seen in service?	X		
8) Are the acceptance/failure criteria clearly defined?	X		

	Yes	No*	N/A
9) If failures occurred during the test program, are adequate justifications provided in the form of a failure analysis such that the qualification is not negated?	X		
10) Are all known synergisms accounted for in the test program?	X		

* All questions which were marked "No" will require additional analysis to justify qualification.

3. CONCLUSIONS AND RECOMMENDATIONS

Reference 1.a fulfills all the requirements of the DOR Guidelines.

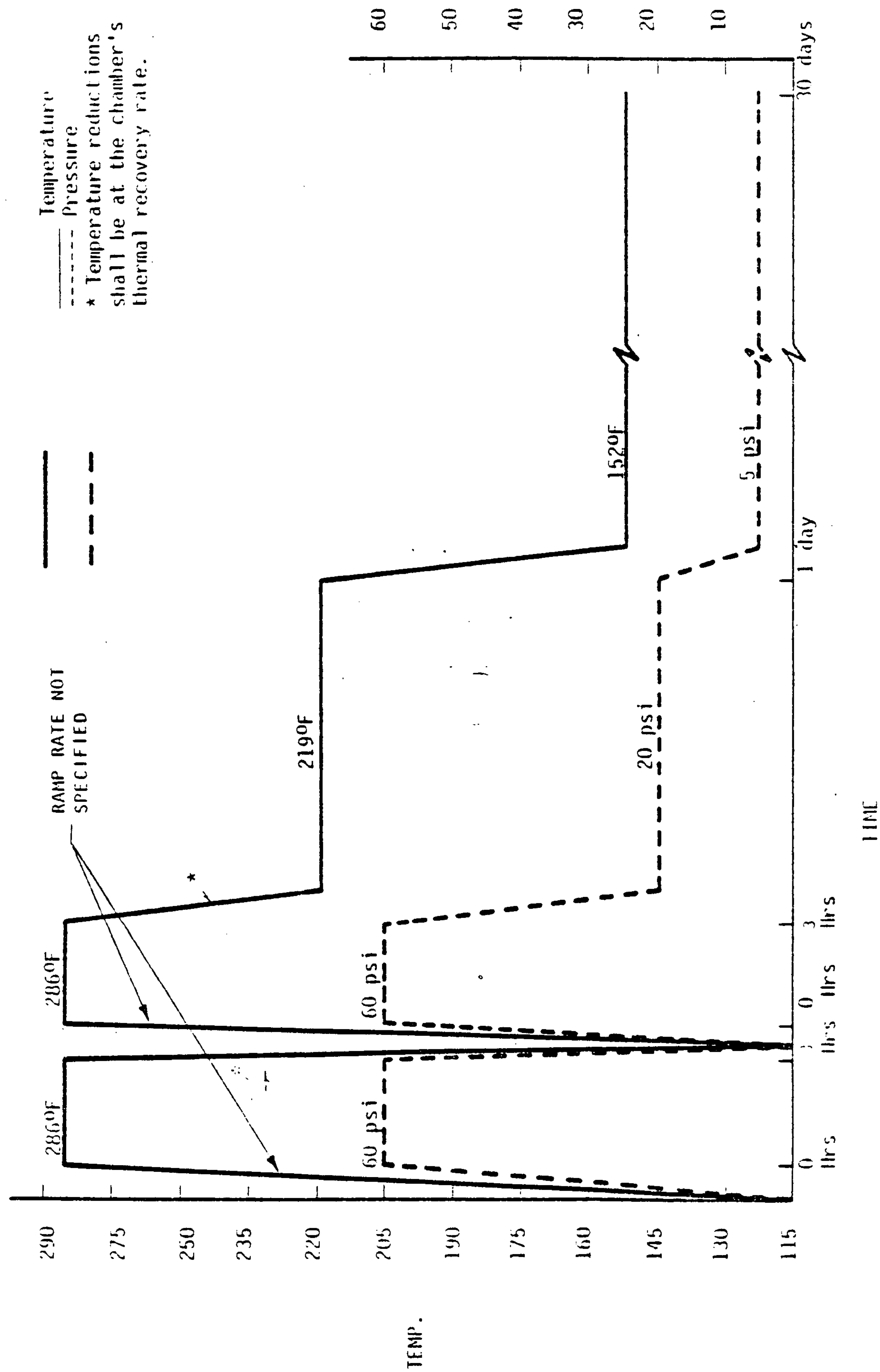

Figure 3
REQUIRED LOCA TEST PROFILE

SECTION III. CONCLUSIONS

Based on the comparison of the qualification test documentation to the normal and accident service conditions postulated for containment, the AMP 53548-1 connector is judged to possess a 40-year qualified life at HBR-2.

This conclusion is based on a review of the test documentation (see Appendix I). The results indicate qualification to the HBR-2 specific environment and a qualified life of greater than 40 years.

Note: These connectors are used as part of a cable splice and their qualification is predicated on their use as part of a cable splice.

TECHNICAL REPORT
PEI-TR-83-6-14
March 28, 1983

FINAL REPORT ON THE EVALUATION OF THE QUALIFICATION OF THE SCOTCH 70 TAPE PROVIDED BY 3M COMPANY FOR USE IN THE H.B. ROBINSON STEAM ELECTRIC PLANT - UNIT 2

by
Michael M. Hall

Prepared for

CARLINA POWER AND LIGHT COMPANY
Raleigh, North Carolina

Contract No.: 82-NPED-04
PEI Job No.: 8310

patel engineers
huntsville, alabama

REPORT NO.: PEI-TR-83-6-14

PREPARED BY: Michael M. Hall, Project Engineer

APPROVED BY: Johnny Jenkins, Vice-President

Q.A. REVIEW: M.J. Kimbrell, Director, Product Assurance

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patel engineers
huntsville, alabama

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INTRODUCTION AND SUMMARY

This document is designed to assess qualification documentation of Class 1E equipment to the H.B. Robinson Steam Electric Plant, Unit 2 (HBR-2), specific requirements. It is divided into four (4) sections. They are as follow:

SECTION I. EQUIPMENT IDENTIFICATION/QUALIFICATION REQUIREMENTS

SECTION II. QUALIFICATION DOCUMENTATION ASSESSMENT

SECTION III. QUALIFICATION JUSTIFICATION ANALYSIS

SECTION IV. CONCLUSIONS

The Scotch (3M) #70 electrical tape assessed has been judged qualified to the DOR Guidelines and NUREG-0588, Category I, requirements for all postulated normal and extreme service conditions within containment at HBR-2 when utilized in cable splice applications. The analysis performed demonstrates qualification in excess of a 40-year life.

Equipment	Manufacturer	Model No.	Location
Electrical Tape	3M Company/ Scotch	70	Containment

SECTION I. EQUIPMENT IDENTIFICATION/QUALIFICATION REQUIREMENTS

1. **EQUIPMENT DESCRIPTION**

System:	Various	**Component I.D.:**	N/A
Manufacturer:	3M/Scotch	**Equipment Type:**	Splice Tape
Serial No.:	N/A	**Model No.:**	70
Location:	Various		

Safety-Related Function: Cable termination protection

2. **QUALIFICATION SPECIFICATIONS**

a. **Applicable Standards**

DOR Guidelines	X
NUREG-0588, Cat. I	X
NUREG-0588, Cat. II	

b. **Normal Service Conditions**

Temperature: 120°F for 84% of qualified life
88°F for 16% of qualified life

Pressure: Atmospheric

Radiation: 2.3×10^3 rads gamma (air equivalent) TID

Relative Humidity: 20% to 90%

c. **Design Basis Events**

Accident Profile: See Figures 1 and 2.

Source:

MSLB	X
HELB	
LOCA	X

Operating Time: 30 days

Radiation:	$1.4x10^7$ rads gamma			
Relative Humidity:	100%			
Submergence:	Yes	___	No	X
Chemical Spray:	Yes	X	No	___
Mode:	Active	X		
	Passive	___		
	Fail-Safe	___		

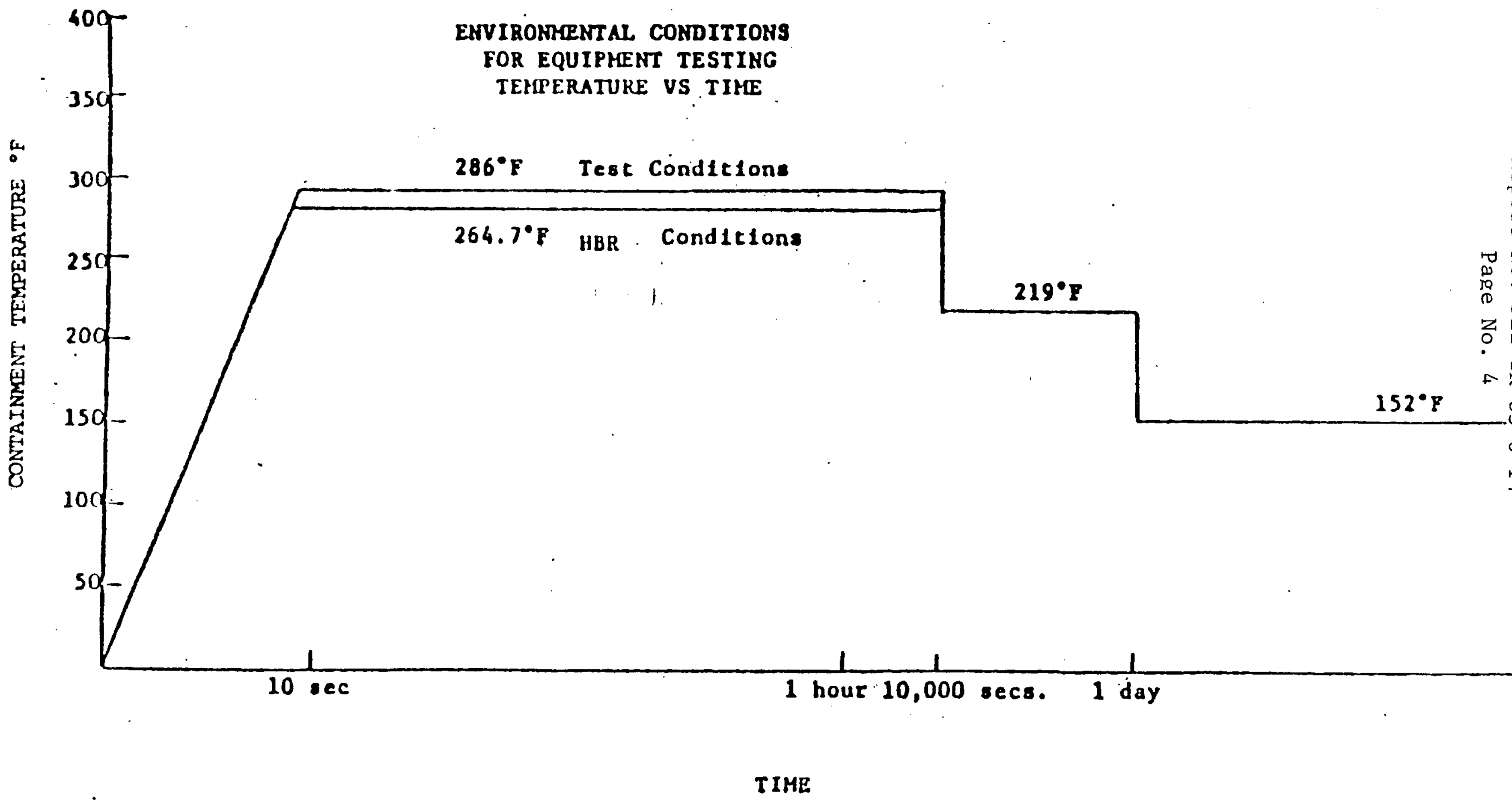

FIGURE 1. CONTAINMENT TEMPERATURE VS. TIME FOLLOWING LOCA/MSLB

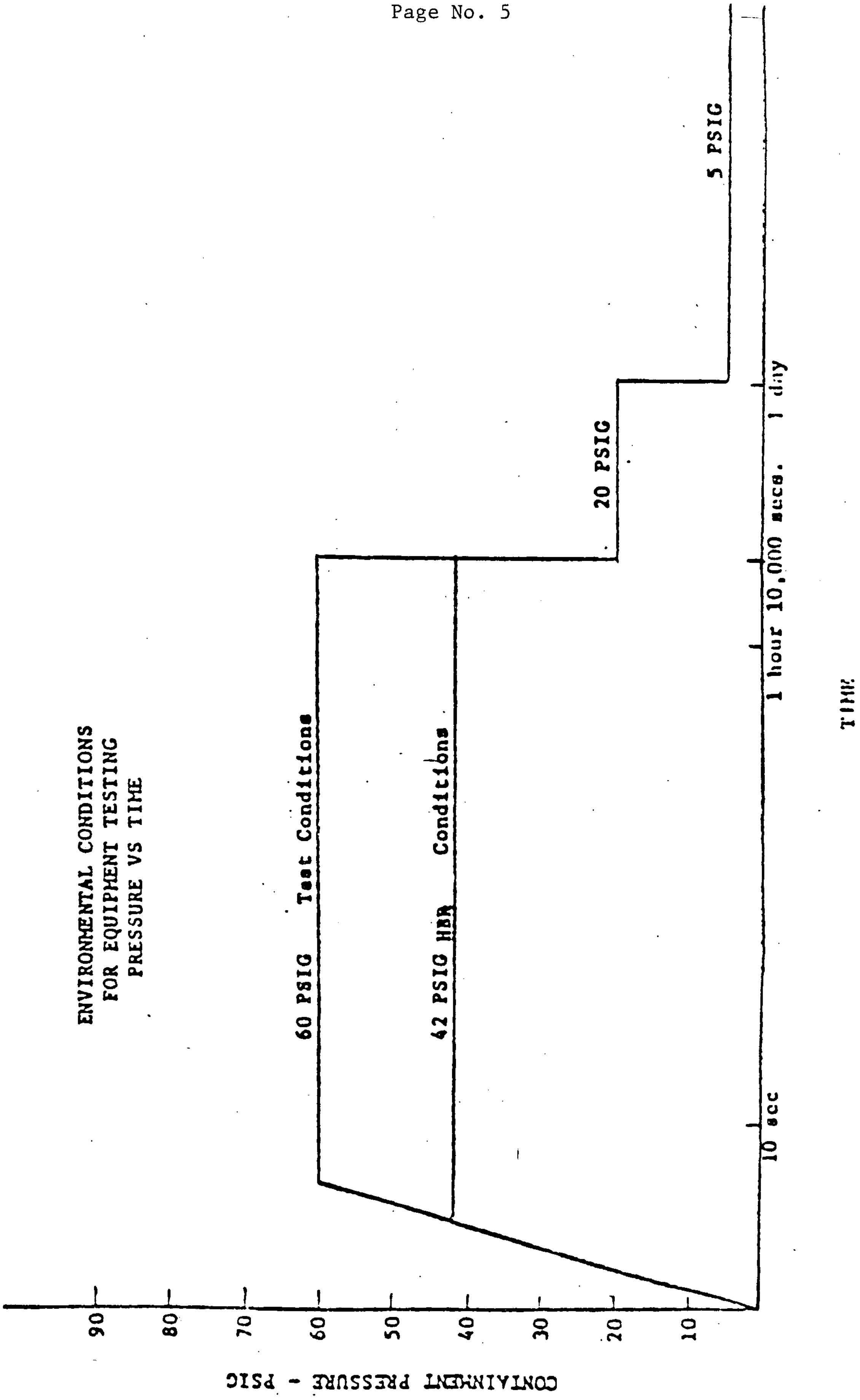

FIGURE 2. CONTAINMENT PRESSURE VS. TIME FOLLOWING LOCA/MSLB

SECTION II. QUALIFICATION ASSESSMENT

1. QUALIFICATION DOCUMENTATION

a. **Title:** Tests of Electrical Cables Under Simultaneous Exposure to Gamma Radiation, Steam, and Chemical Spray While Electrically Energized

Report No.: F-C4020-2 **Date:** March, 1975

Source: Franklin Institute Research Laboratories (FIRL)

b. **Title:** Tests of Electrical Cables Under Simultaneous Exposure to Gamma Radiation, Steam, and Chemical Spray While Electrically Energized

Report No.: F-C4020-1 **Date:** March, 1975

Source: Franklin Institute Research Laboratories (FIRL)

2. QUALIFICATION DOCUMENTATION ANALYSIS

a. **Design Basis Event Analysis**

LOCA Simulation Profile: See Figure 3.

	Yes	No*	N/A
1) Are all peak temperature/pressure and time requirements during the transient phase enveloped?	X		
2) Are all temperature/pressure and time requirements during the post-accident phase enveloped?	X		
3) Are margins as applied consistent with those defined in NUREG-0588, IEEE 323-1974, and/or the DOR Guidelines, as applicable?	X		
4) Are the functional tests as performed adequate to demonstrate that the functional requirements (accuracy, repeatability, insulation resistance, etc.) for the equipment can be met?	X		

		Yes	No*	N/A
5)	Was the normal and accident radiation applied prior to and/or simultaneously with the accident simulation? If yes, to what level? $2.0X10^8$ rads gamma	X		
6)	If submergence is a requirement, does the test demonstrate acceptable operation?			X
7)	Was the requirement for chemical spray enveloped?	X		
8)	Were all known synergisms accounted for in the test sequence?	X		
9)	If failures occurred during the test program, are adequate justifications provided in the form of a failure analysis such that the qualification is not negated?			X

b. **Normal Service Conditions Analysis**

		Yes	No*	N/A
1)	Does the aging analysis provided in the supporting documentation provide for a 40-year qualified life at the HBR-2 NPP-defined service temperature?		X	
2)	Was the aging analysis performed using Arrhenius techniques?		X	
3)	Is the aging analysis auditable?		X	
4)	Was the radiation requirement accomplished by the radiation test?	X		
5)	If any radiation exemptions were utilized, are they auditable?			X

		Yes	No*	N/A
6)	Did the equipment perform successfully at the extremes of its normal service conditions (temperature, radiation, pressure, voltage, current, humidity, etc.) as required by IEEE 323-1974 and NUREG-0588?	X		
7)	Were the functional tests performed adequate to demonstrate operability parameters as seen in service?	X		
8)	Are the acceptance/failure criteria clearly defined?	X		
9)	If failures occurred during the test program, are adequate justifications provided in the form of a failure analysis such that the qualification is not negated?			X
10)	Are all known synergisms accounted for in the test program?	X		

* All questions marked "No" require additional analysis to justify qualification. Section III of this report contains the additional analysis to resolve the qualification deficiencies and justify qualification.

3. CONCLUSIONS AND RECOMMENDATIONS

Reference 1.a fulfills all the requirements of the DOR Guidelines and NUREG-0588, Category I, except for those items listed in Paragraph 4, below.

4. OUTSTANDING ITEMS REQUIRING RESOLUTION

- o Time-Temperature Effects
- o Reference Auditability

5. ADDITIONAL COMMENTS (INCLUDING ANALYSIS TO SUPPORT THIS ASSESSMENT)

5.1 Reference 1.a does not specifically identify the tape utilized for splice preparation. However, information provided in Appendices I, II, and III provides an auditable link to demonstrate that the equipment tested is identical to the equipment described in Section I, Paragraph 1.0.

1. Appendix I contains a summary of testing reported in Reference 1.a, entitled "LOCA Qualification of Kerite 1000 Volt HTK/FR Power Cable," dated July 31, 1980. Paragraph 2, page 2, of this document states that "... 10-foot samples contained a splice made up according to Kerite Drawing No. 38-69..."

2. Appendix II contains Kerite Drawing No. 38-69, which specifically identifies Scotch 70 tape as a splice component. It has been noted that the October 21, 1980, letter indicated that "Kerite Drawing MC-1-NUC should be kept with LOCA Qualification Report for HTK ... cable," which contradicts the statement in No. 1, above. This ambiguity is resolved by the March 17, 1983, letter (Appendix III).

5.2 Reference 1.b reports testing of FR/FR cable specimens which contain splices prepared according to Kerite Drawing MC-1-NUC (Appendix II). The tests performed were similar to those reported in Reference 1.a. For purposes of this assessment effort, this data is considered supplemental.

5.3 Due to their proprietary nature, References 1.a and 1.b have not been appended to this report.

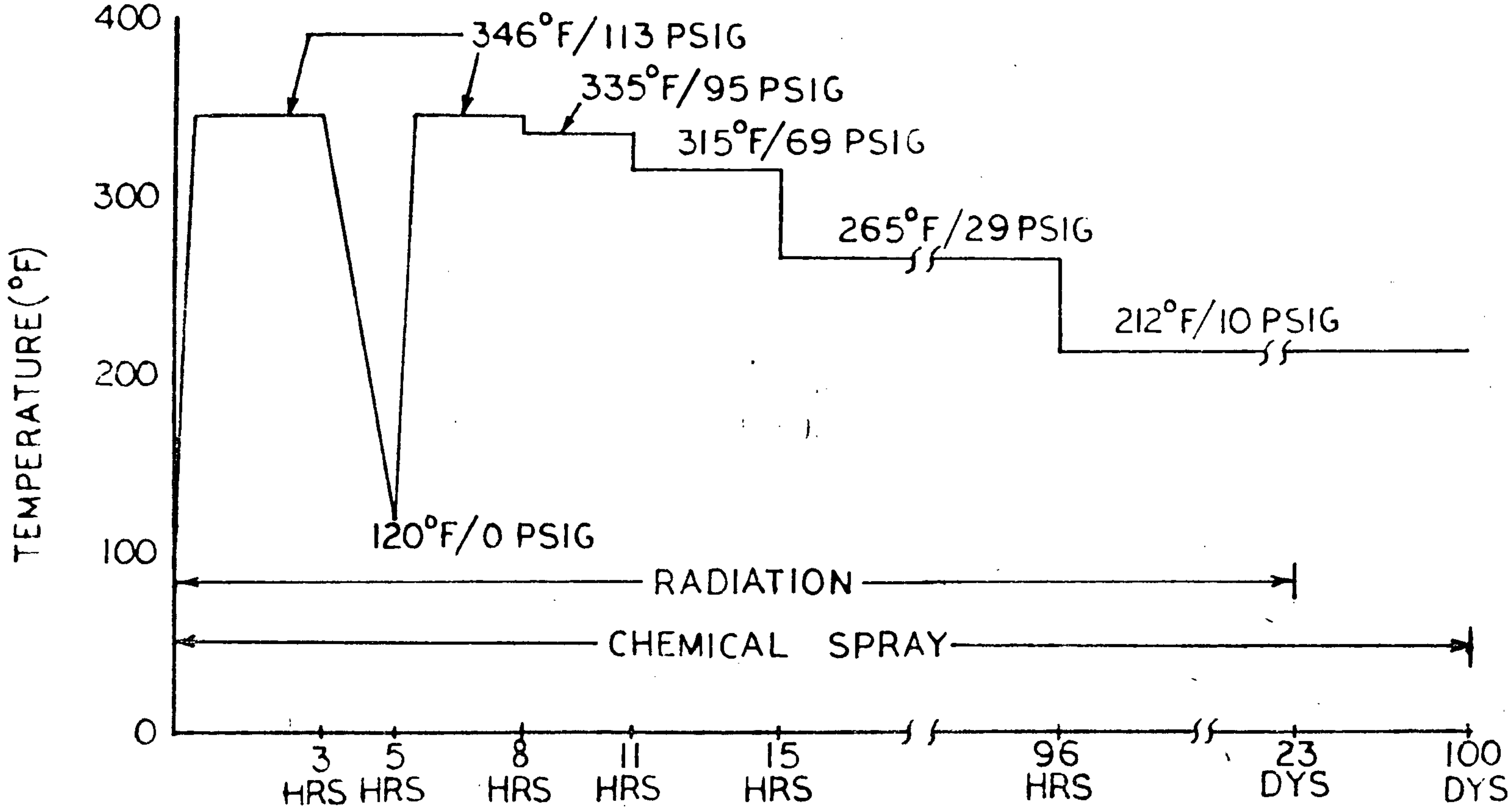

FIGURE 3. LOCA SIMULATION PROFILE

SECTION III. QUALIFICATION JUSTIFICATION ANALYSIS

Where qualification parameters are not clearly defined, when new research highlights potential problem areas, or when the plant requirements are not met, analysis must be performed to augment the existing qualification documentation. The intent of this section is to summarize the results of this analysis. From these results, a specific program is recommended, if required, to maintain the qualification status of the Class 1E equipment.

For the Scotch 70 tape, the following areas were analyzed:

- 1.0 Time-Temperature Effects
- 2.0 Reference Auditability

1.0 TIME-TEMPERATURE EFFECTS

Aging effects on all Class 1E equipment must be considered and included in the qualification program. For time-temperature effects, the present state-of-the-art allows artificial acceleration of these effects associated with organic materials by increasing the temperature. The deterioration due to these effects is judged to be insignificant for metallic materials. Therefore, the aging of the Class 1E equipment will be based on its nonmetallic materials.

For many organic materials, it is known that the degradation process can be defined by a single temperature-dependent reaction that follows the Arrhenius equation (References 1 and 2):

$$k = A \exp(-Ea/k_B T) \qquad (1)$$

where,

k = reaction rate

A = frequency factor

exp = exponent to base e

Ea = activation energy

k_B = Boltzmann's Constant

T = absolute temperature

It is further noted that, for many reactions, the activation energy can be considered to be constant over the applicable temperature range. Equation (1) can be transformed into a form which yields an acceleration factor.

The acceleration factor is defined as t_2/t_1.

The equation is:

$$t_2/t_1 = \exp\left(-(Ea/k_B)(1/T_1 - 1/T_2)\right) \qquad (2)$$

where,

t_1 = accelerated aging time at temperature T_1

t_2 = normal service time at temperature T_2

exp = exponent to base e

Ea = activation energy (eV)

k_B = Boltzmann's Constant (8.617×10^{-5} eV/^{o}K)

T_1 = accelerated aging temperature (^{o}K)

T_2 = normal service temperature (^{o}K)

The transformation of the reaction rate form of the Arrhenius equation to an acceleration form is accomplished as follows:

Life is assumed to be inversely proportional to the chemical reaction rate (References 1 and 2). In terms of life, and after converting to Napierian base logarithm, Equation (1) becomes:

$$\ln(\text{life}) = (Ea/k_B)(1/T) + \text{Constant} \qquad (3)$$

Equation (3) has the algebraic form:

$$y = mx + b \qquad (4)$$

where,

y = ln (life)

x = 1/T

m = Ea/k_B, constant for single dominant reactions

b = constant

The constants, m and b, can be estimated by fitting the experimental data in the form of ln (life) versus 1/T into the above simple linear relationship.

The derivation of an acceleration factor is accomplished by taking the difference between any two points of the linear relationship.

Thus, if we substitute t for life into Equation (3), we obtain:

$$\ln t = (Ea/k_B)(1/T) + \text{Constant} \quad (5)$$

For the set of points (t_1, T_1), Equation (5) becomes:

$$\ln t_1 = (Ea/k_B)(1/T_1) + \text{Constant} \quad (6)$$

For the set of points (t_2, T_2), Equation (5) becomes:

$$\ln t_2 = (Ea/k_B)(1/T_2) + \text{Constant} \quad (7)$$

Subtracting Equation (6) from Equation (7) yields:

$$\ln t_2 - \ln t_1 = (Ea/k_B)(1/T_2) + \text{Constant} - (Ea/k_B)(1/T_1) - \text{Constant} \quad (8)$$

Simplifying and rearranging Equation (8) yields:

$$\ln (t_2/t_1) = -(Ea/k_B)(1/T_1 - 1/T_2) \quad (9)$$

Taking antilogarithm yields:

$$t_2/t_1 = \exp (-(Ea/k_B)(1/T_1 - 1/T_2)) \quad (10)$$

Equation (10) is the same as Equation (2).

The qualified life of the nonmetallics in the equipment is determined by solving Equation (10) for t_2.

$$t_2 = t_1/\exp ((Ea/k_B)(1/T_1 - 1/T_2)) \quad (11)$$

The Scotch 70 tape has two (2) postulated service temperatures during the 40-year service life (see Section I, 2.b., of this report). Therefore, the above equation is modified to:

$$Q.L. = t_1 / \sum_{x=2}^{n+1} P_x \exp((Ea/k_B)(1/T_1 - 1/T_x)) \quad (12)$$

where,

t_1	=	aging time
T_1	=	aging temperature
T_x	=	service temperature
P_x	=	fraction of 40-year life at T_x
exp	=	exponent to base e
Ea/k_B	=	activation energy/Boltzmann's Constant

Since, in most cases, it is not practical to independently accelerate the time-temperature effects of each nonmetallic material, a determination is made as to which material has the lowest activation energy. The time-temperature effects are then accelerated based upon the lowest activation energy for conservatism. This assures that the degradation of each age-sensitive component is accelerated to at least the equivalent degradation as that to be encountered during the operating life.

In determining aging temperatures and service temperatures to be used in calculating qualified life, heat rise must be considered. If the heat rise for each component is known and the device was aged unpowered or aged powered and the temperature of each component measured, a qualified life may be determined directly using these temperatures. If the device is aged while powered and the heat rise for each component was not measured, the qualified life should be determined in a manner which accounts for the heat rise. This is accomplished by adding the worst-case heat rise to both the service temperature and the aging temperature. This can be shown to be conservative by modifying Equation (10) as follows:

$$t_2/t_1 = \exp (-Ea/k_B)(T_2 - T_1/T_1T_2) \quad (13)$$

Since T_1 is larger than T_2, $T_2 - T_1$ is negative and Equation (13) can be rewritten:

$$t_2/t_1 = \exp (-Ea/k_B)(-(T_1 - T_2)/T_1T_2 \quad (14)$$

Simplifying and rearranging Equation (14) yields:

$$t_2 = t_1 \exp (Ea/k_B) ((T_1 - T_2)/T_1T_2) \quad (15)$$

It can be seen from Equation (15) that if heat rise is added to T_1 and T_2, the value of $T_1 - T_2$ will remain the same, but the product $T_1 T_2$ will increase. This increase causes the overall value of the exponent to decrease and the qualified life (t_2) will decrease accordingly. If the qualified life is determined based just on service temperature and aging temperature, ignoring heat rise because the device was aged powered, the qualified life would be significantly greater and less conservative than if heat rise is used in calculating a qualified life.

Based on the specified applications for Scotch 70 tape, it has been assumed that the thermal environment (ambient plus heat rise) during the 40-year life will not exceed 90°C (194°F). Therefore, a constant baseline temperature of 90°C has been assumed for the entire 40-year period for conservatism.

1.1 Specific Analysis of Time-Temperature Effects

The subject equipment was thermally aged (unpowered) prior to the design basis event for 101 hours at 150°C. Using Equation (11):

$$\text{Qualified Life} = t_1/\exp\left((Ea/k_B)(1/T_1 - 1/T_2)\right)$$

where,

t_1 = 101 hours

exp = exponent to base e

Ea = 1.68 eV (Reference 3)

k_B = 8.617×10^{-5} (Boltzmann's Constant)

T_1 = 150°C (aging temperature)

T_2 = 90°C (service temperature)

Solving the equation gives a qualified life of greater than 23.4 years at 90°C (194°F).

Although the thermal aging test does not, by itself, provide justification for a full 40-year qualified life, credit may be taken for thermal degradation resulting from exposure to the first 346°F dwell in the dual-transient test profile (Figure 3). As stated in Reference 1.a, #6 AWG cable with Scotch 70 splice tape was current loaded at 50 amperes during the entire test. It has been conservatively assumed that heat rise due to resistance heating effects during the test was 20°C (36°F). Therefore, the cable insulation bulk temperature

(and, therefore, the splice tape temperature) during the initial transient has been assumed to be 382°F (346°F +36°F heat rise). This condition was maintained for 3 hours. Again using Equation (11):

$$\text{Qualified Life} = t_1 \exp\left((Ea/k_B)(1/T_1 - 1/T_2)\right)$$

where,

t_1 = 3 hours

exp = exponent to base e

Ea = 1.68 eV (Reference 3)

k_B = 8.617×10^{-5} (Boltzmann's Constant)

T_1 = 382°F (aging temperature)

T_2 = 194°F (service temperature)

Solving the equation gives a qualified life of greater than 55.7 years at 90°C (194°F).

Therefore, the equipment was thermally aged to a total of greater than 79.1 years (23.4 plus 55.7 years) at 90°C due to the combined effects of the thermal aging test and the first transient simulation.

Conclusions drawn from the preceding calculations are predicated upon the fact that isothermal test data from which the slope and constant values were obtained indicates that no phase changes occur for silicone rubber over the temperature range under consideration. This is evidenced by the linearity of the Arrhenius plot, even at temperatures exceeding 200°C.

Based on the above, it is concluded that the equipment is qualified for a full 40-year life.

2.0 REFERENCES

In accordance with IEEE 323-1974, all references listed below, including those with Arrhenius or radiation data, are auditable at Patel Engineers.

1. "IEEE Guide for the Statistical Analysis of Thermal Life Test Data," IEEE 101-1972, Library Code 102-82.

2. *Handbook of Engineering Fundamentals*, Wiley, 1975, Library Code 103-82.

3. "Wires and Cords for Original Equipment Manufacturers," General Electric Company, No. WCC-2, Library Code 137-82.

SECTION IV. CONCLUSIONS

Based on the comparison of the qualification test documentation to the normal and accident service conditions postulated for containment, the Scotch 70 tape is judged to possess a 40-year qualified life at HBR-2.

This conclusion is based on analyses performed in the following areas:

- Time-Temperature Effects - Based on the lowest activation energy obtained, 1.68 eV, and using an assumed 90°C baseline service temperature, the equipment possesses a qualified life of greater than 40 years.