Nine Mile Point Unit 1
Equipment Qualification

The Electrical Equipment Qualification Program for Nine Mile Point Unit 1 is an on-going program based on qualification evaluations performed in accordance with the Department of Operating Reactors' "Guidelines for Evaluating Environmental Qualifications of Class 1E. Electrical Equipment in Operating Reactors". As such, evaluations performed are subject to revisions reflecting new data input and quality assurance reviews.

Table I attached lists the reports being provided as requested by Franklin Research Center. In some cases, the reports have been updated and the more recent reports are being provided. The reports upon which our earlier submittal was based are available for review. Conclusions of the more recent reports may effect the qualifications status of certain components from our earlier submittal. Niagara Mohawk is currently reviewing these updated reports and will provide revised system/component evaluation work sheets and additional justification for continued operation, if appropriate, by April 2, 1982. Identified below are those components whose qualification status may be subject to change:

Manuf.	Component	Sept. 81 Status	Possible Change
ASCO	HUA-90-405 Type 546	Qualified	Assessment Ongoing
Fisher	Electropneumatic Transducer	40 Year Life	Assessment Ongoing
Kerite	Cable	Qualified	Assessment Ongoing
Limitorque	Valve Operator	Qualified	Assessment Ongoing
Microswitch	Position Switch	40 Year Life	Assessment Ongoing
Namco	Position Switch	Not Qualified	Assessment Ongoing
Rosemount	1151 DP Transmitter	Qualifed	Assessment Ongoing

In addition, Table II attached, summarizes Franklin Research Center requested information concerning TMI-NUREG 0737 Action Plan/Equipment installed at Nine Mile Point Unit 1.

TABLE I
Equipment Qualification Reports

REPORT REQUESTED BY FRC	REPORT PROVIDED TO NRC	EQUIPMENT AFFECTED
NUS Report 1961-0005	NUS Analysis - 1961-0005-001 Environmental Qualification of D.G. O'Brien Connectors	4 Pin #8, 19 Pin #16
NUS Report 1961-G080-001 Including G.E. Letter Number G-EN-8-18 dated 2/24/78	NUS Analysis 1961-G080-001-R1 Environmental Qualification for G.E. Type EB Terminal Blocks at NMP-1 and G.E. letter Number G-EN-8-18 dated 2/24/78	EB-5, EB-25
Burndy Test Report TD-78-595A	Burndy Lab Test Record 79-601A For YA, YA-DTW, and QA-B Type Uninsulated Terminals	QA-B
NUS Report 1961-A383	This should be NUS Analysis 1961-A382	AMP-Ring Tongue Terminal Connectors and Butt Connectors
NUS Report 1961-G049	NUS ANAL-G049-001 Assessment of O.Z. Gedney Electrical Connectors Serving a Safety Related Function	Type XL & XW
NUS Report 1961-A382	NUS Analysis 1961-A382-001 Assessment of AMP Terminal Connectors Serving A Safety Related Function	Ring Tongue and Butt Terminal Connectors
NUS Report 1961-N007	NUS Analysis 1961-N007-001 Environmental Qualification Assessment of NAMCO Limit Switches Series D2400X and SL3	D2400X and SL3 Limit Switches
NUS Report R369-001	NUS Analysis 1961-R369-001-R1 Environmental Qualification of Rosemount 510 DU Trip Units	Rosemount 510 DU Trip Units
Laurence Bulletin for Series 500 &500 HP Two-Way Rotary Shaft TypeSolenoid Valves Issues and Drawing #2600E	Laurence Bulletin 500 and 500 HP Issues	500 and 500 HP Solenoid Valves

TABLE I (cont'd)
Equipment Qualification Reports

REPORT REQUESTED BY FRC	REPORT PROVIDED TO NRC	EQUIPMENT AFFECTED
NUS Report 1961-A499-001	NUS Analysis 1961-A499-001 Environmental Qualification for Asco Solenoid Valves Model 8300 Series	8300 Series Solenoid Valves
Micro Switch Test Report Ltr-24407 2/24/77	Micro switch test report LTR-24407 dated 2/24/77	Model 11LS1 Limit Switch
NUS Report 1961-M302	NUS Analysis 1961-M302-001 Environmental Qualification Analysis for Micro Switch Model 11LS1	Model 11LS1 Limit Switch
G.E. Letter G-EN-0-164 dated 10/16/80	G.E. Letter G-EN-0-164 dated October 16, 1980	G.E. Motors
NUS Report 1961-R369-002	NUS Analysis 1961-R369-002-R1 Environmental Qualification of Rosemount 1151DP Transmitters	Rosemount 1151DP Transmitters
NUS Report 1961-F080	NUS Analysis 1961-F080-001-R1 Environmental Qualification Assessment of Fenwal 17002-40 Temperature Switches	Type 17002-40 Temperature Switches
NUS Report 1961-F130	NUS Analysis 1961-F135-001 Environmental Qualification Assessment for Fisher Type 546 Electro-Pneumatic Transducer	Type 546 E/P Transducer
BWR Equipment Qualification Summary QSR-44-E-01	BWR Equipment Qualification Summary QSR-44-E-01 G.E. 551 Pressure Transmitters	G.E. Type 551 Transmitters
BWR Equipment Qualification Summary QSR-96-A-03 October 16, 1980	BWR Equipment Qualification Summary QSR-96-A-03 October 16, 1981 - Asco 8300 Series S.V.	Asco 8300 Series Solenoid Valves
G.E. Report 126-62 January 15, 1975	G.E. Report 126-62 Environmental Testing of MSS/RV Air Control Valves	Asco 8300 Series Solenoid Valves

TABLE I (cont'd)
Equipment Qualification Reports

REPORT REQUESTED BY FRC	REPORT PROVIDED TO NRC	EQUIPMENT AFFECTED
BWR Equipment Qualification Summary QSR 111-A-01 October 14, 1980	BWR Equipment Qualification Summary 111-A-01 G.E. ECCS Motors	G.E. Motors
Bechtel Power Corp. File No. 10855-E117 (9)-42-1	Bechtel Power Corp. File No. 10855-E117 (9)-42-1 (Applicable Section)	G.E. AKD-5 Circuit Breakers
BWR Equipment Qualification Summary QSR-010-A-01	BWR Equipment Qualification Summary QSR 010-A-01 03/28/78 - G.E. Terminal Blocks	G.E. Terminal Blocks EB-5, EB-25
NES Document 81A0636 Rev. 0 7/15/80	NES Document 81AD636 Rev..0 7/15/80	Radiation Information
NES Letter 5152-008	NES Letter #5152-008 7/18/80 from M. Jaworsky (NES) / L. McNeer (NMPC)	Radiation Information

TABLE II

TMI ACTION PLAN
EQUIPMENT INSTALLED AT NINE MILE POINT 1

NUREG 0737 CLARIFICATION ITEM	TITLE	DESCRIPTION	APPROXIMATE EQUIPMENT INSTALLATION DATE
II.B.1	Reactor Coolant Vent	i. Modified Power Supplies to Existing Reactor Head Vent System Isolation Valves	Spring 81
		ii. Will Provide New Emergency Condenser Vent to the Torus	June 82
II.B.2	Plant Shielding	Relocated Existing Instrumentation and Solenoid Valve to Areas of Lower Radiation.	N/A
II.B.3	Post-Accident Sampling	Installed Post-Accident Sampling System for Reactor Coolant Sampling.	Jan. 81
II.D.1	Valve Position Indication	Installed Acoustical Monitoring System for Relief and Safety Valves.	March 80
II.E.4.2	Containment Isolation Dependability	Installed New Isolation Valves for Post Accident Sampling Line and Torus to Radwaste Pump Downline.	March 82
		No provisions for Isolation of Vent and Purge Valves Provided.	Generic BWROG Position
II.F.1	Accident-Monitoring		
	1. Noble Gas Monitor	Effluent Monitoring System to be Installed	Jan. 83
	2. Iodine/Particulate Sampling	Effluent Monitoring System to be Installed	Jan. 83
	3. Containment High Range Monitor	Installed Containment High Range Radiation Monitors	Jan. 82

TABLE II (cont'd)

TMI ACTION PLAN
EQUIPMENT INSTALLED AT NINE MILE POINT 1

NUREG 0737 CLARIFICATION ITEM	TITLE	DESCRIPTION	APPROXIMATE EQUIPMENT INSTALLATION DATE
	4. Containment Pressure	Installed Containment Pressure Monitors	Spring 81
	5. Containment Water Level	Installed Torus Water Level Instrumentation	Spring 81
	6. Containment Hydrogen	No Action Required	N/A
II.F.2	Instrumentation for Detection on Inadequate Core Cooling	Installed Fuel Zone Level Instrumentation	Jan. 82
II.K.3	Final Recommendations B&O Task Force		
	14. Iso. Condenser Isol. Mod.	None	None Required Per NRC-SER
	19. Interlock Recir. Pump Modification	None	None Required Per NRC-SER

QUALITY ASSURANCE RECORD

NUS CORPORATION
CONSULTING DIVISION

RECORD OF SYSTEM/COMPONENT ANALYSES

FILE NO.:	NO. OF PAGES:	NUMBER OF VOLUMES OF COMPUTER OUTPUT:
1961-Ø005-001	35	N/A

CLIENT:	PROJECT NO.:
Niagara Mohawk Power Corporation	1961

ANALYSIS TITLE: Environmental Qualification of D.G. O'Brien Connectors.

AUTHOR: M. A. Ippolito

PURPOSE OF ANALYSIS: To determine if the design of the D.G. O'Brien Connector is adequate to assure that they will operate on demand to meet the system performance requirements under Normal and Design Basis Events.

SUMMARY OF ANALYSIS PROCEDURE AND RESULTS:

An aging analysis was conducted on the non-metallic materials in D.G. O'Brien Connectors 4 pin #8 and 19 pin #16 used at NMP-1 and required to mitigate an accident. Also harsh environment conditions were considered. Based on the data in this report it is suggested that 19 pin #16 connectors can be qualified if the Viton O'rings are replaced. The 4 pin #8 cannot be qualified.

DATE COMPLETED:	VERIFICATION REQUIRED:
11/25/81	☑ YES ☐ NO

ANALYSIS REVIEWED AND ACCEPTED: (DISCIPLINE MANAGER)	DATE:
C A Hook [signature]	12-8-81

ANALYSIS:	BY: (FILE NO.)	DISCIPLINE MANAGER:	DATE:
☐ SUPERSEDED ☐ SUPPLEMENTED			

NUS 202 10 REVISED 0181
(Formerly CD-28 12/77)

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

FILE NO.: 1961-0005-001

ANALYSIS TITLE: Environmental Qualification of D.G. O'Brien Connectors

AUTHOR: M. A. Ippolito

NO. OF PAGES: 35

NO. OF VOLUMES OF COMPUTER OUTPUT: N/A

VERIFICATION SCOPE (CHECK AS APPLICABLE):

- [x] METHOD OF ANALYSIS
- [x] ASSUMPTIONS
- [x] INPUT INFORMATION
- [ ] COMPUTER CODE APPLICATION
- [ ] CHECK OF SAMPLE CALCULATION
- [x] SPOT CHECK OF MATHEMATICS
- [x] REASONABLENESS OF RESULTS
- [ ] COMPLETE CHECK OF MATHEMATICS
- [ ] PARTIAL INDEPENDENT ANALYSIS

BUDGET: (APPROXIMATE) 1/4 MANDAYS

DESIRED COMPLETION DATE: ASAP

DESCRIPTION OF VERIFICATION—ACTIVITIES, FINDINGS AND RESOLUTION:

1. Page 4 2.0 AFN missing.
2. Page 5 6.1 Standards - use only required ones. (which ones are required? more [illegible])
3. P 27 I get 1234.76 hrs
4. P 27 9.2.4. Check gas formation or depolution [illegible] - [illegible] depolution may not be important if gas or other product do not [illegible]. - (Switch?) [illegible] evidence that [illegible] the [illegible] gas formation.
5. P 32 11.2 (Elongation and extrusion)

NUS CORPORATION
CONSULTING DIVISION

ANALYSIS VERIFICATION CHECKLIST

ANALYSIS TITLE: Environmental Qualification of D. G. Olson Connectors			ANALYSIS FILE NUMBER: 1961-0005-001
INDICATE "YES, NO, OR N/A (NOT APPLICABLE)," FOR EACH ITEM AND INCLUDE IN ANALYSIS PACKAGE WITH RECORD OF ANALYSIS VERIFICATION	YES	NO	N/A
METHOD OF ANALYSIS			
IS THE METHOD USED APPROPRIATE CONSIDERING THE PURPOSE AND TYPE OF ANALYSIS AND THE USE AND ACCEPTABILITY OF THE RESULTS (i.e., MARGIN TO LIMITS)?	☑	☐	☐
IS THE METHOD IN ACCORDANCE WITH CODES, STANDARDS, AND REGULATORY REQUIREMENTS?	☑	☐	☐
HAS THE METHOD BEEN EMPLOYED ELSEWHERE IN INDUSTRY OR IN LICENSE APPLICATIONS?	☑	☐	☐
ASSUMPTIONS			
ARE ASSUMPTIONS NECESSARY TO PERFORM THE ANALYSIS ADEQUATELY DESCRIBED AND REASONABLE?	☑	☐	☐
WHERE NECESSARY, ARE THE ASSUMPTIONS IDENTIFIED FOR SUBSEQUENT RE-VERIFICATIONS WHEN THE DETAILED DESIGN ACTIVITIES ARE COMPLETED?	☑	☐	☐
INPUT INFORMATION			
ARE THE INPUTS INTO THE ANALYSIS STATED AND THEIR SOURCE IDENTIFIED?	☑	☐	☐
IS THE INPUT INFORMATION FROM THE LATEST AVAILABLE REVISION TO THE DOCUMENT?	☑	☐	☐
IS THE STATUS (PRELIMINARY, CONCEPTUAL, ETC.) OF THE INPUT SOURCE IDENTIFIED FOR LATER CONFIRMATION OF THE VALIDITY OF THE INPUT?	☑	☐	☐
ARE THE INPUTS SUFFICIENT CONSIDERING THE PURPOSE OF THE ANALYSIS?	☑	☐	☐
COMPUTER CODE APPLICATION			
ARE ALL CODES USED IDENTIFIED ALONG WITH SOURCE, COMPUTER TYPE, INPUTS, AND OUTPUTS?	☑	☐	☐
HAS THE CODE BEING USED BEEN ADEQUATELY VERIFIED?	☑	☐	☐
IS THE CODE SUITABLE FOR THE PRESENT ANALYSIS?	☑	☐	☐
DOES THE COMPUTER MODEL (NODING, TIME STEPS, ETC.) ADEQUATELY REPRESENT THE PHYSICAL SYSTEMS?	☑	☐	☐
REASONABLENESS OF RESULTS			
IS THE MAGNITUDE OF THE RESULT REASONABLE?	☑	☐	☐
ARE THE DIRECTION OF TRENDS REASONABLE?	☑	☐	☐
PREPARED BY: [signature]			DATE: 11/25/77

NUS 204 10 REVISED 0181
(Formerly CD-30 Rev. 1)

Resolution of Comments

1. File Number added page 4
2. Standards Removed
3. Numbers Corrected
4. statement added to address hot gas formation And switch changed to connector.
5. Statement added (page rewritten)

VERIFIER'S SIGNATURE: [signature]

DATE: 11/24/81

ACCEPTANCE BY: (DISCIPLINE MANAGER) [signature]

DATE: 12-8-81

FINAL ANALYSIS REVIEW CHECKLIST

Project #/Project Title 1961 Client NMPC

Date: 11/29/87

Analysis File Title: Environmental Qualification of O.C. O'Brien Connectors

Analysis File Number: 1961-0005-001

Checklist Item			Yes	N/A
1.	Unique Analysis File Number assigned to the file.		✓	
2.	Analysis recorded on CD-60		✓	
	a.	pages numbered	✓	
	b.	total pages specified	✓	
	c.	all pages dated	✓	
	d.	client identified on each page	✓	
	e.	correct file number on each page	✓	
	f.	author(s) specified on each page	✓	
	g.	subject specified on each page	✓	
	h.	verifier initials on each page	✓	
3.	Analysis File includes:			
	a.	client identification	✓	
	b.	analysis file number	✓	
	c.	analysis title	✓	
	d.	author(s) identification	✓	
	e.	description of the purpose of the analysis	✓	
	f.	discussion of the general method of analysis	✓	
	g.	identification of input information source	✓	
	h.	identification of input information status	✓	
	i.	major assumptions used in performing the analysis	✓	

3. (Continued)

j.	important references, including material properties	✓	
k.	identification of specific versions of codes used		✓
l.	detailed calculation	✓	
m.	listing of computer input		✓
n.	microfiche of computer output		✓
o.	summary of results.		✓

4.	Record of analysis provided onn CD-28	✓	
5.	All applicable entries on CD-28 correct.	✓	
6.	All referenced NUS internal memos included in analysis file.		✓
7.	All referenced telecons included in analysis file.		✓
8.	Separate computer output labeled with analysis file number.		✓
9.	Record of analysis file verification on CD-29.	✓	
10.	All entries on CD-29 completed and correct.	✓	
11.	Item (7) of CD-29 completed and comments numbered	✓	
12.	Verification checklist CD-30 included.	✓	
13.	Computer code used verified per QAI 3.5.		✓
14.	Corrected items crossed out clearly enough to show on Xerox copies.	✓	
15.	List of input information and major assumptions checked for commpleteness.	✓	
16.	Documents Complete (Page Count)	✓	
17.	Documents Legible and Reproducible	✓	
18.	All Documents Identified on Index Received	✓	
19.	Documents Properly Paginated	✓	
20.	Documents Identified to Project/Item	✓	
21.	All Unsatisfactory Conditions Resolved (List)	✓	

Date 11/29/77

22. Remarks:

Reviewed by: [signature] 11/29/77
Date

[signature] 12-8-81

CLIENT NMPC FILE NO. [illegible] BY M.C. [illegible]

SUBJECT Analysis of O.G. OBrien Connector Checked By [illegible]

Environmental Qualification Of.

O.G. O'Brien Connectors For Use

In Niagara Mohawk Corporation's

Nine Mile Point Unit 1

CLIENT NMPC FILE NO. 1761-0005-001 BY M. A. Capriotti

SUBJECT Analysis of D.G. O'Brien Connectors Checked By [illegible]

Table of Contents

CLIENT NMPC FILE NO. 1961-0005-012 BY M. A. [illegible]

SUBJECT Analysis of D. G. O'Brien Connectors Checked By JBB

CLIENT NMPC FILE NO. 1961-0005-001 BY M. A. Spalite
SUBJECT Analysis of D.G. O'Brien Connectors Checked By [illegible]

List of Tables

List of Figures

1.0 Client Identification

Niagara Mohawk Power Corporation

2.0 Analysis File Number

NUS - 1961-9005 - 001

3.0 Analysis Title

Environmental Qualification of D.G. O'Brien Connectors

4.0 Author Identification

M. A. Appolito

5.0 Purpose of Analysis

The purpose of this analysis is to determine if the design of the D.G. O'Brien Connectors is adequate to assure that they will operate on demand to meet the system performance requirements under normal and harsh environmental conditions at NMP-1.

CLIENT NMPC FILE NO. 7961-B005-002 BY M. O. Ippolito

SUBJECT Analysis of D.G. O'Brien Connectors Checked By

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CLIENT NMPC FILE NO. 1961-0005-01 BY M. A. Apolito

SUBJECT Analysis of D. G. O'Brien Connectors Checked By [signature]

6.0 Input Information

6.1 Equipment Identification

The equipment consists of D.G. O'Brien Electrical Connectors used inside containment and required to mitigate an accident. Table 1 provides a listing of cable connector construction and identifies the system it is used in.

System	I.D. No.	Type
CEE	N/A	4 PIN #8
CEE	N/A	19 PIN #16

6.2 Equipment Description

The D. G. O'Brien connectors used at NMP-1 are of the pin and socket type. The housing is 304 stainless steel. The electrical socket and pin connectors are gold-plated copper. The insulator materials are constructed of one of three materials depending on connector size: diallyl phathalate, high density polyethylene, or GMG (glass impregnated melamine). The sealing function for leak tightness of the penetration is provided in the interior of the connector receptacle by molded glass. To assure leak tightness of the connector internals, two areas of ingress are considered. 1) The plug-receptacle interface uses a double Viton O-ring seal. 2) The cable-plug interface is sealed with individual Viton O-rings

Table 1 (Ref 12.11)

ELECTRICAL PENETRATION CONNECTORS REQUIRED TO MITIGATE AN ACCIDENT

Penetration Number	Service	PENETRATION ELECTRICAL CONNECTOR CONSTRUCTI[ON] Pin Construction	Front Insulator	Mid Insulator	Rear Insul
X-E178D	Core Spray IV 40-01 Power	4#8	HDPE	HDPE	GMG
X-E178H	Core Spray IV 40-01 Control	19#16	DIAL	DIAL	DIA
X-E179A	Clean-Up Return IV 33-01 Power	4#8	HDPE	HDPE	GMG
X-E179B	Clean-Up Supply IV 33-02 Power	4#8	HDPE	HDPE	GMG
X-E179E	Clean-Up Return IV 33-01 Control	19#16	DIAL	DIAL	DIA
X-E179F	Clean-Up Supply IV 33-02 Control	19#16	DIAL	DIAL	DIA
X-E188G	Electromatic Valves NR108C, NR108D	19#16	DIAL	DIAL	DIA
X-E188H	Electromatic Valve NR108F	19#16	DIAL	DIAL	DIA
X-E189D	Core Spray IV 40-09 Power	4#3	HDPE	HDPE	GMG
X-E189H	Core Spray IV 40-09 Control	19#16	DIAL	DIAL	DIA
X-E202-H	Main Steam IV 01-02 Control	19#16	DIAL	DIAL	DIA
X-E210-B	Core Spray IV 40-10 Power	4#8	HDPE	HDPE	GMG
X-E210-E	Core Spray IV 40-10 Control	19#16	DIAL	DIAL	DIA
X-212A	Main Steam IV 01-02 Power	4#8	HDPE	HDPE	GMG
X-212E	Main Steam IV 01-02 Control	19#16	DIAL	DIAL	DIA

Table 1 (Continued)

ELECTRICAL PENETRATION CONNECTORS REQUIRED TO MITIGATE AN ACCIDENT

		PENETRATION ELECTRICAL CONNECTOR CONSTRUCTI			
Penetration Number	Service	Pin Construction	Front Insulator	Mid Insulator	Re Insu
X-E228F	Electromatic Valves NR108A NR108B	19#16	DIAL	DIAL	DI
X-E228G	Electromatic Valve NR108E	19#16	DIAL	DIAL	DI
X-E228H	Main Steam IV 01-01 Control	19#16	DIAL	DIAL	DI
X-E229A	Main Steam IV 01-01 Power	4#8	HDPE	HDPE	GM
X-E229E	Main Steam IV 01-01 Control	19#16	DIAL	DIAL	DI
X-E231D	Core Spray IV 40-11 Power	4#8	HDPE	HDPE	GM
X-E231H	Core Spray IV 40-11 Control	19#16	DIAL	DIAL	DI
X-E233A	Reactor Shutdown Cooling System Supply IV 38-01 Power	4#8	HDPE	HDPE	GM
X-E233B	Reactor Shutdown Cooling System Supply IV 38-13 Power	4#8	HDPE	HDPE	GM
X-E233E	Reactor Shutdown Cooling System Supply IV 38-01 Control	19#16	DIAL	DIAL	DI
X-E233F	Reactor Shutdown Cooling System Supply IV 38-13 Control	19#16	DIAL	DIAL	DI

Material Abbreviations

HDPE - High Density Polyethylene
DIAL - Diallyl Phthalate
GMG - Glass Impregnated Melamine

Pin Construction

First Number - Number of Pins (Cont
Second Number - Pin Diameter in AWG (American Wire Gauge

CLIENT NMPC FILE NO. 1961-0005-002 BY [illegible]

SUBJECT Analysis of D.G. O'Brien Connectors Checked By [illegible]

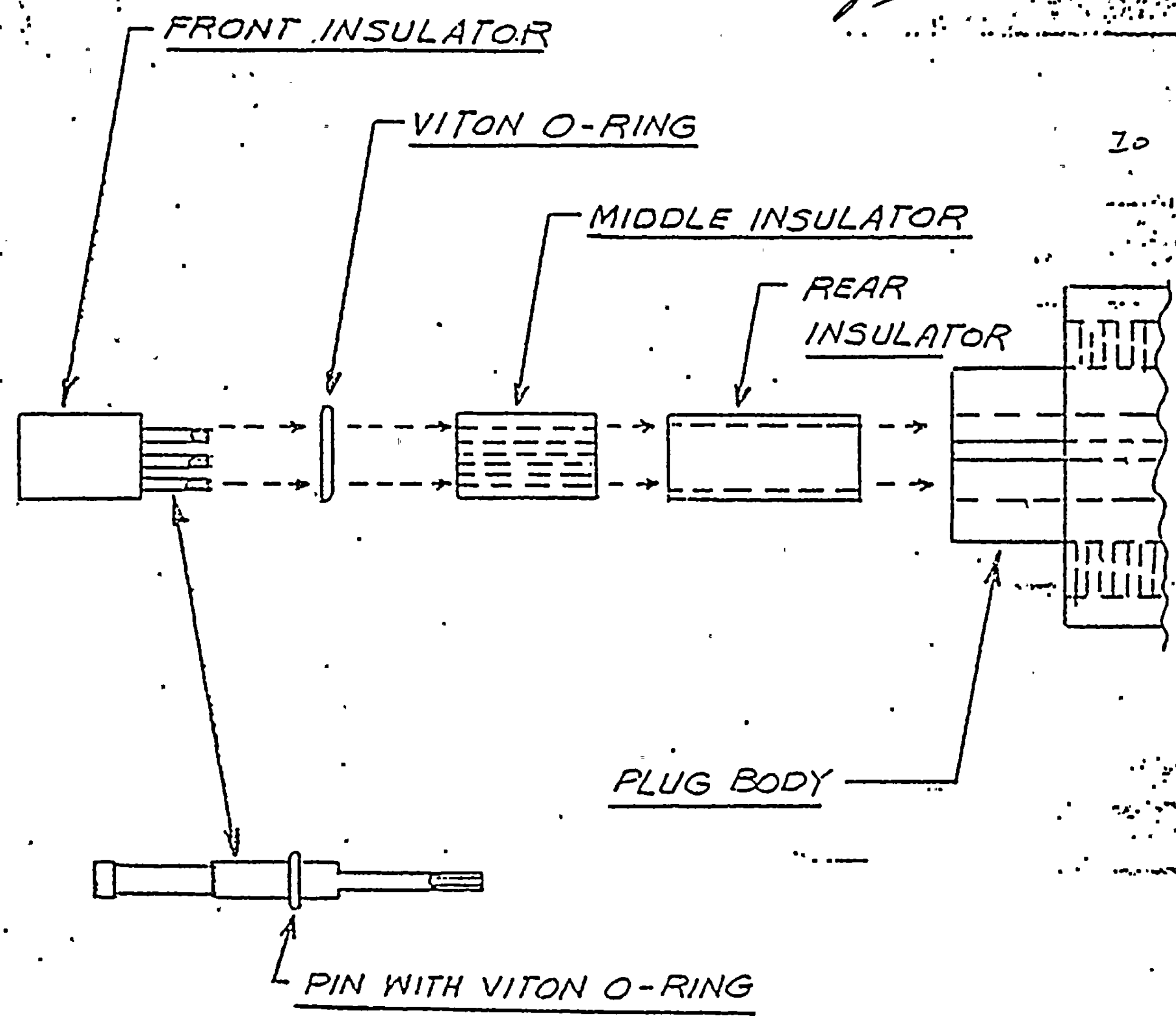
around each pin and a Viton O-ring around an insulator. Each pin passes through three insulators within the plug assembly. Additionally, a polyurethane potting compound and heat shrinkable neoprene or polyolefin boot are used to further protect the assembly (fig. I, II) (Ref 12.11; Ref 12.13)

A material analysis for each material has been conducted by NUS Corporation and is summarized in Table 2.

6.3 Safety-Related Function

Maintain Containment Integrity And Provide Electrical Interface Between Equipment Inside And Outside Containment. (Ref 12.17)

Figure 1
(Ref 12.11)



NIAGARA MOHAWK

NIAGARA MOHAWK POWER CORPORATION

NINE MILE POINT NUCLEAR STATION

PLUG ASS'Y

DR.	TR.	CK.	DATE	SCALE
APPROVED		APPROVED		INDEX
APPROVED		APPROVED		NO.

MK.	DATE	BY	REVISION	CK.	APP

Figure 2

ELECTRICAL PENETRATIONS - LOW VOLTAGE

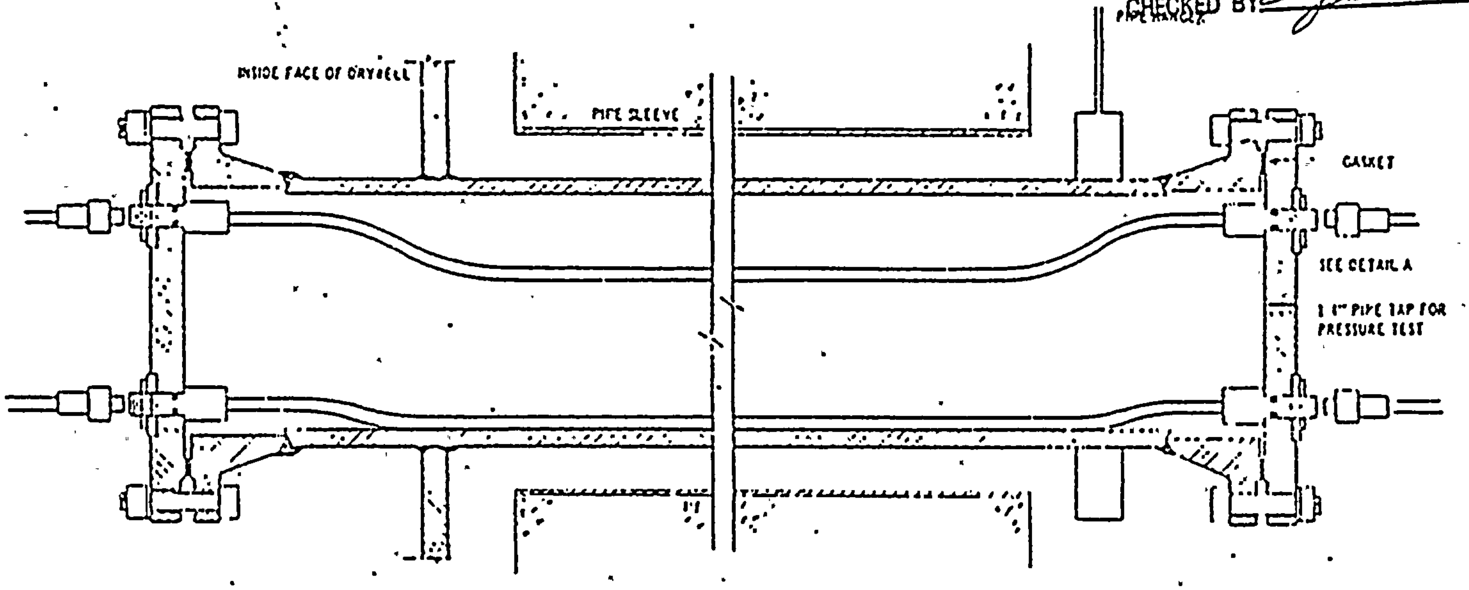
DATE 11/25/81

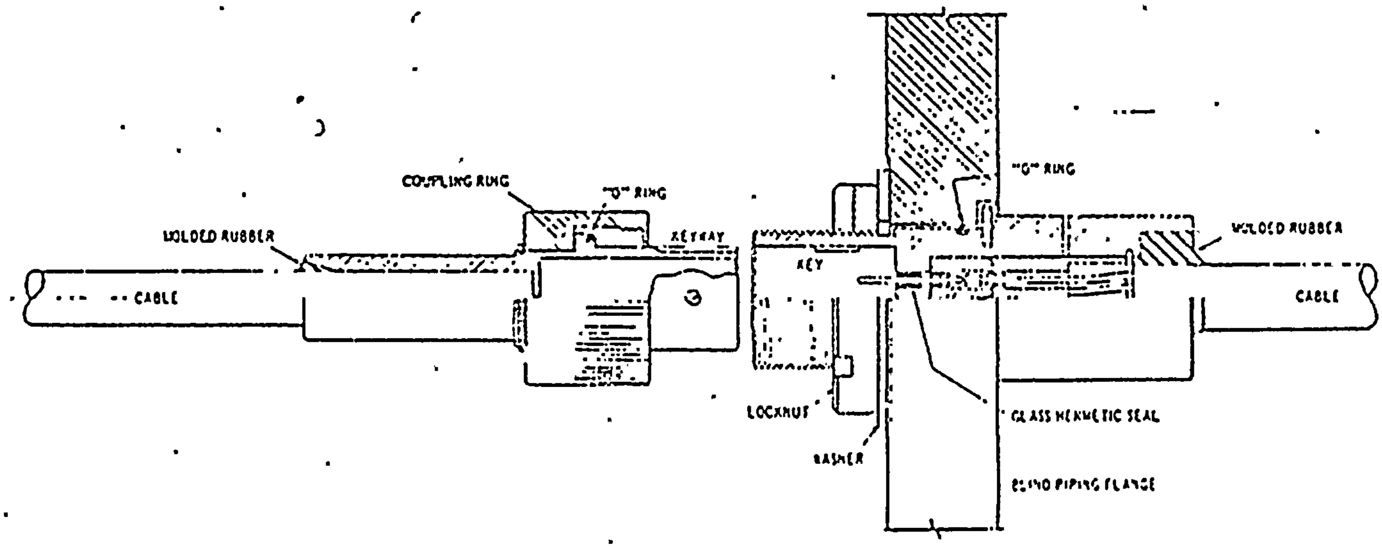
Ref 12.11

FILE NO. 1961-Y005-001

BY M.A. Lapilito

CHECKED BY JB





DETAIL A

Table 2
Materials List and Qualification Data for D.G. O'Brien Connectors

Component Material	Manufacturer Rating	Radiation Data: Material Analyzed	Radiation Data: Radiation Threshold (RADS)	Radiation Data: Ref. No.	Aging Data: Material Analyzed	Aging Data: Activation Energy (eV)	Aging Data: Intercept	Aging Data: Ref. No.
1.0) 4 PIN #8								
1.1) INSULATORS								
Hi-Density Polyethylene	UNKNOWN	Polyethylene	2×10^7	12.10	Hi-density Polyethylene	1.1652	-31.07726	12.5
GMG*	UNKNOWN	GMG*	6.6×10^7	12.10	Melamine Formaldehyde	1.5709	-34.4037	12.7
1.2) Potting Boot**								
Neoprene	UNKNOWN	Neoprene	5×10^7	12.10	Neoprene	1.0421	-23.8443	12.9
Polyolefin (Raychem 202)	UNKNOWN	Polyolefin	5×10^8	12.10	Polyolefin (Raychem)	1.165	-25.0578	12.12
1.3) Potting Compound								
Polyurethane (PR-1538)	UNKNOWN	Polyurethane	4.3×10^7	12.10	Exempt (See Sec. 9.2.4)			
1.4) Seals								
Viton A	UNKNOWN	VITON A	1×10^7	12.10	Viton A	0.799	-14.481	12.8

* Glass impregnated melamine.

** Potting boot could be either neoprene or Polyolefin.

Table 2 (Cont'd)

		Radiation Data			Aging Data			
Component Material	Manufacturer Rating	Material Analyzed	Radiation Threshold (Rads)	Ref. No.	Material Analyzed	Activation Energy (eV)	Intercept	Ref. No.
2.0) 19 Pin # 16								
2.1) Insulator								
Diallylphthalate	Unknown	Diallylphthalate	10^9	12.10	Diallylphthalate Type SDG F	1.17	-48.9230	12.6
2.2) Potting Boot								
Neoprene	Unknown	Neoprene	5×10^7	12.10	Neoprene	1.0421	-23.8443	12.9
2.3) Potting Compound								
Polyurethane (PR 1538)	Unknown	Polyurethane	4.3×10^7	12.10	Exempt (See Sec. 9.4.2)			
2.4) Seals								
Viton A	Unknown	Viton A	1×10^7	12.10	Viton A	0.799	-14.481	12.8

CLIENT NMPC FILE NO. 1961-0005-007 BY M. A. Appolito
SUBJECT Analysis of D.G. O'Brien Connectors Checked By

6.4 Service Conditions

6.4.1 Normal Service Conditions

The following normal service conditions are as specified by NMPC.

- Temperature 103 °F (12.2)
- Pressure 0 psig
- Relative Humidity 50-90% (assumed)
- Radiation 1×10^4 rads (assumed)
- Duration 40 years
- Operational Cycling N/A

6.4.2 Harsh Environment Conditions

The following harsh environment conditions are the peak conditions as obtain by NUS Corporation from NMPC 79-01B submittal of 10/31/80. (See Figures 3 and 4, same as profile Figure 4-12A, and 4-12B, Ref. 12.1)

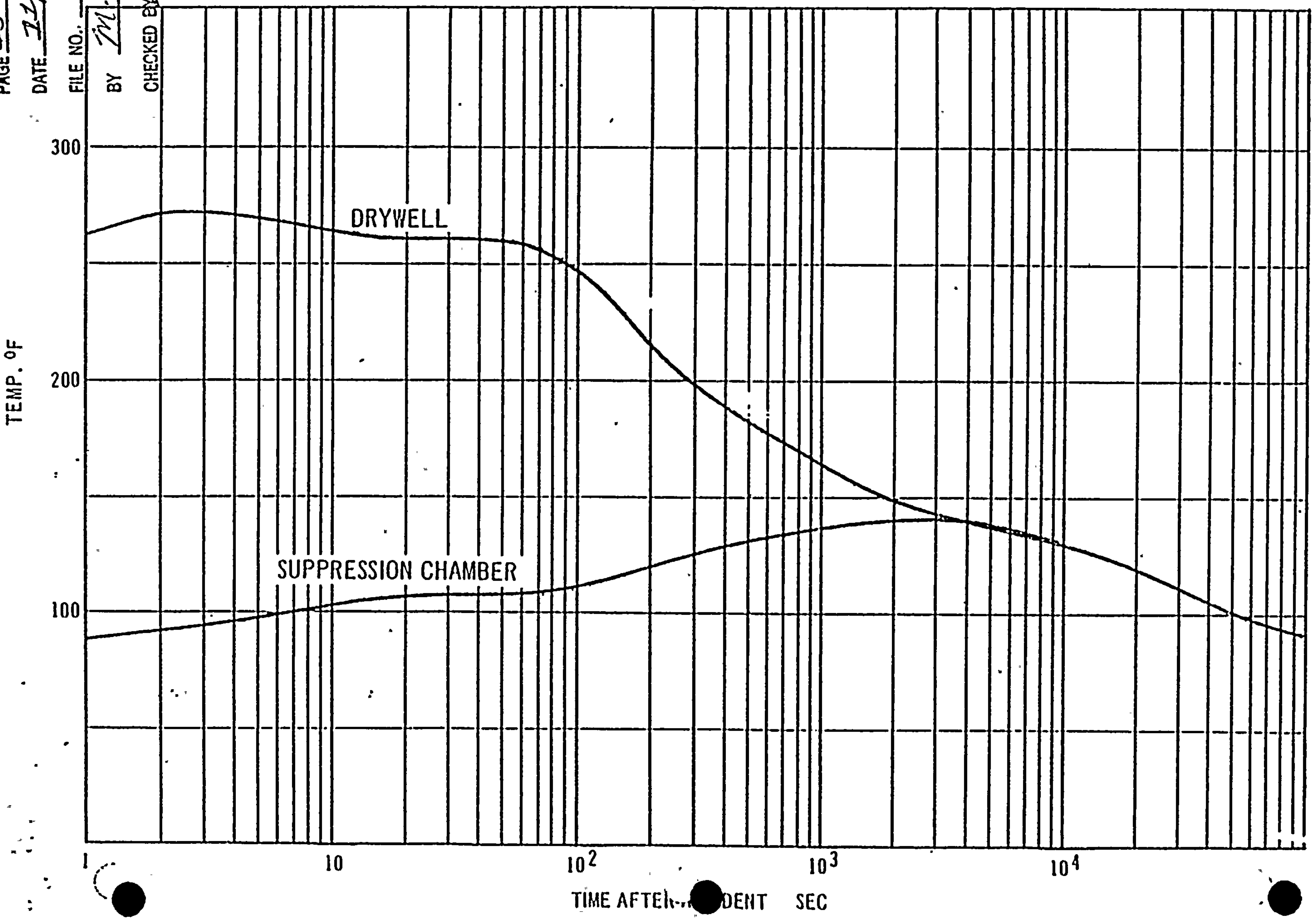
- Temperature 301 °F (Ref. 12.3)
- Pressure 35 psig (Ref. 12.3)
- Relative Humidity 100%
- Radiation 5×10^7 rads (Ref 12.4)

PAGE 15 OF 35
DATE 11/25/81
FILE NO. I961-0015-002
BY M.A. [illegible]
CHECKED BY [illegible]

Figure 3 (Ref 12.1)

FIGURE 4-12A

LOSS OF COOLANT ACCIDENT
CONTAINMENT TEMPERATURE – WITH CORE SPRAY
STRETCH POWER

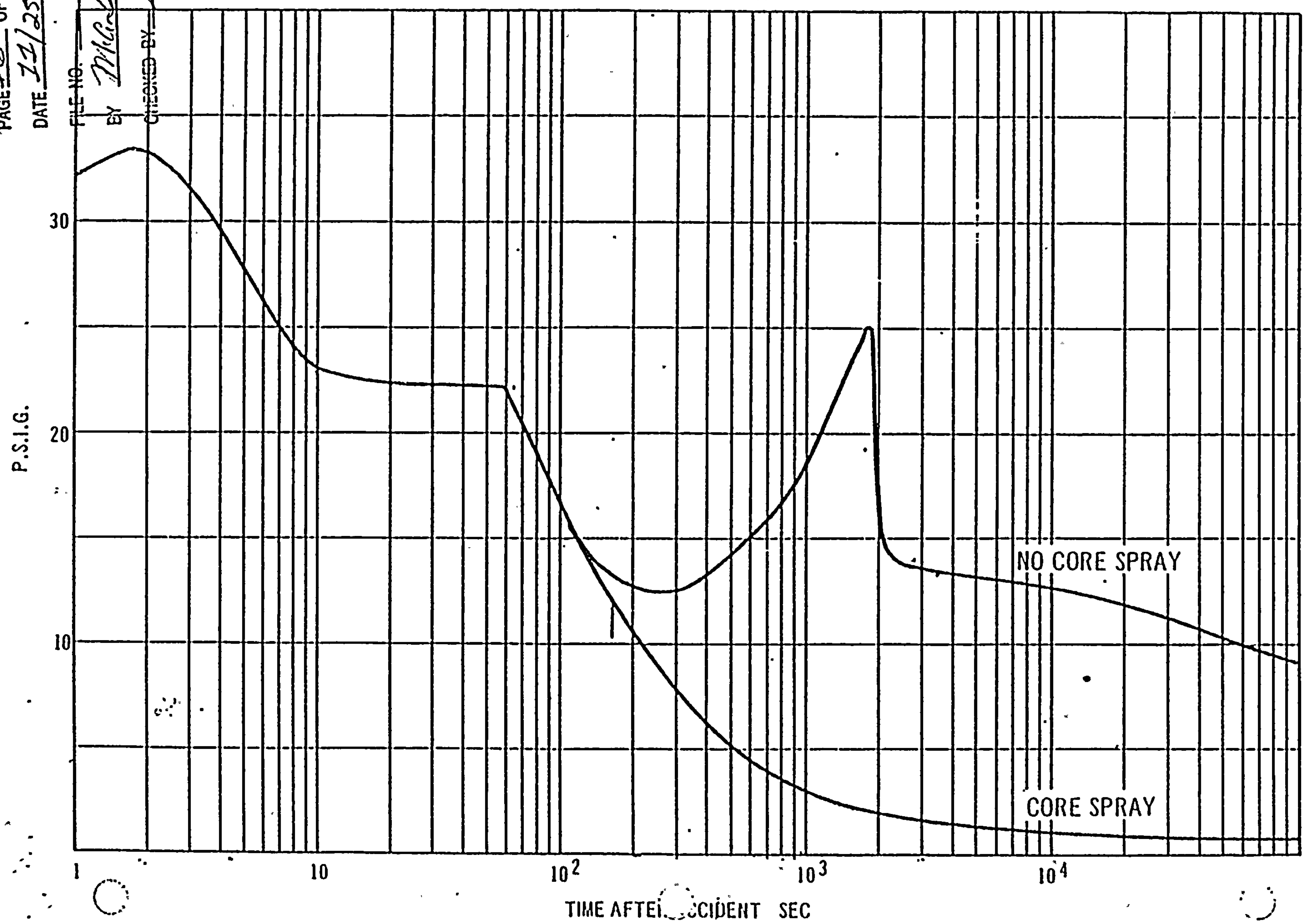


PAGE 16 OF 35
DATE 11/25/82
FILE NO. 1962-0005
BY
CHECKED BY

Figure 4 (Ref. II.1)

FIGURE 4-12B

LOSS OF COOLANT ACCIDENT
DRYWELL PRESSURE
STRETCH POWER



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SUBJECT Analysis of D. G. O'Brien Connectors Checked By JB

- Duration 28 hrs (1 min peak) (Fig 4)
- Operational Cycling Not Applicable

7.0 Method of Analysis

7.1 <u>Materials</u>

The manufacturer of the component was contacted and a list of the non-metallic components used in the switch was obtained. A literature search was then conducted to obtain radiation and temperature threshold levels and time / temperature aging data for those materials that may be subject to degradation from those factors.

7.2 <u>Radiation</u>

A literature search was conducted and the manufacturer was contacted to determine the radiation thresholds for the organic materials used in the component.

7.3 <u>Time Temperature Effects</u>

The present state of the art allows acceleration of the aging effects of temperature by subjecting a material to increased temperatures for a relatively short duration. For many non-metallic materials, it is known that the degradation process can be defined by a single temperature-dependent reaction that follows the

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SUBJECT Analysis of O.G. O'Brien Connectors Checked By [signature]

Arrhenius equation:

$$K = Ae^{-(Ea/k_BT)} \qquad (1)$$

Where,

K = Reaction rate

A = Frequency factor

e = Exponent to base e

Ea = Activation energy

K_B = Boltzmann's Constant

T = Absolute temperature

Equation (1) can also be expressed in a form which yields an expected life of the material at a specific temperature. This form is:

$$Ln(t_i) = Ea/k_B \, (1/T_i) + I \qquad (2)$$

Where,

Ln = Natural logarithm

t_i = Expected life at T_i (hours)

T_i = Service Temperature (°K)

I = Constant (intercept)

Equation (2) can also be represented by a linear equation of the form:

$$y_i = Mx_i + I \qquad (3)$$

Where,

$y_i = \ln(t_i)$

$x_i = 1/T_i$

$M = E_a/k_B$

$I =$ Constant (intercept)

For the purpose of this analysis, Equation (2) was used to calculate the expected life of the materials used in the component. Time/temperature test data were collected from the available literature on each temperature sensitive material and the activation energies and intercepts calculated for the specified failure criteria. These activation energies and intercepts were then used to calculate the expected life of the materials under the maximum harsh environment temperature conditions. If the life calculated for all materials at the harsh environment conditions exceed 40 years, no further analysis was done because the maximum harsh environment temperature envelopes all other temperature conditions. If the material life as calculated above did not exceed 40 years,

then the expected life at ambient conditions was also calculated and a determination of the expected life was made using the combination of 40 years at normal service conditions and the specified duration of a design basis event.

7.4 Harsh Environment

The test specimens were exposed to a steam and high humidity environment in accordance with Figure 5. The test included two required 10-second rapid rises to 300°F, 72 psig (accomplished within 6 and 7 seconds, respectively). The test also included 12 and 60 second dwells at 300°F, 52 psig. The remaining dwells at at decreasing temperatures and pressures were provided within normal experimental tolerances. The total duration of the steam exposure including the second rapid rise in temperature was 28.0 hours. (Ref 12.14)

7.4.1 Radiation

The test specimen were subjected to gamma irradiation from a cobalt-60 source at a dose rate of 0.5 megarads/hr for an accumulated air equivalent dose of 26 megarads of gamma radiation. Measurements of insulation resistance tests before and after radiation indicated that no appreciable change had occured (Ref 12.14)

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SUBJECT Analysis of D.G. OBrien Connectors Checked By JB

The test specimen for both of these tests are of the type of connectors used at NMP-1; in fact the tests were done for NMP-1.

7.5 Cycling

Operational cycling is not considered an applicable aging mechanism for the subject connectors.

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SUBJECT Analysis of D.G. O'Brien Connectors Checked By [illegible]

8.0 Major Assumptions

- It is assumed that for the purpose of this Analysis, the deterioration of metallic components due to time/temperature effects and radiation exposure is insignificant.
- It is assumed that the organic materials used rather than the inorganic materials will be the limiting materials for time/temperature effects and radiation exposure.

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SUBJECT Analysis of D.B. O'Brien Connectors Checked By [signature]

9.0 Detailed Calculations

9.1 Procedure

The following procedure will be used to determine the expected life of D.B. O'Brien Connectors used at NMP-1, based on a harsh environment temperature of 301°F (422.44°K) and a Normal ambient temperature of 103°F (312.44°K).

1. The expected life will be calculated for each material at the harsh environment temperature. If the expected life is greater than 40 years the material is qualified.
2. If the expected life at the harsh environment temperature is less than 40 years, the expected life will be calculated at the ambient temperature. If the expected life is less than 40 years the material is not qualified.
3. If the expected life at ambient is greater than 40 years, then 40 years will be subtracted and the remaining life will be used to calculate the life remaining at the harsh environment temperature (301°F), using the following equation:

$$t_1 = t_2 \exp\left[(E_a/K_B)(1/T_1 - 1/T_2)\right] \quad (4)$$

Where,

t_1 = life remaining at temperature T_1 (hrs)
T_1 = harsh environment temperature 301°F (422.44°K)
t_2 = expected life at Ambient minus 40 years (years)
T_2 = Ambient temperature 103°F (312.44°K)

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SUBJECT Analysis of O.G. O'Brien Connectors Checked By JB

Ea = Activation energy eV
KB = Boltzmann's Constant (8.617×10^{-5} eV/°K)

9.2 Calculations

9.2.1 Insulators

Diallylphthalate

$$\ln(t_i) = 2.17/8.617 \times 10^{-5} (1/T) - 48.9230 \qquad (5)$$

Step 1: at 301°F (422.44°K)
t_i = 43872.692 hrs · $\frac{1 \text{ year}}{8760 \text{ hrs}}$ = 5.00 years

Step 2: at 103°F (312.44°K)
$t_i = 5.712 \times 10^{13}$ hrs × $\frac{1 \text{ year}}{8760 \text{ hrs}}$ = 6.52×10^{9} years.

Step 3: 6.52×10^9 – 40% 6.52×10^9 years
substituting into equation (4)

$$t_1 = 6.52 \times 10^9 \exp\left[\left(\frac{2.17}{8.617 \times 10^{-5}}\right)\left(\frac{1}{422.44} - \frac{1}{312.44}\right)\right]$$

t_1 = 5 years × 8760 hrs/yr = 43844.31 hrs

Hi-density Polyethylene

$$\ln(t_i) = 1.1652/8.617 \times 10^{-5} (1/T_i) - 31.07726 \qquad (6)$$

Step 1: at 301°F (422.44°K)
t_i = 2.54 hours

Step 2: at 103°F (312.44°K)
t_i = 199145.99 hrs × $\frac{1 \text{ year}}{8760 \text{ hrs}}$ = 22.73 years.

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SUBJECT Analysis of D.G. OBrien Connectors Checked By [illegible]

Glass Impregnated Melamine

$$\ln(t_i) = 1.5709/8.617\times10^{-5}(1/T_i) - 34.4037 \quad (7)$$

Step 1: At 301°F (422.44 °K)
$t_i = 6316.57$ hrs x 1 yr/8760 hrs = 0.721 yr.

Step 2: at 103 °F (312.44°K)
$t_i = 2.505\times10^{10}$ hrs x 1 yr/8760 hrs = 2.86×10^6 yrs.

Step 3: $2.86\times10^6 - 40 \approx 2.86\times10^6$
substituting into equation (4)

$$t_1 = 2.86\times10^6 \exp[(1.5709/8.617\times10^{-5})(1/422.44 - 1/312.44)]$$

t_1 = 0.721 years (6316.57 hrs) remaining at 301°F after being aged 40 years at 103°F ambient.

9.2.2 Seals (O-rings)

Viton A

$$\ln(t_i) = 0.799/8.617\times10^{-5}(1/T_i) - 14.481 \quad (8)$$

Step 1: At 301 °F (422.44 °K)
$t_i = 1752.067$ hrs x 1 yr/8760 hrs = 0.2 yrs.

Step 2: at 103°F (312.44 °K)
$t_i = 3.978\times10^6$ hrs x 1 yr/8760 hrs = 454.10 yrs.

Step 3: 454.10 − 40 = 414.10 yrs.
substituting into equation (4)

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SUBJECT Analysis of D.G. O'Brien Connectors Checked By [illegible]

$t_1 = 414.10 \exp[(0.799/8.617\times10^{-5})(1/422.44 - 1/312.44)]$

$t_1 = 0.1824$ yrs $\times$ 8760 hrs/year = 1597.72 hrs.

– 9.2.3 Potting Boot

Neoprene

$LN(t_i) = 1.0421/8.617\times10^{-5} (1/T_i) - 23.8443$ (9)

Step 1: at 301 °F (422.44 °K)
t_i = 119.52 hrs × 1 yr/8760 hrs = 0.01364 yrs.

Step 2: at 103 °F (312.44 °K)
$t_i = 2.8489\times10^6$ hrs × 1 yr/8760 hrs = 325.22 yrs.

Step 3: 325.22 − 40 = 285.22 yrs
substituting into equation (4)

$t_1 = 285.22 \exp[(\frac{1.0421}{8.617\times10^{-5}})(1/422.44 - 1/312.44)]$

t_1 = 0.011966 years × 8760 hr/year = 104.82 hours.

Polyolefin

$LN(t_i) = 1.165/8.617\times10^{-5} (1/T_i) - 25.0578$ (10)

Step 1: at 301 °F (422.44 °K)
t_i = 1039.23 hrs × 1 yr/8760 hrs = 0.1186 yrs.

Step 2: at 103 °F (312.44 °K)
$t_i = 8.13\times10^7$ hrs × 1 yr/8760 hr = 9282.384 yrs.

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Step 3: 9282.384 − 40 = 9242.384 yrs.
substituting into equation (1)

$$t_1 = 9242.384 \exp\left[\left(\frac{1.165}{8.617\times10^{-5}}\right)\left(1/422.44 - 1/322.44\right)\right]$$

$$t_1 = 0.1181 \text{ yrs} \times 8760 \text{ hrs/yr} = 1034.75 \text{ hrs.}$$

9.2.4 Potting Compound

The D. G. O'Brien Connectors, at the electrical penetrations, have a potting boot covering the interface between the incoming cable and the connector body. Inside the potting boot is a polyurethane potting compound. It is suggested that if the boot can be qualified (and it can be by the above analysis), then the polyurethane can be exempted on the basis that it is covered by a qualified material and as such will not be severely degraded (the boot would have to be severely degradated first). It is suggested further that even if the potting compound was severely degraded, it would not impede the safety function of the connector. Furthermore, since the peak harsh environment is only for a short time (Approximately 1 minute), there should be no hot gas formation caused by degradation of the boot and compound.

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SUBJECT Analysis of D.G. O'Brien Connectors Checked By [illegible]

10.0 Results

10.1 Radiation

Samples of the subject equipment were successfully tested to 2.6×10^7 rads of gamma radiation. Since the expected dose is 5×10^7 rads a radiation analysis was conducted for each of the materials. The results are as follows:

Insulators	Radiation (Rads)*
Diallylphthalate	10^9
Hi-density polyethylene	10^8
Glass Impregnated Melamine	6.6×10^7
Seals	
Viton A	10^7
Potting Boot	
Neoprene	5×10^7
Polyolefin (Raychem 202)	5×10^8
Potting Compound	
Polyurethane	4.3×10^7

* Reference 12.10

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SUBJECT Analysis of D. G. O'Brien Connectors Checked By JB

10.2 Time/Temperature Effects

A time/temperature analysis was conducted by NUS (section 9), the results are as follows:

Insulators	Life Remaining at 301°F * (hrs)
Diallylphathalate	43,844.31
Hi-density Polyethylene	None
Glass Impregnated Melamine	6316.57
Seals	
Viton A	1597.72
Potting Boot	
Neoprene	104.82
Polyolefin	1023.56
Potting Compound	
Polyurethane	Exempt **

* Life remaining at 301°F after being aged 40 years at 103°F ambient temperature

** See Section 9.2.4.

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SUBJECT Analysis of O.G. O'Brien Connectors Checked By [signature]

10.3 Harsh Environment

The test specimens were successfully tested to a peak environment of 300°F and 72 PSIG with dwells at decreasing temperatures and pressures for a total duration of 28 hours. (Ref 12.14) (Fig 5)

10.4 Cycling

Not Applicable

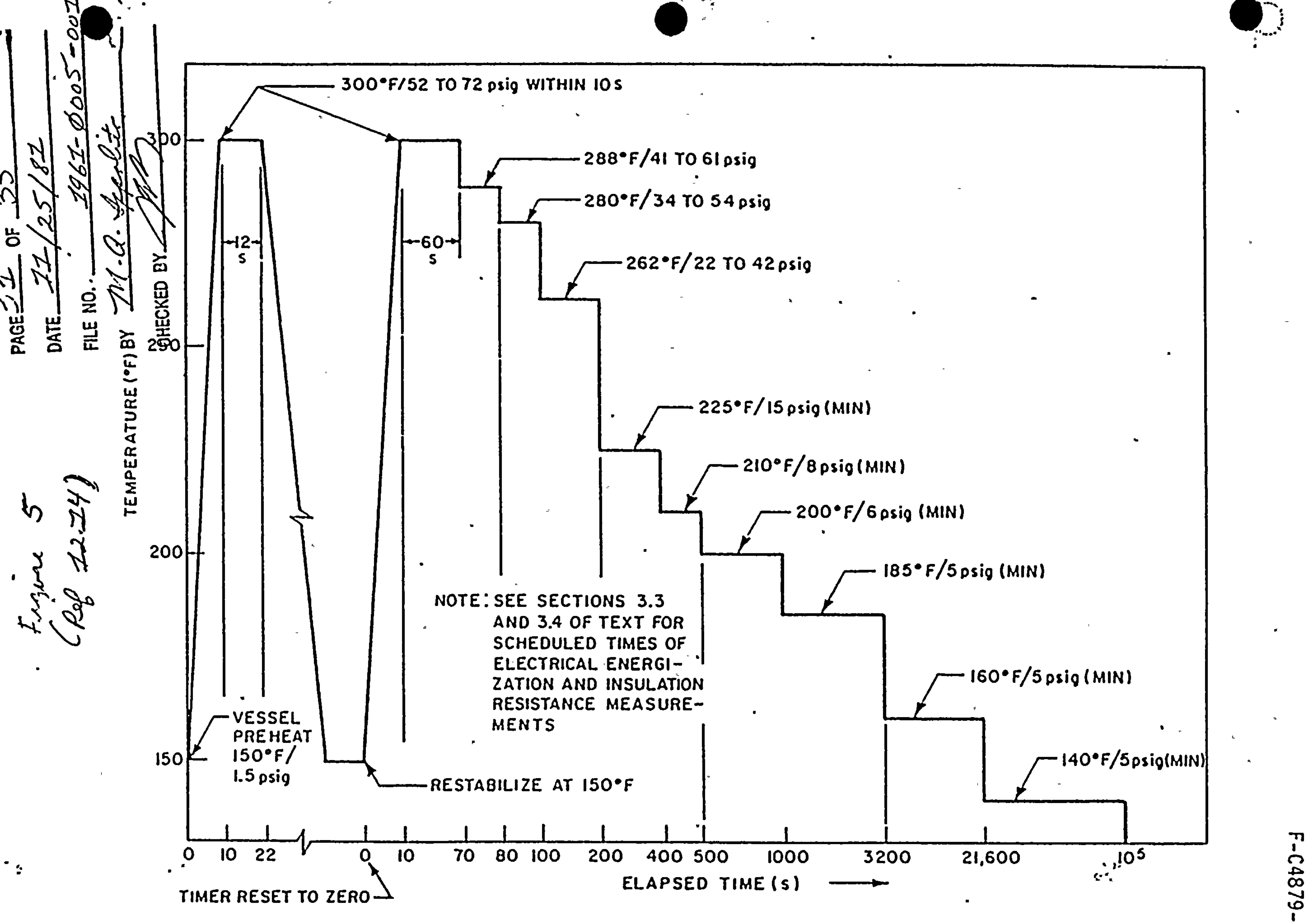

Figure 6. Specified Temperature and Pressure Profile

11.0 Summary of Results / Conclusions

11.1 Radiation

From the results of the literature search it can be seen that only Viton A will be significantly affected by a radiation dose of 5x10^7 rads TID. It is suggested that the Viton A O-rings be replaced with more radiation resistant O-rings such as Neoprene or Viton B (Ref 12.18)

11.2 Time/Temperature Effects

From sections 9.0 and 10.2 it is suggested that all of the materials except for the polyurethane and the Hi-density Polyethylene are qualified. As noted in section 9.2.4 the polyurethane can be exempted. As for the Hi-density polyethylene, it is felt that the reason the expected life is low is because the failure criteria is based on Oxidation rather than an applicable mechanical property (elongation and extrusion). The Oxidation criteria provides an acceptable activation energy, but the y-intercept is felt to high of a negative number. It is felt that if the failure criteria was based on elongation that the activation energy would be about the same but the y-intercept would be a lower negative number. Furthermore, since the peak conditions during harsh environment is for only

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SUBJECT Analysis of D.G. O'Brien Connectors Checked By [illegible]

one minute and since Hi-density polyethylene is rated for continuous use upto 225°F (Ref. 12.15), it is our engineering judgement that the Hi-density polyethylene is qualified for its use.

11.3 Harsh Environment

The peak harsh environment conditions are 301°F and 35 psig. The test specimens were successfully tested to 300°F / 72 psig (Ref 12.14). It is suggested that since the peak conditions will last only a short time (Ref 12.11), and since the the test was run specifically for NMP-1, that the D.G. OBrien connectors are qualified for harsh environment.

11.4 Overall Conclusions

Based on the data presented in this analysis the following conclusion is suggested:

- The 19 pin #16 and 4 pin #8 connectors can be qualified if their Viton-A O-rings are replaced with a more radiation resistant material such a neoprene or Viton B.

12.0 References

12.1 NMPC 79-01B Submittal dtd 10/31/80

12.2 Memo Dave Green (NMPC) to Deepak Bhatia (NUS), "NMPC Supplied Normal Service Conditions" dated 3/11/81

12.3 Memo Dave Green (NMPC) to Environmental Qualification File, "Peak Temperature and Pressure for Drywell Environmental Qualification" 7/16/81

12.4 "Radiation Environmental Specifications For NMP1", NUS-1961-R-1. dated 10/25/81

12.5 NUS Generic Analysis NUS-LA-P-5 "Material Analysis of Polyethylene" dated 11/14/81,

12.6 NUS Generic Analysis NUS-LA-D-1 "Material Analysis of Diallylphathalate" dated 11/18/81

12.7 NUS Generic Analysis NUS-LA-M-1 "Determination of Aging Parameters for Melamine-Formaldehyde" dated 11/15/81

12.8 NUS Generic Analysis NUS-LA-V-1 "Material Analysis of Vinylidene Fluoride Hexafluoropropylene" dated 11/14/81.

12.9 NUS Generic Analysis NUS-LA-C-2 "Material Analysis of Chloroprene" dated 11/15/81

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DATE 11/25/81

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12.10 Memo No. CD-ENG-853, J. Wanless (NUS) to A. Carepa (NUS), "Resolution of Status of Ongoing Qualification Items", dated 11/24/81

12.11 Ltr From R.R. Schneider (NMPC) to Boyce H. Grier (NRC) dated 11/28/77

12.12 NUS Generic Analysis NUS-LA-P-4 "Material Analysis of Polyolefin" dtd 11/18/81.

12.13 LTR NO. N-3317, H.P. Hilberg (D.G. O'Brien) To Gene Miller (NUS) dated 6/14/81

12.14 FIRL Report F-C4879-1, "Gamma Radiation Exposure And LOCA Simulation Test of Electrical Penetration Connector Assemblies Phase II" dated 4/78

12.16 Electronic Design, dated 6/7/79, pg 86.

12.17 Memo No. CD-ENG-926 From S. Gayda (NUS) TO A. Carepa (NUS), "Qualified Components Safety Function Identification", dated 11/23/81

NUS CORPORATION
CONSULTING DIVISION

RECORD OF SYSTEM/COMPONENT ANALYSES

FILE NO.: 1961-6080-001-R1	NO. OF PAGES: 18	NUMBER OF VOLUMES OF COMPUTER OUTPUT: N/A
CLIENT: NIAGARA MOHAWK POWER CORPORATION		PROJECT NO.: 1961

ANALYSIS TITLE: ENVIRONMENTAL QUALIFICATION ASSESSMENT FOR GENERAL ELECTRIC TYPE EB TERMINAL BLOCKS

AUTHOR: ROGER STEINBERG

PURPOSE OF ANALYSIS: TO PROVIDE QUALIFICATION ASSESSMENT OF GENERAL ELECTRIC TYPE EB TERMINAL BLOCKS AT NINE MILE POINT-UNIT 1 NUCLEAR POWER GENERATING STATION

SUMMARY OF ANALYSIS PROCEDURE AND RESULTS:

A REVIEW OF VARIOUS TEST REPORTS WAS CONDUCTED TO DETERMINE IF THE GENERAL ELECTRIC TYPE EB TERMINAL BLOCKS WERE QUALIFIED FOR USE AT NINE MILE POINT-UNIT 1. USING A COMBINATION OF INFORMATION OBTAINED FROM THESE REPORTS IT WAS FOUND THAT THE TERMINAL BLOCKS ARE QUALIFIED FOR ALL SPECIFIED CONDITIONS AS DEFINED BY NMPC.

DATE COMPLETED: FEB 25, 1982	VERIFICATION REQUIRED: ☒ YES ☐ NO
ANALYSIS REVIEWED AND ACCEPTED: (DISCIPLINE MANAGER) Klein [signature]	DATE: 2-25-82

ANALYSIS: ☐ SUPERSEDED ☐ SUPPLEMENTED	BY: (FILE NO.)	DISCIPLINE MANAGER:	DATE:

NUS 202 10 REVISED 0181
(Formerly CD-28 12/77)

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

FILE NO.:	PAGE
1961-6080-001-R1	1 OF 2

ANALYSIS TITLE:

ENVIRONMENTAL QUALIFICATION ASSESSMENT FOR GENERAL ELECTRIC TYPE EB TERMINAL BLOCKS

AUTHOR:	NO. OF PAGES:	NO. OF VOLUMES OF COMPUTER OUTPUT:
R. STEINBERG	18	N/A

VERIFICATION SCOPE (CHECK AS APPLICABLE):

- [x] METHOD OF ANALYSIS
- [x] ASSUMPTIONS
- [x] INPUT INFORMATION
- [ ] COMPUTER CODE APPLICATION
- [ ] CHECK OF SAMPLE CALCULATION
- [ ] SPOT CHECK OF MATHEMATICS
- [x] REASONABLENESS OF RESULTS
- [ ] COMPLETE CHECK OF MATHEMATICS
- [ ] PARTIAL INDEPENDENT ANALYSIS

BUDGET: (APPROXIMATE)	DESIRED COMPLETION DATE:
1/4 MANDAYS	2-25-82

DESCRIPTION OF VERIFICATION—ACTIVITIES, FINDINGS AND RESOLUTION:

NONE.

NUS 203A 10 REVISED 0181
(Formerly CD-29(1) 12/77)

VERIFIER'S SIGNATURE: [signature]	DATE: 2-25-82
ACCEPTANCE BY: (DISCIPLINE MANAGER) [signature]	DATE: 2-25-82

NUS CORPORATION
CONSULTING DIVISION

ANALYSIS VERIFICATION CHECKLIST

ANALYSIS TITLE: ENVIRONMENTAL QUALIFICATION ASSESSMENT FOR GENERAL ELECTRIC TYPE EB TERMINAL BLOCKS	ANALYSIS FILE NUMBER: 1961-6080-001-R1		
INDICATE "YES, NO, OR N/A (NOT APPLICABLE)," FOR EACH ITEM AND INCLUDE IN ANALYSIS PACKAGE WITH RECORD OF ANALYSIS VERIFICATION	YES	NO	N/A
METHOD OF ANALYSIS			
IS THE METHOD USED APPROPRIATE CONSIDERING THE PURPOSE AND TYPE OF ANALYSIS AND THE USE AND ACCEPTABILITY OF THE RESULTS (i.e., MARGIN TO LIMITS)?	☒	☐	☐
IS THE METHOD IN ACCORDANCE WITH CODES, STANDARDS, AND REGULATORY REQUIREMENTS?	☒	☐	☐
HAS THE METHOD BEEN EMPLOYED ELSEWHERE IN INDUSTRY OR IN LICENSE APPLICATIONS?	☒	☐	☐
ASSUMPTIONS			
ARE ASSUMPTIONS NECESSARY TO PERFORM THE ANALYSIS ADEQUATELY DESCRIBED AND REASONABLE?	☒	☐	☐
WHERE NECESSARY, ARE THE ASSUMPTIONS IDENTIFIED FOR SUBSEQUENT RE-VERIFICATIONS WHEN THE DETAILED DESIGN ACTIVITIES ARE COMPLETED?	☒	☐	☐
INPUT INFORMATION			
ARE THE INPUTS INTO THE ANALYSIS STATED AND THEIR SOURCE IDENTIFIED?	☒	☐	☐
IS THE INPUT INFORMATION FROM THE LATEST AVAILABLE REVISION TO THE DOCUMENT?	☒	☐	☐
IS THE STATUS (PRELIMINARY, CONCEPTUAL, ETC.) OF THE INPUT SOURCE IDENTIFIED FOR LATER CONFIRMATION OF THE VALIDITY OF THE INPUT?	☒	☐	☐
ARE THE INPUTS SUFFICIENT CONSIDERING THE PURPOSE OF THE ANALYSIS?	☒	☐	☐
COMPUTER CODE APPLICATION			
ARE ALL CODES USED IDENTIFIED ALONG WITH SOURCE, COMPUTER TYPE, INPUTS, AND OUTPUTS?	☐	☐	☒
HAS THE CODE BEING USED BEEN ADEQUATELY VERIFIED?	☐	☐	☒
IS THE CODE SUITABLE FOR THE PRESENT ANALYSIS?	☐	☐	☒
DOES THE COMPUTER MODEL (NODING, TIME STEPS, ETC.) ADEQUATELY REPRESENT THE PHYSICAL SYSTEMS?	☐	☐	☒
REASONABLENESS OF RESULTS			
IS THE MAGNITUDE OF THE RESULT REASONABLE?	☒	☐	☐
ARE THE DIRECTION OF TRENDS REASONABLE?	☒	☐	☐
PREPARED BY: [signature]	DATE: 2-25-82		

NUS 204 10 REVISED 0181
(Formerly CD-30 Rev. 1)

FINAL ANALYSIS REVIEW CHECKLIST

Project #/Project Title 1961 Client NMPC

Date: FEB 25, 1982

Analysis File Title: ENVIRONMENTAL QUALIFICATION ASSESSMENT FOR GENERAL ELECTRIC TYPE EB TERMINAL BLOCKS

Analysis File Number: 1961-6080-001-R1

Checklist Item	Yes	N/A
1. Unique Analysis File Number assigned to the file.	X	
2. Analysis recorded on CD-60	X	
a. pages numbered	X	
b. total pages specified	X	
c. all pages dated	X	
d. client identified on each page	X	
e. correct file number on each page	X	
f. author(s) specified on each page	X	
g. subject specified on each page	X	
h. verifier initials on each page	X	
3. Analysis File includes:		
a. client identification	X	
b. analysis file number	X	
c. analysis title	X	
d. author(s) identification	X	
e. description of the purpose of the analysis	X	
f. discussion of the general method of analysis	X	
g. identification of input information source	X	
h. identification of input information status	X	
i. major assumptions used in performing the analysis	X	

Date: 2-25-82

3. (Continued)

j.	important references, including material properties	X	
k.	identification of specific versions of codes used		X
l.	detailed calculation		X
m.	listing of computer input		X
n.	microfiche of computer output		X
o.	summary of results	X	
4.	Record of analysis provided onn CD-28	X	
5.	All applicable entries on CD-28 correct.	X	
6.	All referenced NUS internal memos included in analysis file.		X
7.	All referenced telecons included in analysis file.		X
8.	Separate computer output labeled with analysis file number.		X
9.	Record of analysis file verification on CD-29.	X	
10.	All entries on CD-29 completed and correct.	X	
11.	Item (7) of CD-29 completed and comments numbered	X	
12.	Verification checklist CD-30 included.	X	
13.	Computer code used verified per QAI 3.5.		X
14.	Corrected items crossed out clearly enough to show on Xerox copies.	X	
15.	List of input information and major assumptions checked for commpleteness.	X	
16.	Documents Complete (Page Count)	X	
17.	Documents Legible and Reproducible	X	
18.	All Documents Identified on Index Received	X	
19.	Documents Properly Paginated	X	
20.	Documents Identified to Project/Item	X	
21.	All Unsatisfactory Conditions Resolved (List)	X	

Date 2-25-82

22. Remarks:

Reviewed by: [signature] 2-25-82
Date

NUS CORPORATION

Page N/A of ______

DATE FEB 24, 1982

CLIENT NMPC FILE NO. 1961-G080-001-R1 BY [signature]

SUBJECT N/A Checked By [signature]

ENVIRONMENTAL QUALIFICATION ASSESSMENT

FOR

GENERAL ELECTRIC

TYPE EB TERMINAL BLOCKS

FOR USE IN

NIAGARA MOHAWK POWER CORPORATION'S

NINE MILE POINT - UNIT 1

NUCLEAR POWER GENERATING STATION

DATE FEB 24, 1982

CLIENT NMPC FILE NO. 5961-6080-001-R1 BY [signature]

SUBJECT ENVIRONMENTAL QUALIFICATION FOR G.E TYPE EB TERMINAL BLOCKS Checked By [signature]

TABLE OF CONTENTS

CLIENT NMPC FILE NO. 961-G080-001-R1 BY R Silbey

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TABLE OF CONTENTS

CLIENT NMPC FILE NO. 1961-G080-001-R1 BY [signature]

SUBJECT ENVIRONMENTAL QUALIFICATION FOR G.E. TYPE EB TERMINAL BLOCKS Checked By [signature]

1.0 CLIENT IDENTIFICATION

NIAGARA MOHAWK POWER CORPORATION (NMPC)

2.0 ANALYSIS FILE NUMBER

1961-G080-001-R1

3.0 ANALYSIS TITLE

ENVIRONMENTAL QUALIFICATION ASSESSMENT SUMMARY FOR GENERAL ELECTRIC TYPE EB TERMINAL BLOCKS FOR USE IN NMPC'S NINE MILE POINT-UNIT 1 NUCLEAR POWER GENERATING STATION

4.0 AUTHOR IDENTIFICATION

ROGER STEINBERG

5.0 PURPOSE OF ANALYSIS

THE PURPOSE OF THIS ANALYSIS IS TO PROVIDE AN ENVIRONMENTAL QUALIFICATION ASSESSMENT OF THE GENERAL ELECTRIC TYPE EB TERMINAL BLOCKS USED IN THE NINE MILE POINT-UNIT 1 NUCLEAR POWER GENERATING STATION.

6.0 INPUT INFORMATION.

6.1 EQUIPMENT IDENTIFICATION

THE GENERAL ELECTRIC TYPE EB TERMINAL BLOCKS CONSIST OF TWO TYPES, TYPE EB-5 AND TYPE EB-25. THE TERMINAL BLOCKS ARE PART OF THE COMMON ELECTRICAL EQUIPMENT USED INSIDE CONTAINMENT AT NINE MILE POINT - UNIT 1 (REF. 13.1).

6.2 MATERIALS

THE GENERAL ELECTRIC TYPE EB TERMINAL BLOCKS CONSIST OF CELLULOSE FILLED PHENOLIC, WHICH IS THE ONLY NON-METALLIC MATERIAL USED IN ITS MANUFACTURE. (REF. 13.2).

6.3 SAFETY RELATED FUNCTION

THE SAFETY RELATED FUNCTION OF THE TYPE EB TERMINAL BLOCKS IS TO PROVIDE INTERFACE BETWEEN POWER OR CONTROL CABLES TO ELECTRICAL EQUIPMENT. (REF. 13.7).

6.4 SERVICE CONDITIONS

THE NORMAL SERVICE CONDITIONS FOR THE TERMINAL BLOCKS AS SPECIFIED BY NMPC (REF. 13.3) ARE AS FOLLOWS:

TEMPERATURE	103°F
PRESSURE	0 PSIG
RELATIVE HUMIDITY	10-90% ASSUMED
RADIATION	1×10^4 ASSUMED
DURATION	40 YRS - PLANT DESIGN LIFE
OPERATIONAL CYCLING	NONE SPECIFIED

THE HARSH ENVIRONMENT CONDITIONS FOR THE TERMINAL BLOCKS, WERE OBTAINED FROM NUS ANALYSIS 1961-SA-A1 (REF. 13.4) AND 1961-R-1 (REF. 13.5). THE MAXIMUM CONDITIONS THAT THE TERMINAL BLOCKS MAY BE SUBJECTED TO ARE AS FOLLOWS:

TEMPERATURE	301° F
PRESSURE	35 PSIG
RELATIVE HUMIDITY	100 %
RADIATION	5×10^7 RADS
DURATION	28 HOURS

TEMPERATURE AND PRESSURE PLOTS FOR A DBE ARE SHOWN IN FIGURE I AND II.

7.0 METHOD OF ANALYSIS

7.1 MATERIALS

THE ONLY NON METALLIC MATERIAL USED IN THE TYPE EB TERMINAL BLOCKS IS CELLULOSE FILLED PHENOLIC (REF. 13.2) A LITERATURE SEARCH WAS CONDUCTED TO OBTAIN RADIATION AND TEMPERATURE THRESHOLD LEVELS AND TIME/TEMPERATURE AGING DATA FOR CELLULOSE FILLED PHENOLIC. ALSO A SEARCH WAS CONDUCTED TO OBTAIN ANY TESTING DATA AVAILABLE THAT WOULD ASSIST IN DETERMINEING THE SAFE RADIATION LEVEL AND QUALIFIED LIFE DUE TO TIME/TEMPERATURE DEGRADATION, FOR THE TYPE EB TERMINAL BLOCKS.

7.2 RADIATION

A LITERATURE SEARCH WAS CONDUCTED TO DETERMINE THE SAFE RADIATION THRESHOLD OF THE TERMINAL BLOCKS BY ACTUAL TESTING, OR TO FIND A SAFE RADIATION THRESHOLD LEVEL FOR CELLULOSE FILLED PHENOLICS. IT WAS SUBSEQUENTLY FOUND THAT RADIATION

7.2 CONTINUED

TESTING HAD BEEN CONDUCTED ON A GENERAL ELECTRIC EB-25 TERMINAL BLOCK BY WYLE LABS (REF. 13.8). THE GENERAL ELECTRIC TYPE EB-5 AND EB-25 TERMINAL BLOCKS ARE CONSTRUCTED OF THE SAME MATERIAL, THEREFORE THIS DATA WILL APPLY TO BOTH TYPES OF BLOCKS IN USE AT NINE MILE POINT UNIT-1.

7.3 TIME/TEMPERATURE EFFECTS

A LITERATURE SEARCH WAS CONDUCTED TO FIND TIME/TEMPERATURE AGING DATA ON CELLULOSE FILLED PHENOLICS, AND ALSO TO FIND ANY THERMAL AGING TESTING THAT MAY HAVE BEEN DONE ON GENERAL ELECTRIC TYPE EB TERMINAL BLOCKS. IT WAS FOUND THAT THERMAL AGING TESTING AND EVALUATION HAD BEEN CONDUCTED BY WYLE LABS (REF. 13.8) ON A GENERAL ELECTRIC TYPE EB-25 TERMINAL BLOCK. THE GENERAL ELECTRIC EB-5 AND EB-25 TERMINAL BLOCKS ARE CONSTRUCTED OF THE SAME MATERIAL, THEREFORE THIS DATA WILL APPLY TO BOTH TYPES OF BLOCKS IN USE AT NINE MILE POINT - UNIT 1.

7.4 HARSH ENVIRONMENT - DESIGN BASIS EVENT

A SEARCH WAS CONDUCTED TO OBTAIN INFORMATION ON HARSH ENVIRONMENT TESTING THAT WAS APPLICABLE TO THE TYPE EB TERMINAL BLOCKS. IT WAS FOUND THAT A GENERAL ELECTRIC TYPE CR151 TERMINAL BLOCK WAS EXPOSED TO HARSH ENVIRONMENT CONDITIONS IN A TEST CONDUCTED BY R.M. SCHUSTER FOR GENERAL ELECTRIC (REF. 13.2). THE CR151 TERMINAL

BLOCK IS CONSTRUCTED OF THE SAME MATERIAL AS GENERAL ELECTRIC TYPE EB TERMINAL BLOCKS (Ref 13.2). IT WAS ALSO FOUND THAT A GENERAL ELECTRIC EB-25 TERMINAL BLOCK WAS TESTED AT HARSH ENVIRONMENT CONDITIONS BY FRANKLIN RESEARCH INSTITUTE (Ref: 13.6), AND BY WYLE LABS (Ref 13.8.)

7.5 CYCLING

CYCLING IS NOT APPLICABLE TO THE TYPE EB TERMINAL BLOCKS.

8.0 COMPUTER CODES

COMPUTER CODES WERE NOT USED IN THIS ANALYSIS.

9.0 MAJOR ASSUMPTIONS

9.1 IT IS ASSUMED FOR THE PURPOSE OF THIS ANALYSIS THAT THE DETERIORATION OF METALLIC COMPONENTS DUE TO TIME/TEMPERATURE AND RADIATION EFFECTS IS INSIGNIFICANT.

10.0. DETAILED CALCULATIONS

BECAUSE TIME/TEMPERATURE TESTING HAS BEEN DONE ON THE TYPE EB-25 TERMINAL BLOCK (Ref. 13.8), DETAILED CALCULATIONS WERE NOT NECESSARY TO DETERMINE THE QUALIFIED LIFE OF THE TYPE EB TERMINAL BLOCKS.

CLIENT Nmpc FILE NO. E61-G080-001-R1 BY [signature]

SUBJECT ENVIRONMENTAL QUALIFICATION FOR G.E. TYPE EB TERMINAL BLOCKS Checked By [signature]

11.0 RESULTS

11.1 RADIATION

A RADIATION TEST WAS CONDUCTED ON A TYPE EB-25 TERMINAL BLOCK BY WYLE LABS (REF. 13.8). THE TEST SUBJECTED THE TERMINAL BLOCK TO GAMMA RADIATION AT A DOSE RATE OF 5.25×10^5 RADS UNTIL A TOTAL EXPOSURE OF 2×10^8 RADS WAS ACHEIVED. THE RADIATION TEST WAS PERFORMED FOLLOWING COMPLETION OF THERMAL AGING TESTS.

11.2 TIME/TEMPERATURE EFFECTS

PRIOR TO RADIATION TESTING, A TYPE EB-25 TERMINAL BLOCK (SAME BLOCK AS IN 11.1) WAS THERMALLY AGED AT 140°C WITH UNCONTROLLED HUMIDITY CONDITIONS FOR 641.5 HOURS BY WYLE LABS (REF. 13.8). THIS TEST AND SUBSEQUENT CALCULATIONS BY WYLE SHOW THE LIFE OF THE TYPE EB-25 TERMINAL BLOCK TO BE GREATER THAN 40 YEARS AT 160°F.

11.3 HARSH ENVIRONMENT

A GENERAL ELECTRIC CR-151 TERMINAL BLOCK WAS SUBJECTED TO THE FOLLOWING HARSH ENVIRONMENT CONDITIONS (REF. 13.2)

TEMP	260°F	320°F	340°F	320°F	260°F
PSIG	21	75	103	75	21
% RH	100	100	100	100	100
DURATION	1.5 DAYS	1.5 HRS	3 HRS	4.5 HRS	8 DAYS

THE INSULATION RESISTANCE WAS RECORDED AT LEAST ONCE A DAY

AND AT EACH SIGNIFICANT TEMPERATURE CONDITION. AFTER COMPLETION OF THE 10 DAY TEST, THE TEST VESSEL WAS OPENED FOR 36 HOURS BEFORE FINAL INSULATION RESISTANCE MEASUREMENTS WERE TAKEN. THE RESULTS OF THIS TEST INDICATE THAT AT THESE HARSH ENVIRONMENT CONDITIONS, THE INSULATION RESISTANCE OF THE BLOCKS CAN BE EXPECTED TO DROP TO APPROXAMATLY 2.0×10^4 OHMS. HOWEVER THE BLOCKS WILL RECOVER THEIR ORIGINAL RESISTANCE VALUE ONCE THE STEAM ENVIRONMENT IS REMOVED.

A GENERAL ELECTRIC EB-25 TERMINAL BLOCK WAS EXPOSED TO THE FOLLOWING HARSH ENVIRONMENT CONDITIONS. (REF. 13,6).

TEMP	286°F	282°F	286°F
PSIG	40	35	40
% RH	100	100	100
DURATION	15 MIN	1 MIN	APPROX 30 HRS.

THE CONDITIONS WERE LOWERED AFTER THE 30 HOURS IN SIX UNIFORM STEPS OVER A 3 HOUR PERIOD TO 232°F 7 PSIG AND 100% HUMIDITY AND HELD FOR ALMOST 101 HOURS. IT SHOULD BE NOTED THAT THE TERMINAL BLOCKS WERE MOUNTED ONE EACH INSIDE A STEEL BOX AND AN ALUMINUM BOX, FOR THE TEST. THE BOXES HAD DRAIN AND VENT HOLES. FOR THE FIRST 24 HOURS OF THE TEST, A CHEMICAL SPRAY OF BORATED WATER WITH 2640 PPM. BORON WAS SPRAYED INTO THE TEST CHAMBER. THE TERMINAL BLOCK IN THE ALUMINUM BOX FAILED 30 MINUTES INTO THE TEST; HOWEVER THE TERMINAL BLOCK IN THE STEEL BOX NEVER FAILED. BOTH TERMINAL BLOCKS WERE ENERGIZED DURING THE TEST WITH 525 VOLTS ON THE END TERMINALS WITH THE ADJACENT TERMINAL POINTS WIRED TO GROUND. ALL OTHER TERMINALS WERE WIRED WITH A 20 AMP LOAD. A PROFILE OF THIS TEST

IS SHOWN IN FIGURE III.

THE SAME TYPE EB-25 TERMINAL BLOCK THAT HAD BEEN THERMALLY AGED AND IRRADIATED BY WYLE LABS (Ref. 8) WAS SUBJECTED TO HARSH ENVIRONMENT CONDITIONS. DETAILS OF THE TEST ARE NOT GIVEN, HOWEVER A PROFILE OF THE TEST IS SHOWN IN FIGURE IV

12.0 SUMMARY OF RESULTS AND CONCLUSIONS

12.1 RADIATION

A TYPE EB-25 TERMINAL BLOCK WAS SUCESSFULLY IRRADIATED TO A TOTAL DOSE OF 2×10^8 RADS. BECAUSE THE TYPE EB-25 AND EB-5 ARE CONSTRUCTED OF THE SAME MATERIALS, THE TERMINAL BLOCKS AT NINE MILE POINT-1 ARE QUALIFIED FOR RADIATION IN EXCESS OF THAT SPECIFIED FOR NINE MILE POINT UNIT ONE.

12.2 TIME/TEMPERATURE EFFECTS

A TYPE EB-25 TERMINAL BLOCK WAS THERMALLY AGED AT 140°C FOR 641.5 HOURS. THIS TEST AND SUBSEQUENT CALCULATIONS SHOW THE LIFE OF THE TERMINAL BLOCK TO BE GREATER THAN 40 YEARS AT 160°F. BECAUSE BOTH THE EB-25 AND EB-5 TERMINAL BLOCKS ARE CONSTRUCTED OF THE SAME MATERIAL, THEY ARE QUALIFIED FOR GREATER THAN 40 YEARS FOR THE SPECIFIED 103°F NORMAL SERVICE CONDITIONS FOR INCONTAINMENT USE.

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SUBJECT ENVIRONMENTAL QUALIFICATION FOR G.E TYPE EB TERMINAL BLOCKS Checked By [signature]

12.3 HARSH ENVIRONMENT

A GENERAL ELECTRIC TYPE CR-151 TERMINAL BLOCK WAS SUCESSFULLY TESTED TO A PEAK CONDITION OF 340°F, 103 PSIG, AND 100% HUMIDITY FOR 3 HOURS AS PART OF A 10 DAY TEST. THESE CONDITIONS ARE IN EXCESS OF THE SPECIFIED CONDITIONS FOR A DESIGN BASIS EVENT AT NINE MILE POINT-1. BECAUSE THE CR-151 TERMINAL BLOCK IS MADE OF THE SAME MATERIAL AS THE TYPE EB-5 AND EB-25 TERMINAL BLOCK, THIS TEST QUALIFIES THE BLOCKS IN USE AT NINE MILE POINT-1 FOR HARSH ENVIRONMENT.

THE HARSH ENVIRONMENT TEST OF A EB-25 TERMINAL BLOCK (REF 136) IS INCONCLUSIVE AS ONE BLOCK IN AN ALUMINUM BOX FAILED, AND ONE IN A STEEL BOX DID NOT FAIL. THE FAILURE MAY HAVE BEEN CAUSED BY THE CHEMICAL REACTION OF BORATED WATER IN CONTACT WITH ALUMINUM. ALSO THE LEVELS OF THIS TEST DID NOT MEET OR EXCEED THE LEVELS SPECIFIED FOR A DESIGN BASIS EVENT AT NINE MILE POINT-1.

REVIEW OF THE PROFILE OF A HARSH ENVIRONMENT TEST DONE BY WYLE LABS (FIG. IV) ON A PREVIOUSLY THERMALLY AGED AND IRRADIATED EB-25 TERMINAL BLOCK, SHOWS THAT THE BLOCK IS QUALIFIED FOR LEVELS IN EXCESS OF THOSE SPECIFIED FOR A DESIGN BASIS EVENT AT NINE MILE POINT-1.

12.4. CONCLUSIONS

THE GENERAL ELECTRIC TYPE EB-5 AND EB-25 TERMINAL BLOCKS ARE QUALIFIED FOR USE AT NINE MILE POINT-1

CLIENT NMPC FILE NO. 1961-G080-001-R1 BY [signature]

SUBJECT ENVIRONMENTAL QUALIFICATION FOR G.E TYPE EB TERMINAL BLOCKS Checked By [signature]

TO LEVELS OF RADIATION, HARSH ENVIRONMENT, AND AGING, IN EXCESS OF THOSE SPECIFIED BY NMPC.

13.0 REFERENCES

13.1 NIAGARA MOHAWK POWER CORPORATION'S NMP-1 ONGOING QUALIFICATION ASSESSMENT SUMMARY, REVISION 4 11/5/81

13.2 G-EN-8-18 DATED 2/24/78 "QUALIFICATION OF TYPE EB TERMINAL BOARDS".

13.3 NIAGARA MOHAWK POWER CORPORATION SUPPLIED NORMAL SERVICE CONDITIONS. MEMO FROM GREEN (NMPC) TO BAHTIA (NUS) DATED 3/11/81

13.4 NUS ANALYSIS 1961-SA-A1 DATED 12/9/80 "PRESSURE AND TEMPERATURE MODEL FOR REACTOR BUILDING".

13.5 NUS ANALYSIS 1961-R-1 DATED 10/25/81 "NMPC RADIATION ENVIRONMENT SPECIFICATIONS FOR NMP-1".

13.6 QSR-010-A-01 DATED 9/23/80 "ENVIRONMENTAL QUALIFICATION OF TERMINAL BLOCKS/BOXES."

13.7 NUS INTERNAL CORRESPONDENCE GAZDA TO CANEPA CD-ENG-926 DATED 11/23/78. "NMPC SER RESPONSE PROJECT 1961 QUALIFIED COMPONENTS SAFETY RELATED FUNCTION".

13.8 WYLE TEST REPORT 17436-15 DATED 12/1/80 FINAL REPORT ON THE EVALUATION OF THE QUALIFICATION OF TERMINAL BLOCK, MODEL EB-25 (GENERAL ELECTRIC CO.) FOR USE IN NORTHEAST UTILITIES SERVICE COMPANY'S MILLSTONE NUCLEAR POWER STATION UNIT ONE. PROPRIETARY INFORMATION RELEASED BY NUSCO TO NUS FOR USE ON NIAGARA MOHAWK NINE MILE POINT PER LETTER GEE-82-12 DATED 1/5/82

CLIENT 1961 FILE NO. 1961-6080-001-R1 BY [signature]

SUBJECT ENVIRONMENTAL QUALIFICATION FOR G.E. TYPE EB TERMINAL BLOCK Checked By [signature]

13.0 References - Continued

13.9 NMPC Response to NRC Safety Evaluation Report of 6/8/81 for NMP-1 dated 9/8/81

FIGURE 4-12A

LOSS OF COOLANT ACCIDENT
CONTAINMENT TEMPERATURE – WITH CORE SPRAY
STRETCH POWER

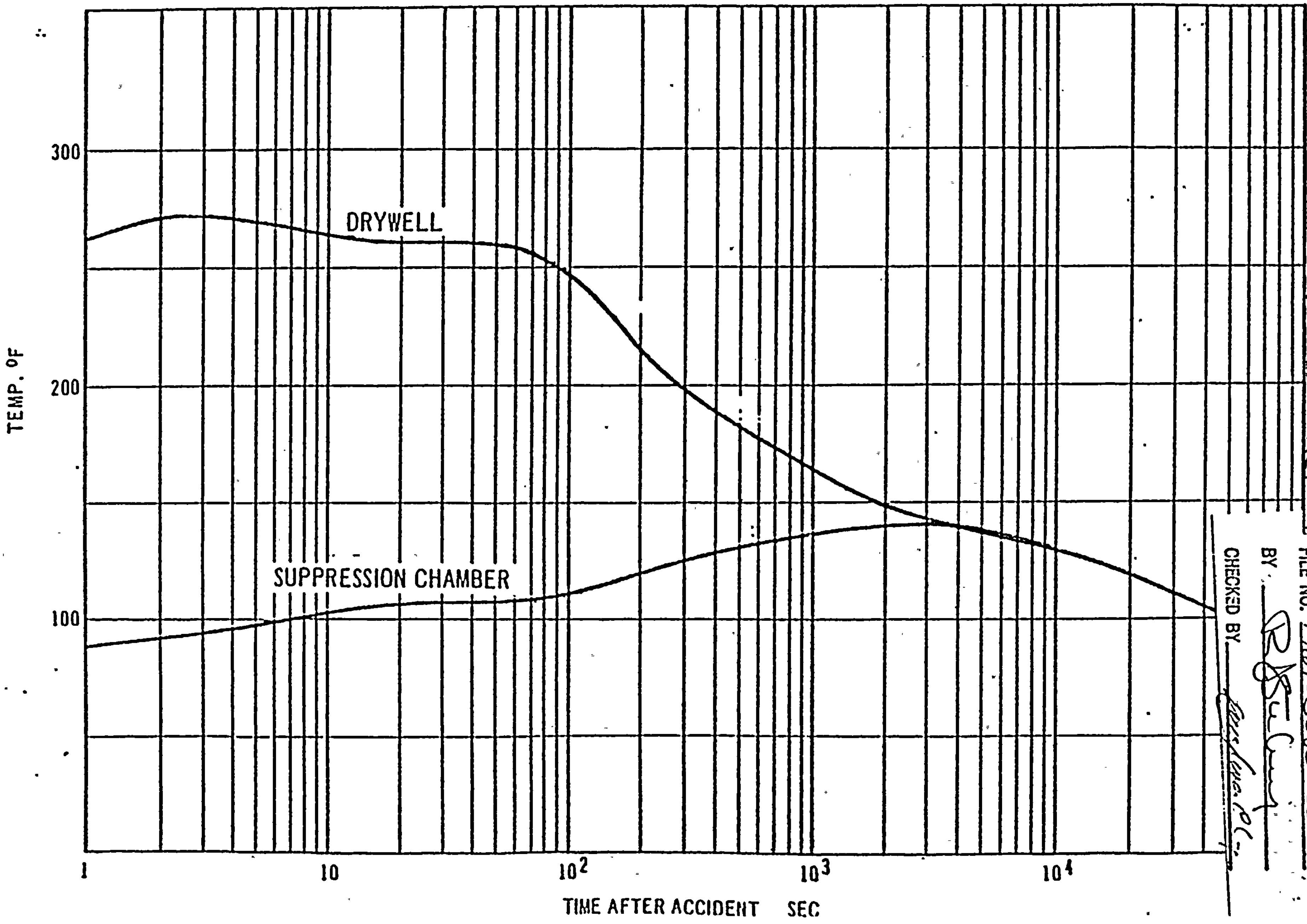

FIGURE I Ref. 9

DATE FEB 24, 1982
FILE NO. 1961-6080-001-R1
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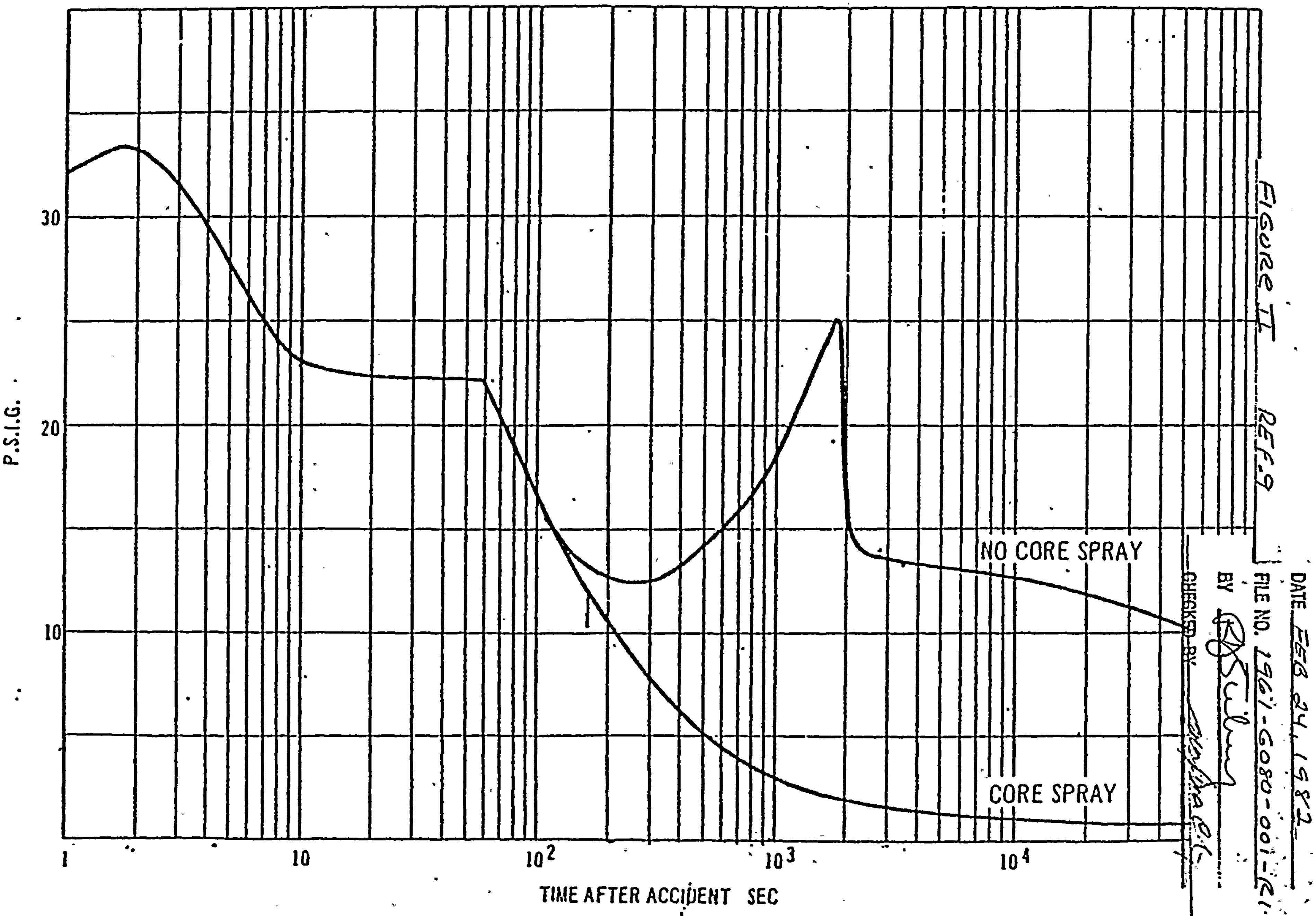
FIGURE 4-12B

LOSS OF COOLANT ACCIDENT
DRYWELL PRESSURE
STRETCH POWER



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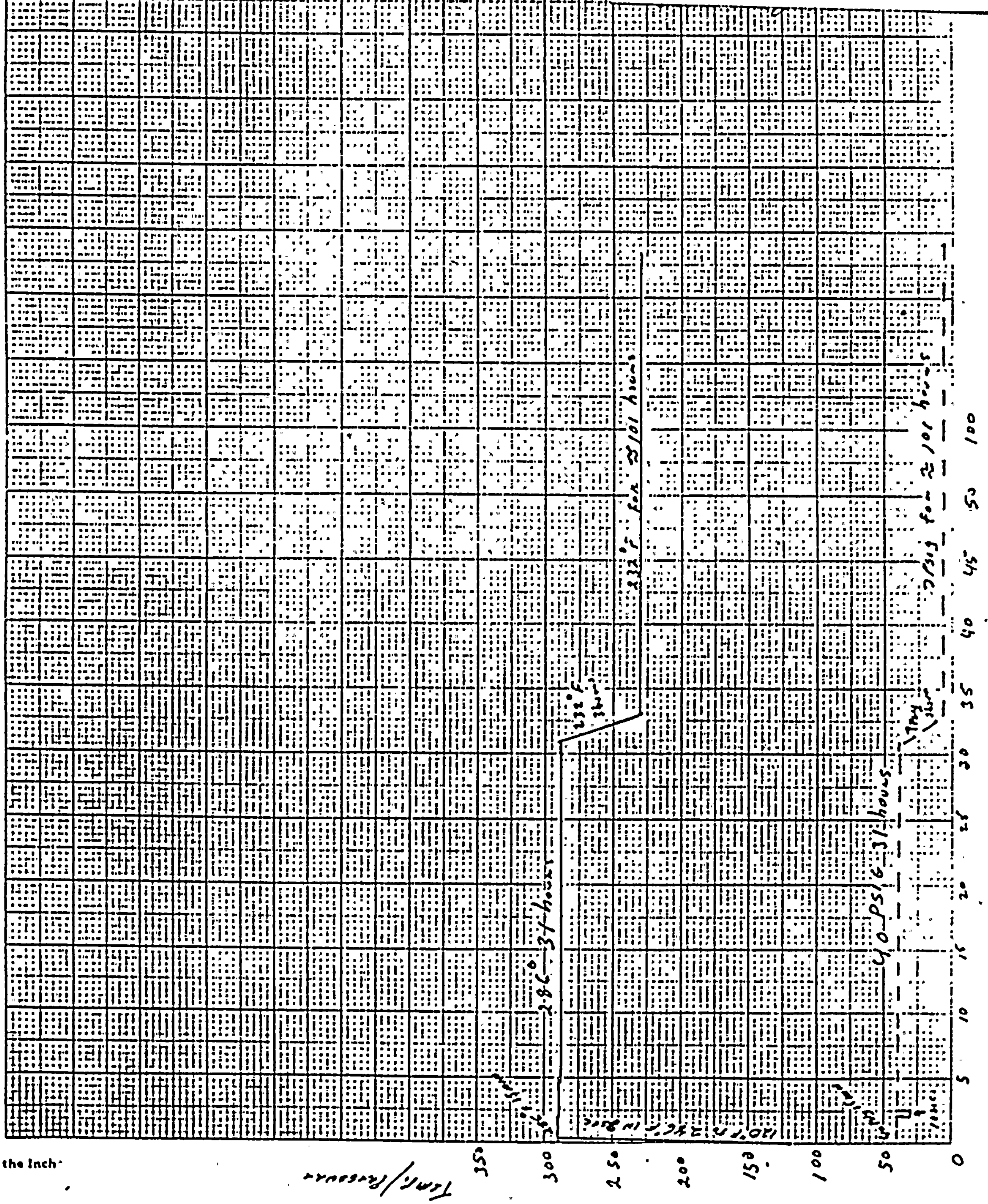

20 Squares to the Inch

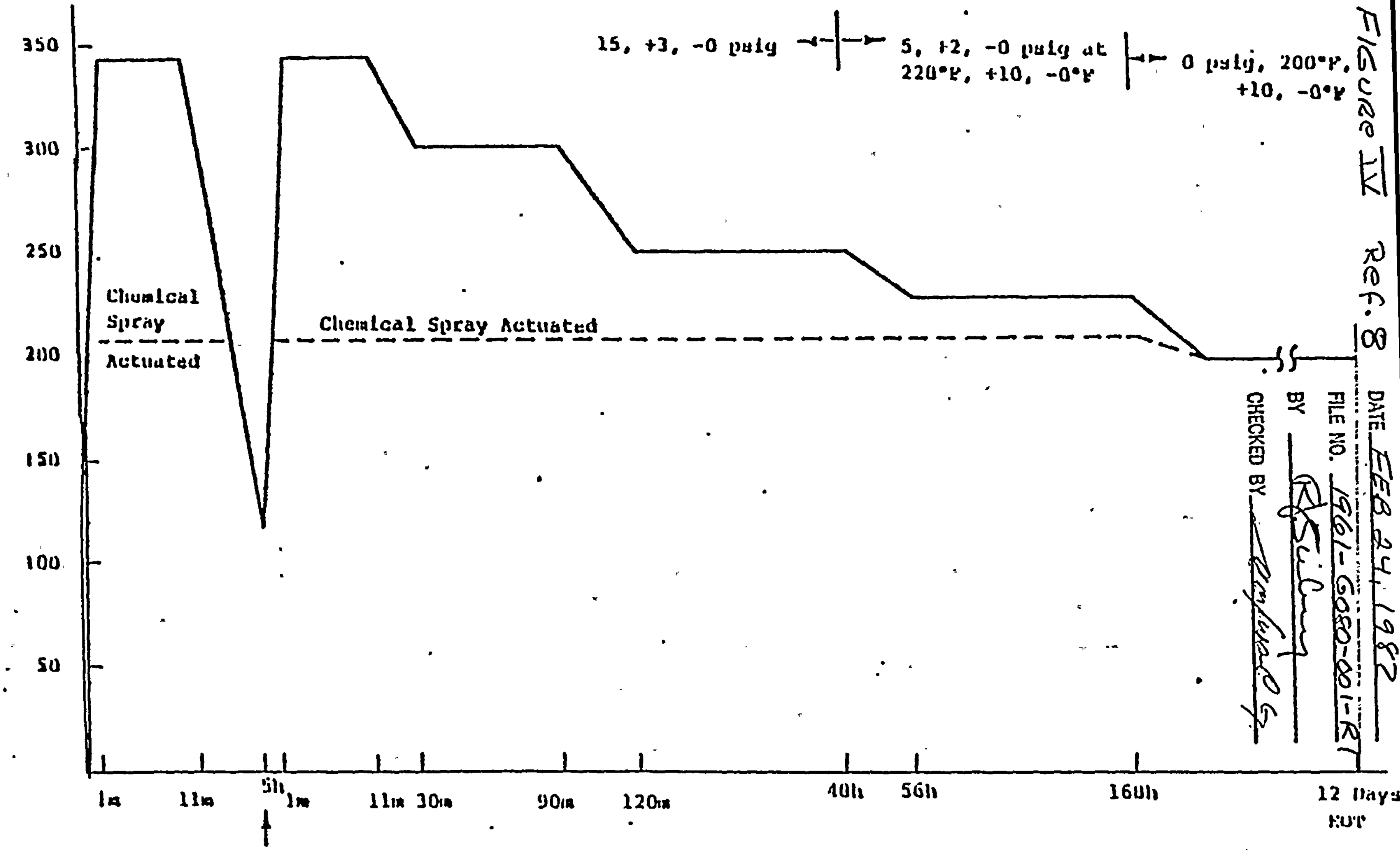

Figure IV Ref. 8

DATE FEB 24, 1982
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BY
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(m = minutes
h = hours)

FIGURE 1. Environmental Profile.

Proprietary

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, 25 COMMERCE DRIVE, CRANFORD, N.J. 07016
Phone (201) 467-5400

INSTALLATION AND
SERVICE ENGINEERING
DEPARTMENT

G-EN-8-18

T. Crimmons
T. Madden → GWB
R. Pinelli
T. Tipton
J. Carroll

COPY

February 24,1978

RECEIVED
MAY 29 1981
ENGINEERING SERVICES
SOUTHERN OPERATIONS

Mr. D.A. Ross
Jersey Central Power and Light Company
Madison Avenue At Punchbowl Road
Morristown,N.J. 07960

SUBJECT: QUALIFICATION OF EB TERMINAL BOARD

Reference: (1) G.E. Quotation #414-TY-12-EN-1
(2) Test report by RM Schuster, 11/6/73, "Terminal Block LOCA Test for Electrical Penetration Assemblies"
(3) NRC IE Bulletin No. 78-02, 1/30/78, "Terminal Block Qualification"

Dear Sir:

An autoclave test (reference 2) for General Electric terminal block CR151B showed that performance was not siginificantly effected by high temperature, pressure and humidity experienced under LOCA conditions.

There is very little difference between CR151B and EB terminal boards. They are made of the same material (cellulose filled phenolic). They are of similar physical size and mechanical arrangement. The phenolic material used will tolerate radiation doses well above that expected in the drywell due to a LOCA without significant mechanical degradation. Both can accomodate wiring up to size AWG#10. Both are rated at 30 amp continuous, 600 v. The CR151B6 is a molded one-piece board, while the EB5 is fabricated circuit by circuit.

GENERAL ELECTRIC

These comparisons and analysis together with the type testing (reference 2) might be used to argue qualification allowable under IEEE 323. Type testing allows for generic representation of design variations in tests.

The terminal boards for the MSIV solenoid valve and switches are needed to operate in their safety function during the first few seconds of a LOCA when containment pressure reaches 2 psig. The solenoid valves have applied power during normal plant operation. Any loss of power would initiate closure of the MSIV. MSIV closure is the safe condition. It might be said that the environmental qualification of the terminal blocks need not consider any time period greater than a minute, or the time it takes for the isolation signal to reach the MSIV's.

However, if Oyster Creek has exposed terminal blocks for safety equipment that might experience an accident environment, arrangements should be made to provide some type of enclosure, preferably NEMA4 or better. Having an enclosure should satisfy any concerns the NRC may have re terminal blocks, see Reference 3.

If you should have any questions relative to this letter, please contact us.

Very truly yours,

W. Popow, Nuclear Service Manager
I&SE - MECHANICAL & NUCLEAR

WP/lk

Attachment to G-EN-0-2

RECEIVED

MAY 29 1981

ENGINEERING SERVICES
SOUTHERN OPERATIONS

BCC 2350

Terminal Block
LOCA Test
For Electrical Penetration Assemblies

By
R. M. Schuster
11-6-73

General Electric Company
BWRSD - C&I Engineering
Peripheral Equipment Engineering

1.0 PURPOSE

The purpose of this test is to determine the effect of the high temperature, pressure and humidity experienced during a LOCA on G.E. and States type terminal blocks.

2.0 REFERENCES

Letter from Bechtel Power Corporation to Mr. W. E. Olson dated August 31, 1973.

3.0 SUMMARY OF RESULTS

3.1 Results

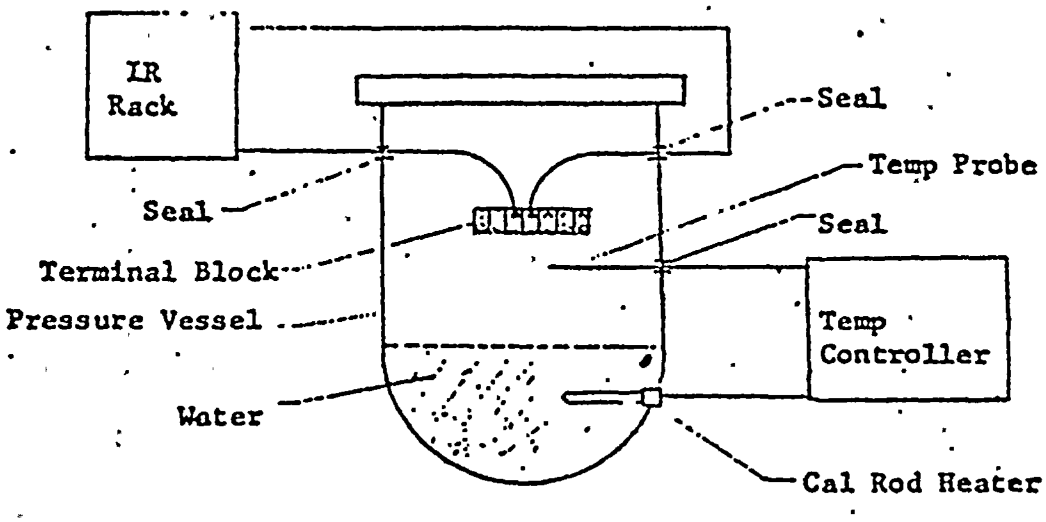
This test demonstrated that during LOCA conditions the insulation resistance on both types of terminal blocks would decrease from greater than 10^{10} ohms to approximately 2×10^{4} ohms. After completion of testing the insulation resistance was 4.0×10^{9} ohms.

3.2 Conclusions

The results of this test showed that if the terminal blocks were subjected to LOCA conditions their insulation resistance can be expected to drop to approximately 2.0×10^{4} ohms. However the terminal blocks will almost fully recover to their initial values of insulation resistance once the steam environment is removed. Each type of block showed no deterioration after testing except for some slight discoloration of the phenolic material.

4.0 TEST PROCEDURE

4.1 Test Circuit Diagram



BCL2382

4.2 Description of Test

Two adjacent terminals of each terminal block were connected to an IR rack with #16AWG wire passing through two sealed ports in the pressure vessel. (See Test Circuit Diagram).

The insulation resistance was measured between the 2 terminals with 500 vdc power supply at ambient condition. The terminal blocks were then subjected to the LOCA condition as shown in Table 1. The insulation resistance was recorded at least once a day and at each significant temperature condition during the test. After completion of the 10 day test the cover was removed and the vessel was left open for 36 hours before final insulation resistance measurements were recorded. See Test Data Sheet for specific values.

TABLE 1

TEMPERATURE °F	260	320	340	320	260
PRESSURE PSIG	21	75	103	75	21
RELATIVE HUMIDITY %	100	100	100	100	100
DURATION	1.5 days	1.5 hrs	3 hrs	4.5 hrs	8 days

4.3 Test Equipment

Pressure Vessel
IR Rack
Chromel Alumel temperature probe
Temperature Controller
G.E. Terminal Block CR 151 B
States Co. Terminal Block-type N.T.

→ NtK 10/7/75 contry to complete

BC 2333

TERMINAL BLOCK

TEST DATA SHEET

DATE	TIME	TEMP °F	PRESSURE PSIG	INSULATION RESISTANCE OHMS G.E.	INSULATION RESISTANCE OHMS STATES
10-10	Pretest	70°	0	$>10^{10}$	$>10^{10}$
10-10	@20:15 hr	260°	21	Start Test	
10-11	@08:10 hr	260°	21	$2.2x10^4$	$2.4x10^4$
10-12	@09:30 hr	320°	75	$2.2x10^4$	$2.4x10^4$
10-12	@11.04 hr	340°	103	$2.2x10^4$	$2.6x10^4$
10-12	@14:04 hr	340°	102	$1.9x10^4$	$2.4x10^4$
10-12	@15.10 hr	320°	75	$1.9x10^4$	$2.4x10^4$
10-12	@18:30 hr	320°	75	$1.9x10^4$	$2.4x10^4$
10-13	@07:00 hr	260°	22	$2.2x10^4$	$2.4x10^4$
10-14	@08:00 hr	260°	21	$2.2x10^4$	$2.4x10^4$
10-15	@08:00 hr	260°	22	$2.2x10^4$	$2.4x10^4$
10-16	@08:00 hr	260°	22	$2.4x10^4$	$2.5x10^4$
10-17	@08:00 hr	260°	22	$2.2x10^4$	$2.4x10^4$
10-18	@08:00 hr	260°	21	$2.4x10^4$	$2.5x10^4$
10-19	@08:00 hr	260°	22	$2.4x10^4$	$2.5x10^4$
10-20	@20:15 hr	260°	22	End Test	
10-22	Post Test	70°F	0	$3.5x10^9$	$4.4x10^9$

BURNDY

December 5, 1979

To: Daniel International

Attn: Leon Galemore

Re: Wolf Creek Nuclear Facility

Burndy YA and YS tin plated copper compression connectors, when properly installed, will be certified for a qualified life of 40 years.

This is based on our excellent proven field experience of 45 years on sizes 4/0 to 1000 kcmil and 35 years on sizes smaller than 4/0 and on the following applicable references.

1. Thermal aging, Vibration-Seismic, Radiation Aging and a LOCA test, Report No. TD79-601A.
2. Underwriters Laboratories Test Report 3/31/41 per file E9498 (updated 9/7/77).
3. Secureness, Heating and Pullout tests per UL486, TD77-571A.
4. 1000 hour Salt Spray and Room Aging test, TD69-511A.
5. Heat Cycle test per ANSI C119.4 (formerly EEI-NEMA TDJ162) TD75-530A. This test was primarily for an aluminum stacking adapter requiring 500 heat cycles at a conductor temperature rise of 100°C. The YA terminals were part of this test set-up and remained stable throughout the test. This is far beyond any existing standard for copper connectors.

The temperatures and pressures imposed on the Burndy samples during the 110 day LOCA test were significantly higher than those shown in paragraph 5.4.2.4 of the Bechtel Specification #E01013. The Burndy test is therefore considered equivalent to the 1 year profile specified.

The above data documents the Qualified Life of these connectors for 40 years in a nuclear facility.

These connectors will be certified that they were produced in a facility that complies with 10CFR50 and 10CFR21.

M. R. Monashkin
Assistant Director of Engineering

BURNDY
Norwalk, Connecticut 06852

LABORATORY TEST RECORD No. TD 79-601A

YA, YA-DTW AND QA-B TYPE UNINSULATED TERMINALS

THERMAL CURRENT AGEING, VIBRATION-SEISMIC, RADIATION AGEING AND LOCA

Test requested by: R. Lai, on: 8 / 2 /19 78, authorized by: E. S. Raila
Test completed by: Burndy & Wyle, on: 10 / 1 /19 79, recorded by: R. C. Hack RCH
Copy of this record to: R. Lai, E.S.Raila, M.R.Monashkin, on 11 / 19 /19 79
File: Test Data Sheets, YlaN, KlaN 12a, 15 Approved by: E.S.Raila ESR/RCH 11/20/79
Reference:

REQUESTING DEPARTMENT: Power Product Development

TEST REQUESTED: Thermal current ageing, vibration seismic ageing, radiation ageing and a LOCA simulation.

PURPOSE OF TEST: To qualify Burndy YA, YA-DTW and QA-B type terminals to IEEE Standards 323-1974 and 383-1974 for Class 1E equipment for nuclear power generating stations.

CONCLUSIONS: The results of the tests showed the ability of the YA, YA-DTW and QA-B type terminals to meet the requirements of IEEE Standards 323-1974 and 383-1974.

MATERIALS SUBMITTED:

Uninsulated YA26 compression terminals, drawing no. SD79849
Uninsulated YA26DTW compression terminals, drawing no. SD79849
Uninsulated QA26-B clamp type terminals, drawing no. SA8947

Conductor: 2/0 stranded copper conductor with XHHW insulation rated at 600V.

Tooling: Y35 tool, drawing no. SD32005

Dies: U26RT dies, index no. 13, drawing no. SD14385

TEST PROCEDURES:

YA26 terminals were installed on both ends of two lengths of 2/0 stranded copper building wire with XHHW insulation, 2 ft. long, after removing the appropriate amount of insulation from the conductor ends. Two crimps were made on each terminal with a Y35 tool and die index no. 13 dies.

YA26DTW terminals were similarly installed on two more 2 ft. lengths of the same conductor. Again two crimps were made on each terminal with the same tooling.

QA26-B terminals were installed on both ends of two lengths of the same conductor, 2 ft. long, after removing the appropriate amount of insulation from the conductor ends. Using a torque wrench the nut on each terminal was tightened to the recommended torque of 150 in.-lb.

End.

LABORATORY TEST RECORD No. TD 79-601A

Ageing and Testing Procedures

All test assemblies were subjected to the following sequence of tests:

1. Continuity and Voltage Drop: The continuity of each wire-connector assembly was verified, using a V.O.M., and then the voltage drop was measured from terminal to terminal using a 10 amp measuring current and the 4-wire method of measurement.

2. Thermal Current Ageing: The six conductor-terminal assemblies were assembled into a series loop by bolting together the appropriate terminals with steel hardware. Included in the loop was a 3 ft. length of the same conductor from which the loop was assembled, with terminals on each end. This length of conductor served as a control conductor and, after attaching thermocouples to the wire strands at the center of the control, the loop was energized with a current sufficient to obtain a 100°C temperature rise above room ambient on the control conductor. Current was then cycled through the loop as follows:
   5 cycles, current on 4 1/2 hr., current off 1/2 hr.
   10 cycles, current on 2 hr., current off 1/2 hr.
   25 cycles, current on 1/2 hr., current off 1/2 hr.

3. Voltage Drop: The voltage drop measurements described in 1 were repeated.

4. Vibration-Seismic: The terminal on one end of each of the six assemblies was bolted to the table of an electro-magnetic exciter and the terminal on the opposite end of each was attached to a rigid support. Care was taken in mounting the assemblies so that no slack or tension existed in the conductor.

   After mounting, all assemblies were vibrated at a double amplitude of 0.050 in. through the frequency range 5 Hz to 60 Hz and back to 5 Hz within a minute. The vibration test was run for one hour on each of two axes mutually perpendicular to the axis of the wire.

5. Voltage Drop: The voltage drop measurements described in 1 were repeated.

6. Radiation Exposure: The test assemblies were placed in a hot cell and exposed to a cobalt-60 source so that a total dose of gamma radiation of 224.9M rads was reached at an average dose rate of 0.65M rads per hour.

7. Voltage Drop: The voltage drop measurements were repeated.

8. LOCA Simulation: The terminals on the six assemblies were attached to the upper ends of threaded steel rods, about 3 in. long. The rods were mounted vertically on a fiber-glass reinforced panel. Series loops were assembled by attaching the appropriate terminals to the threaded rods and securing them with nuts and washers above and below the terminals. The panel was placed in the test chamber

(autoclave) and positioned so that the samples would not be exposed to direct impingement of the chemical spray during the test.

Electrical leads required to energize the test assemblies were connected to the appropriate test terminals and the opposite ends were routed through the chamber penetrations. These penetrations consisted of piping filled with a two-part electrically insulating potting compound which provided a pressure barrier seal. All samples were subjected to an electrical continuity test and then connected to the various power supplies used to energize them during the LOCA test.

All assemblies were energized with a current of 171 amps and this current was maintained throughout the test.

The LOCA test was run for 110 days according to the profile shown in Figure 1 with the following exceptions:

During the first temperature/pressure/time transient, the test was aborted at a temperature of 275°F and a pressure of 40 psig because of excessive steam leaks at the cable/chamber penetrations.

The leaks were repaired and the test was restarted.

Again during the first temperature/pressure/time transient, this time at a temperature of 305°F and a pressure of 64 psig excessive steam leakage occurred at one of the cable/chamber penetrations and the test was again aborted.

The penetrations were repaired and additional supports were installed to ensure their pressure integrity. After completion of this modification, the chamber was pressurized with air to the maximum operating pressure and each penetration was checked for air leaks. None were observed and the test was restarted.

The first temperature/pressure/time transient was initiated. The chamber temperature and pressure conditions of 300°F and 54 psig were obtained within 10 seconds. The required chamber pressure of 66 psig was obtained in 5 minutes. The recorded time from 300°F to 385°F was 1 hour and 4 minutes. The recorded chamber temperature during this phase of the test was approximately 25°F lower than the actual internal chamber steam temperature. The chamber temperature was maintained between 300°F and 341°F for approximately 20 minutes while calibration of the recorder could be checked. When the temperature of 385°F was reached, that temperature and a pressure of 66 psig were maintained for 11 minutes.

The chamber temperature was then reduced to 340°F and the pressure reduced to 45 psig and these conditions were maintained for 3.81 hours. After completion of 4 hours at these temperature/pressure conditions, the first temperature/pressure/time transient was completed and the test chamber was allowed to return to 135°F and 0 psig.

The second ramp of the LOCA test was initiated. The chamber temperature and pressure conditions of 300°F, 54 psig, were obtained in 10 seconds. The required chamber pressure of 66 psig was obtained in 3 minutes. The recorded time from 300°F to 385°F was 37 minutes 50 seconds.

The remainder of the test followed the profile shown in Figure 1. The chemical spray was turned off after 33 days. The test was terminated after 110 days.

Note: The chemical spray used for this test consisted of 6,200 ppm boron, 50 ppm hydrazine, 0.064 molar sodium thiosulphate mixed with demineralized water and buffered to 10.5 pH with sodium phosphate.

9. Post LOCA tests: All samples were examined visually for damage and/or degredation. They were then subjected to a continuity test and voltage drop measurements.

RESULTS:

Visual Examination

Much of the tin plating had disappeared from the exposed surfaces of the YA26 and YA26DTW terminals. In the areas where there were no plating the copper had discolored to an almost black color.

The QA26-B terminals were uniformly dark, almost black in color except for the surfaces which had been in contact with other terminals or the securing hardware.

The exposed strands of the copper conductor were similarly dark in color. There was no evidence of damage or degradation to the conductor insulation.

Continuity

All sample assemblies demonstrated electrical continuity when checked with a V.O.M.

Voltage Drop

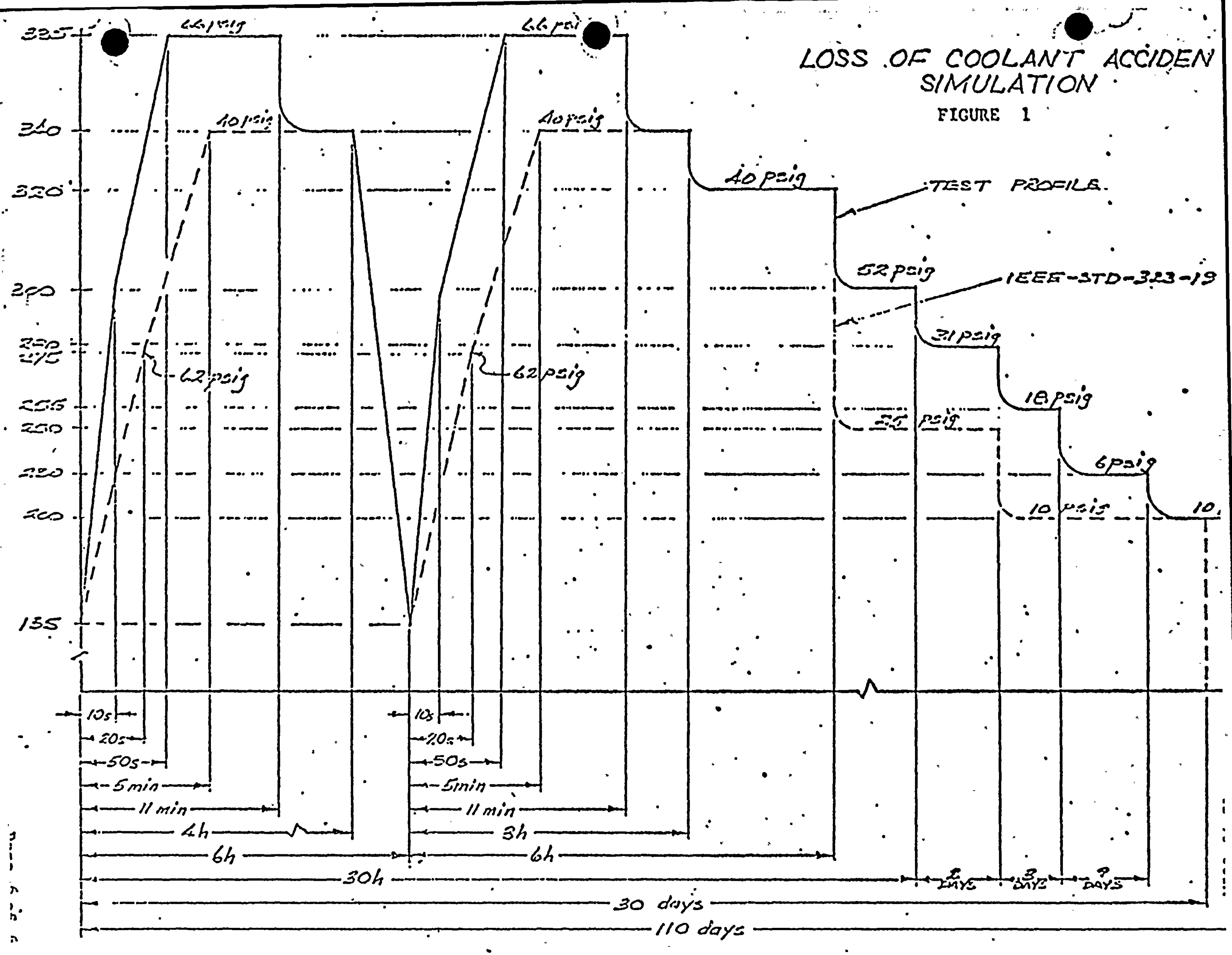
The results of the voltage drop measurements are shown in Appendix 1. The resistance values for each measurement were expressed as % relative resistance by dividing each measured value, corrected to 20°C, by the nominal value for each assembly. The nominal values were calculated by multiplying the length of each assembly in inches by the nominal resistance per inch of the wire at 20°C.

BURNDY
NORWALK, CONNECTICUT 06852

LABORATORY TEST RECORD No. TD 79-601A

The relative resistances of the YA26 and YA26DTW terminals remained constant throughout the test. The resistances of the QA26B terminal assemblies did exhibit some increases after the radiation ageing but returned to their original level by the end of the LOCA test.

SUMMARY: These results demonstrate the ability of all the samples tested to perform their intended function both during and after a LOCA accident.



LOSS OF COOLANT ACCIDEN SIMULATION

FIGURE 1

ADDENDUM TO

LABORATORY TEST RECORD No. TD 79-601A

EQUIPMENT LIST

Some, or all of the equipment listed below was used to perform the tests described in this report.

BURNDY EQUIPMENT NO.	DESCRIPTION	MANUFACTURER	MODEL NO.	CALIBRATION FREQUENCY MONTHS
4	Thermometer, 0-120°F	Taylor	Hi-Lite	24
17	Dielectric Strength Test Set, 0-7500VAC	Industrial Instruments	P3A	12
135	Current Shunt, 500A, 50 mV	Weston	9992	24
139	Current Shunt, 200A, 50mV	Weston	9992	24
141	Current Shunt, 100A, 50mV	Weston	9992	24
142	Current Shunt, 50A, 50mV	Weston	9992	24
144	Current Shunt, 20A, 50mV	Weston	9992	24
150	Current Shunt 1A, 50mV	Weston	9992	24
273	Vibration Exciter and Amplifier 1200 force pounds	M B Electronics	C10E 3402	N/A N/A
274	Altitude - Temperature Chamber, 150,000 ft, -125°F to +325°F	Conrad	FH-27-5-5	12
278	Tensile and Compression Tester Calibration Weights	Instron -11-	TT-CMM1.6 10 lb	12 36
360	DC Regulated Power Supply 0-50V, 0-1.5A	NJE	RB-50-1.5	See Note (1)

Form B 207-38 4-67

LABORATORY TEST RECORD No. TD 79-601A

Equipment List continued

BURNDY EQUIPMENT NO.	DESCRIPTION	MANUFACTURER	MODEL NO.	CALIBRATION FREQUENCY MONTHS
392	Digital Voltmeter	Hewlett-Packard	3440A/ 3443A	12
398	D.C. Regulated Power Supply, 0-50A, 0-20V	Harrison Labs.	6428A	See Note (1)
438	Vibration Exciter and Amplifier, 3200 force pounds	M B Electronics	C 60 T 351	N/A
442	Air Circulating Oven 60-300°C	Blue M	POM-146BX	12
483	Current Cycling Console	Burndy	-	N/A
500	Volt OHM Meter	Simpson	260	See Note (2)
645	Oscillator-Servo Programmer	Unholtz-Dickie	OSC-1/ SP-7	12
646	Accelerometer	Unholtz-Dickie	5D21-8	24
680	Digital Voltmeter Calibration Reference Module 1 Ser.No.1177A00121 Calibration Reference Module 2 Ser.No.1177A1954	Hewlett-Packard Hewlett-Packard Hewlett-Packard	3455A 11177A 11177A	N/A 24 24
08247	Salt Spray Chamber	Develco	2297	As Used
08258	Current Cycling Console	Burndy	-	N/A
08264	Temperature Indicator	Leeds and Northrup	Speedomax	As Used

NOTE: (1) Output checked with calibrated voltmeter and shunt before each test.
(2) This instrument is used for non-critical measurements only.

Form B 207-3S 4-67

LABORATORY TEST RECORD No. TD 79-601A

Appendix To TD 79-601A

Pages 1.1 and 1.2

TD NO 79-601 A

RESISTANCE DATA SHEET

SAMP. NO.	CONNECTOR	CONDUCTOR	REMARKS	M.D. INCH	NOMINAL μΩ–20°C	
1	YA26	2/0 STRANDED	Y35 Tooc, DIE INDEX	28.1	186.13	NOMINAL RESIS. FOR 2/0 COPPER
2	YA26	COPPER BUILDING	13 DIES	28.1	186.13	
		WIRE WITH XHHW	↓			
3	YA26DTW	INSULATION	↓	22.8	148.1	AT 20°C = 6.494μ
4	YA26DTW	↓	↓	24.0	155.9	
		↓				
5	QA26B	↓	NUTS TIGHTENED TO	26.3	170.8	
6	QA26B	↓	150 in.-lb.	27.15	176.3	

INSTALLATION COMPLETED (DATE & TIME)—

CURRENT TURNED ON (DATE & TIME)—

BURND

D NO. 79-601 A

RESISTANCE DATA SHEET

.P.).	NOM.	OBS. RES. μΩ 26°C	R.R. %	OBS. RES. μΩ 27.5°C	R.R. %	OBS. RES. μΩ 26°C	R.R. %	OBS. RES. μΩ 22°C	R.R. %	OBS. RES. μΩ 22°C	R.R. %	OBS. RES. μΩ °C	R.R. %
	186.1	184.7	98	188.4	98	185.4	97	186.0	99	186.8	100		
	186.1	184.8	98	188.3	98	185.2	97	184.0	98	183.7	98		
	148.1	147.9	98	151.3	99	148.5	98	152.0	102	150.6	101		
	155.9	155.8	98	159.4	99	156.3	98	160.0	102	154.4	98		
	170.8	213.0	122	209.4	119	210.0	120	220.0	128	202.3	118		
	176.3	211.8	117	212.0	117	211.9	117	230.0	130	209.4	118		
TE-TIME	8/17/78		10/27/78		11/16/78		2/7/79		9/20/79				
OBSERVER	RCH		RCH		RCH		WYLE		WYLE				

RESULTS

The joint between the connector and the tested wire was intact at the end of two hours of operation.

HEATING TESTS

METHOD

Samples having completed the secureness test were used for this test. Terminal lugs were connected in pairs back to back and current was passed through to the connectors. Temperatures were observed by means of thermocouples attached to the connectors and readings were taken with a suitable indicator until the temperatures became constant.

RESULTS

The table below gives the measured temperature rise in degrees C. In each case, the maximum temperature rise observed on a pair of lugs was recorded.

Cat.No.	Wire Size	Current in Amperes	Observed Temperature Rise	Permissible Temperature Rise
YA6C	6	50	11	20
YA1C	1	100	11	20
YA28	4-0	225	15	25
YA34	500	400	16	25
YA44	1000	650	18	25

PULLOUT TESTS

METHOD

After completing the secureness and heating tests, each terminal lug was subjected to a direct pull between the connector and the conductor. Also following the secureness test, the Type YT connectors were tested with the main cable supported at two points, one on each side of the tap, and tension was exerted along the tested wire. The Type YP connectors were tested with line of force approximately in line with both cables. The value of the tension used for each connector depends on the wire size as indicated in the following table:

Wire Size AWG or MCM	Tension in Pounds
6	100
2	180
1	200
1-0	250
4-0	450
250	500
500	1000
1000	1000

RESULTS

Each sample withstood the indicated tension for one minute without separation of cable and connectors. At the end of the test, each sample was examined and no conductor strands were broken at the edge or outside the connector. Internal examination of Cat. Nos. YA3C, YA34, YA44 showed that no conductor strands were broken inside the connectors.

C O N C L U S I O N

The devices covered by this report have been found to comply with the present requirements covering the class, and are judged to be acceptable for listing under the Reexamination Service of Underwriters' Laboratories, Inc.

TESTS & REPORT BY:

W.B. Westphal

W. B. WESTPHAL,
Asst. Electrical Engineer

REVIEWED BY:

F. Neumer

F. NEUMER,
Asst. Electrical Engineer

E.

TEST RECORD NO. 2

SAMPLES:

Commercial samples of Cat. No. Types YA-L, YS-L were submitted by the manufacturer and formed the basis of this report. Tests were conducted on YA-L only; YA-L connector has same barrel end as YS-L, YA, YS except smaller.

SECURENESS, HEATING AND PULLOUT TEST:

METHOD

Samples of the subject devices were assembled as intended and subjected to the secureness, heating and pullout tests as outlined in the Underwriters Standard for Wire Connectors and Soldering Lugs.

RESULTS

The acceptable results of the above test are indicated in the following tabulation.

Cat. No.	Tool	SECURENESS TEST Wire Size	Weight Pounds	Results	HEATING TEST Current Amperes	Rise Deg. C	PULLOUT TEST Force Pounds	Results
YA6C-L	Hand	No. 6 Str. Cu	18	OK	—	—	100	OK
YA6C-L	tool	No. 6 Str. Cu	18	OK	—	—	100	OK
YA2C-L	Hand	No. 2 Str. Cu	30	OK	—	—	180	OK
YA2C-L	tool	No. 2 Str. Cu	30	OK	—	—	180	OK
YA26-L	Hand	No. 2/0 Str. Cu	50	OK	—	—	300	OK
	tool	No. 2/0 Str. Cu	50	OK	—	—	300	OK
YA29-L	Hand	No. 250 MCM Str. C	60	OK	250	15	500	OK
	tool	No. 250 MCM Str. C	60	OK	250	15	500	OK
YA48-L	L48RT press	No. 2000 MCM Str. Cu	240	OK	1050	19	1000	OK
	1/6 OD die index 34	No. 2000 MCM Str. Cu	240	OK	1050	19	1000	OK
YA48-L	C48D (Nest)	No. 2000 MCM Str. Cu	240	OK	1050	19	1000	OK
	1/48 PR Indent die index 34	No. 2000 MCM Str. Cu	240	OK	1050	19	1000	OK

T.D'A.

QUALITY ASSURANCE RECORD

NUS CORPORATION
CONSULTING DIVISION

RECORD OF SYSTEM/COMPONENT ANALYSES

FILE NO.: 1961-G049-001	NO. OF PAGES: 6	NUMBER OF VOLUMES OF COMPUTER OUTPUT: None
CLIENT: Niagara Mohawk Power Corporation		PROJECT NO.: 1961

ANALYSIS TITLE: Assessment of O.Z. Gedney Electrical Connectors serving a Safety Related Function at NMP-1

AUTHOR: D. N. Perkey

PURPOSE OF ANALYSIS: To determine if the design of the O.Z. Gedney Electrical connectors is adequate to assure that they will operate on demand to meet the system performance requirements under normal and harsh Environmental conditions

SUMMARY OF ANALYSIS PROCEDURE AND RESULTS:

Based on the all Metallic design of the O.Z. Gedney Electrical connectors it is believed that they will meet performance requirements for the 40 year plant life.

DATE COMPLETED: 12/4/81	VERIFICATION REQUIRED: ☒ YES ☐ NO

ANALYSIS REVIEWED AND ACCEPTED: (DISCIPLINE MANAGER) [signature]	DATE: 12-6-81

ANALYSIS:	BY: (FILE NO.)	DISCIPLINE MANAGER:	DATE:
☐ SUPERSEDED ☐ SUPPLEMENTED			

NUS 202 10 REVISED 0181
(Formerly CD-28 12/77)

NUS CORPORATION CONSULTING DIVISION	RECORD OF ANALYSIS VERIFICATION

FILE NO.: 1961-6049-001

PAGE 1 OF 2

ANALYSIS TITLE:

Assessment of O.Z. Gedney Electrical Connectors serving a Safety Related Function at NMP-1

AUTHOR:	NO. OF PAGES:	NO. OF VOLUMES OF COMPUTER OUTPUT:
D.N Perkey	6	NA

VERIFICATION SCOPE (CHECK AS APPLICABLE):

- [x] METHOD OF ANALYSIS
- [x] ASSUMPTIONS
- [x] INPUT INFORMATION
- [ ] COMPUTER CODE APPLICATION
- [ ] CHECK OF SAMPLE CALCULATION
- [ ] SPOT CHECK OF MATHEMATICS
- [x] REASONABLENESS OF RESULTS
- [ ] COMPLETE CHECK OF MATHEMATICS
- [ ] PARTIAL INDEPENDENT ANALYSIS

BUDGET: (APPROXIMATE) 1/4 MANDAYS

DESIRED COMPLETION DATE: 12/4/81

DESCRIPTION OF VERIFICATION—ACTIVITIES, FINDINGS AND RESOLUTION:

OK

NUS 203A 10 REVISED 0181
(Formerly CD-29(1) 12/77)

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

VERIFIER'S SIGNATURE:	DATE: Dec 4, 1981
ACCEPTANCE BY: (DISCIPLINE MANAGER)	DATE: 12-6-81

NUS CORPORATION
CONSULTING DIVISION

ANALYSIS VERIFICATION CHECKLIST

ANALYSIS TITLE: Assessment of O.Z. Gedney Electrical Connectors serving a Safety Related Function at NMP-1	ANALYSIS FILE NUMBER: 1961-6049-001		
INDICATE "YES, NO, OR N/A (NOT APPLICABLE)," FOR EACH ITEM AND INCLUDE IN ANALYSIS PACKAGE WITH RECORD OF ANALYSIS VERIFICATION	YES	NO	N/A
METHOD OF ANALYSIS			
IS THE METHOD USED APPROPRIATE CONSIDERING THE PURPOSE AND TYPE OF ANALYSIS AND THE USE AND ACCEPTABILITY OF THE RESULTS (i.e., MARGIN TO LIMITS)?	✓	☐	☐
IS THE METHOD IN ACCORDANCE WITH CODES, STANDARDS, AND REGULATORY REQUIREMENTS?	✓	☐	☐
HAS THE METHOD BEEN EMPLOYED ELSEWHERE IN INDUSTRY OR IN LICENSE APPLICATIONS?	✓	☐	☐
ASSUMPTIONS			
ARE ASSUMPTIONS NECESSARY TO PERFORM THE ANALYSIS ADEQUATELY DESCRIBED AND REASONABLE?	✓	☐	☐
WHERE NECESSARY, ARE THE ASSUMPTIONS IDENTIFIED FOR SUBSEQUENT RE-VERIFICATIONS WHEN THE DETAILED DESIGN ACTIVITIES ARE COMPLETED?	✓	☐	☐
INPUT INFORMATION			
ARE THE INPUTS INTO THE ANALYSIS STATED AND THEIR SOURCE IDENTIFIED?	✓	☐	☐
IS THE INPUT INFORMATION FROM THE LATEST AVAILABLE REVISION TO THE DOCUMENT?	✓	☐	☐
IS THE STATUS (PRELIMINARY, CONCEPTUAL, ETC.) OF THE INPUT SOURCE IDENTIFIED FOR LATER CONFIRMATION OF THE VALIDITY OF THE INPUT?	✓	☐	☐
ARE THE INPUTS SUFFICIENT CONSIDERING THE PURPOSE OF THE ANALYSIS?	✓	☐	☐
COMPUTER CODE APPLICATION			
ARE ALL CODES USED IDENTIFIED ALONG WITH SOURCE, COMPUTER TYPE, INPUTS, AND OUTPUTS?	☐	☐	✓
HAS THE CODE BEING USED BEEN ADEQUATELY VERIFIED?	☐	☐	✓
IS THE CODE SUITABLE FOR THE PRESENT ANALYSIS?	☐	☐	✓
DOES THE COMPUTER MODEL (NODING, TIME STEPS, ETC.) ADEQUATELY REPRESENT THE PHYSICAL SYSTEMS?	☐	☐	✓
REASONABLENESS OF RESULTS			
IS THE MAGNITUDE OF THE RESULT REASONABLE?	✓	☐	☐
ARE THE DIRECTION OF TRENDS REASONABLE?	✓	☐	☐
PREPARED BY: [signature]	DATE: Jun 4, 1987		

NUS 204 10 REVISED 0181
(Formerly CD-30 Rev. 1)

FINAL ANALYSIS REVIEW CHECKLIST

Project #/Project Title   Client

Date: Jan 4, 1997

Analysis File Title: Assessment of O.Z. Gedney Electrical Connectors Serving a Safety Related Function at NMP-1

Analysis File Number: 1961-G049-001

Checklist Item	Yes	N/A
1. Unique Analysis File Number assigned to the file.	✓	
2. Analysis recorded on CD-60	✓	
a. pages numbered	✓	
b. total pages specified	✓	
c. all pages dated	✓	
d. client identified on each page	✓	
e. correct file number on each page	✓	
f. author(s) specified on each page	✓	
g. subject specified on each page	✓	
h. verifier initials on each page	✓	
3. Analysis File includes:		
a. client identification	✓	
b. analysis file number	✓	
c. analysis title	✓	
d. author(s) identification	✓	
e. description of the purpose of the analysis	✓	
f. discussion of the general method of analysis	✓	
g. identification of input information source	✓	
h. identification of input information status	✓	
i. major assumptions used in performing the analysis	✓	

Date: ____________________

3.	(Continued)		
	j. important references, including material properties	✓	
	k. identification of specific versions of codes used		✓
	l. detailed calculation		✓
	m. listing of computer input		✓
	n. microfiche of computer output		✓
	o. summary of results		✓
4.	Record of analysis provided onn CD-28	✓	
5.	All applicable entries on CD-28 correct.	✓	
6.	All referenced NUS internal memos included in analysis file.	✓	
7.	All referenced telecons included in analysis file.	✓	
8.	Separate computer output labeled with analysis file number.		✓
9.	Record of analysis file verification on CD-29.	✓	
10.	All entries on CD-29 completed and correct.	✓	
11.	Item (7) of CD-29 completed and comments numbered	✓	
12.	Verification checklist CD-30 included.	✓	
13.	Computer code used verified per QAI 3.5.		✓
14.	Corrected items crossed out clearly enough to show on Xerox copies.	✓	
15.	List of input information and major assumptions checked for commpleteness.	✓	
16.	Documents Complete (Page Count)	✓	
17.	Documents Legible and Reproducible	✓	
18.	All Documents Identified on Index Received	✓	
19.	Documents Properly Paginated	✓	
20.	Documents Identified to Project/Item	✓	
21.	All Unsatisfactory Conditions Resolved (List)	✓	

Date Dec 4, 1958

22. Remarks:

Reviewed by: [signature] Dec 4, 1958
Date

cw

NUS CORPORATION

Page NA of

DATE 12/4/81

CLIENT NMPC FILE NO. 1961-G049-001 BY D. M. [illegible]

SUBJECT Assessment of O.Z. Gedney Electrical Connectors Serving a Safety Related Function at NMP-1 Checked By [illegible]

ASSESSMENT

OF

O.Z. GEDNEY ELECTRICAL CONNECTORS

SERVING A SAFETY RELATED FUNCTION

AT

NMP-1

Prepared for

NIAGARA MOHAWK POWER CORPORATION

PROJECT 1961

NUS CORPORATION

DATE 12/4/81

CLIENT NMPC FILE NO. 1961-G047-001 BY D. M. [illegible]

SUBJECT Assessment of O.Z. Gedney Electrical Connectors Serving a Safety Related Function At NMP-1 Checked By [illegible]

Table of Contents

CLIENT NMPC FILE NO. 1961-G049-001 BY D. N. Perkey

SUBJECT Assessment of O. Z. Gedney Electric Connectors Serving a Safety Related Function At NMP-1 Checked By [signature]

1.0 Client Identification

Niagara Mohawk Power Corporation

2.0 Analysis File Number

1961-G049-001

3.0 Analysis Title

Assessment of O. Z. Gedney Electrical Connectors Serving a safety Related Function at NMP-1

4.0 Author Identification

D. N. Perkey

5.0 Purpose of Analysis

The purpose of this analysis is to determine if the designs of the O. Z. Gedney type XL and type XW electrical connectors are adequate to assure that they will operate on demand to meet the system performance requirements under normal and harsh environmental conditions and during design basis events at NMP-1

CLIENT NMPC FILE NO. 1961-G049-001 BY D. M. [illegible]

SUBJECT Assessment of O.Z. Gedney Electrical Connectors Serving a Safety Related Function at NMP-1 Checked By [illegible]

6.0 Input Information

6.1 Equipment Identification

O.Z. Gedney type XL and type XW electrical connectors are used in the Common Electrical Equipment System (CEE) in areas outside of containment. (Ref. 12.1). Plant identification numbers have not been assigned to these connectors.

6.2. Materials

The O.Z. Gedney type XL connectors consist of bronze castings with bronze plates and screws. The type XW connectors consist of copper castings with copper plates and screws (Ref 12.2)

6.3. Safety-Related Function

The O.Z. Gedney connectors are used in conjunction with various safety-related systems throughout the plant

6.4 Service Conditions

The maximum ambient environment to which O.Z. Gedney connectors may be subject is 144°F (Ref. 12.3), 0 PSIG, 50% to 90% relative humidity and 1×10^4 rad of gamma radiation (assumed).

CLIENT NMPC FILE NO. 1961-G049-001 BY A. M. Paley

SUBJECT Assessment of O.Z. Gedney Electrical Connectors Serving a Safety Related Function at NMP-2 Checked By [signature]

6.4 Service Conditions Cont.

The maximum harsh environment conditions (design basis event) are: 308 °F, 77.3 PSIG, 100% relative humidity (Ref. 12.4 and 12.5) and 1.6×10^6 rads of gamma radiation (Ref 12.6)

7.0 Method of Analysis

O.Z. Gedney was contacted and a list of the materials used in both the type XL and the type XW connectors was obtained. After reviewing the materials list it was decided that a further literature search to determine radiation thresholds, time/temperature aging data, harsh environment effects and cycling data was not necessary to perform a qualification analysis on these connectors.

8.0 Major Assumptions

8.1 It is assumed that for the purpose of this analysis the deterioration of Metallic components due to time/temperature effects, the specified harsh environment and radiation exposure is insignificant.

9.0 Detailed Calculations

Calculations were not performed.

10.0 Results

Based on the all metallic structure of the O. Z. Gedney electrical connectors degradation due to radiation exposure, time/temperature effects and harsh environment conditions (design basis event) are expected to be minimal during the 40 year life of the plant.

11.0 Summary

Due to the brevity of this analysis a summary is not included

12.0 References

12.1 NMPC - NMP-1 On-going Qualification assessment Summary, Revision 4 Dated November 5, 1981

12.2 NUS Telecon, Jerry Martin, O.Z. Gedney and E. Miller, NUS, Dated February 3, 1981

12.3 NMPC Supplied Normal Service Conditions. Transmittal Memo from D. Green (NMPC) to D. Bhatia (NUS) Dated March 11, 1981

CLIENT NMPC FILE NO. 1961-G049-001 BY D. M. [illegible]

SUBJECT Assessment of O.Z. Gedney Electrical Connectors, Serving a Safety Related Function at NMP-1 Checked By [illegible]

12.0 References (Cont.)

12.4 NUS Analysis 1961-SA-A1 - NMPC, NMP-1 "Pressure and Temperature Model for Reactor Building" Dated December 9, 1980

12.5 NUS Analysis 1961-SA-A2 - NMPC, NMP-1, "Steam Tunnel/Turbine Building High Energy Line Break Analysis" Dated November 25, 1980

12.6 NUS Analysis 1961-R-1 - "Radiation Environment Specifications for NMP-1", Dated October 25, 1981

QU... RECORD

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

FILE NO.: 1961-A382-001 | PAGE 1 OF

ANALYSIS TITLE: Assessment of AMP Terminal Connectors, Serving a Safety Related Function, at NMP-1

AUTHOR:	NO. OF PAGES:	NO. OF VOLUMES OF COMPUTER OUTPUT:
D. M. Ribey	6	N/A

VERIFICATION SCOPE (CHECK AS APPLICABLE):

- [x] METHOD OF ANALYSIS
- [x] ASSUMPTIONS
- [x] INPUT INFORMATION
- [ ] COMPUTER CODE APPLICATION
- [ ] CHECK OF SAMPLE CALCULATION
- [ ] SPOT CHECK OF MATHEMATICS
- [x] REASONABLENESS OF RESULTS
- [ ] COMPLETE CHECK OF MATHEMATICS
- [ ] PARTIAL INDEPENDENT ANALYSIS

BUDGET: (APPROXIMATE) 4 MANDAYS

DESIRED COMPLETION DATE: 12/4/81

DESCRIPTION OF VERIFICATION—ACTIVITIES, FINDINGS AND RESOLUTION:

1. add -001 to file number for standardization

Resolution: 001 added to file number

NUS 203A 10 REVISED 0181
(Formerly CD-25(1) 12/77)

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

OK

VERIFIER'S SIGNATURE: [signature] | DATE: Dec 4, 1981

ACCEPTANCE BY: (DISCIPLINE MANAGER) [signature] | DATE: 12/6/81

NUS CORPORATION
CONSULTING DIVISION

ANALYSIS VERIFICATION CHECKLIST

ANALYSIS TITLE: Assessment of AMP Terminal Connectors Serving a Safety Related Function at [illegible]	ANALYSIS FILE NUMBER: 1961-A382-001		
INDICATE "YES, NO, OR N/A (NOT APPLICABLE)," FOR EACH ITEM AND INCLUDE IN ANALYSIS PACKAGE WITH RECORD OF ANALYSIS VERIFICATION	YES	NO	N/A
METHOD OF ANALYSIS			
IS THE METHOD USED APPROPRIATE CONSIDERING THE PURPOSE AND TYPE OF ANALYSIS AND THE USE AND ACCEPTABILITY OF THE RESULTS (i.e., MARGIN TO LIMITS)?	☑	☐	☐
IS THE METHOD IN ACCORDANCE WITH CODES, STANDARDS, AND REGULATORY REQUIREMENTS?	☑	☐	☐
HAS THE METHOD BEEN EMPLOYED ELSEWHERE IN INDUSTRY OR IN LICENSE APPLICATIONS?	☑	☐	☐
ASSUMPTIONS			
ARE ASSUMPTIONS NECESSARY TO PERFORM THE ANALYSIS ADEQUATELY DESCRIBED AND REASONABLE?	☑	☐	☐
WHERE NECESSARY, ARE THE ASSUMPTIONS IDENTIFIED FOR SUBSEQUENT RE-VERIFICATIONS WHEN THE DETAILED DESIGN ACTIVITIES ARE COMPLETED?	☑	☐	☐
INPUT INFORMATION			
ARE THE INPUTS INTO THE ANALYSIS STATED AND THEIR SOURCE IDENTIFIED?	☑	☐	☐
IS THE INPUT INFORMATION FROM THE LATEST AVAILABLE REVISION TO THE DOCUMENT?	☑	☐	☐
IS THE STATUS (PRELIMINARY, CONCEPTUAL, ETC.) OF THE INPUT SOURCE IDENTIFIED FOR LATER CONFIRMATION OF THE VALIDITY OF THE INPUT?	☑	☐	☐
ARE THE INPUTS SUFFICIENT CONSIDERING THE PURPOSE OF THE ANALYSIS?	☑	☐	☐
COMPUTER CODE APPLICATION			
ARE ALL CODES USED IDENTIFIED ALONG WITH SOURCE, COMPUTER TYPE, INPUTS, AND OUTPUTS?	☐	☐	☑
HAS THE CODE BEING USED BEEN ADEQUATELY VERIFIED?	☐	☐	☑
IS THE CODE SUITABLE FOR THE PRESENT ANALYSIS?	☐	☐	☑
DOES THE COMPUTER MODEL (NODING, TIME STEPS, ETC.) ADEQUATELY REPRESENT THE PHYSICAL SYSTEMS?	☐	☐	☑
REASONABLENESS OF RESULTS			
IS THE MAGNITUDE OF THE RESULT REASONABLE?	☑	☐	☐
ARE THE DIRECTION OF TRENDS REASONABLE?	☑	☐	☐
PREPARED BY: [signature]	DATE: 12/04/87		

NUS 204 10 REVISED 0181
(Formerly CD-30 Rev. 1)

FINAL ANALYSIS REVIEW CHECKLIST

Project #/Project Title   Client

Date: Dec 3 1987

Analysis File Title: Assessment of AMP Terminal Connectors ··· at NMP-1

Analysis File Number: 1961-A382

Checklist Item	Yes	N/A
1. Unique Analysis File Number assigned to the file.	✓	
2. Analysis recorded on CD-60	✓	
a. pages numbered	✓	
b. total pages specified	✓	
c. all pages dated	✓	
d. client identified on each page	✓	
e. correct file number on each page		
f. author(s) specified on each page	✓	
g. subject specified on each page	✓	
h. verifier initials on each page	✓	
3. Analysis File includes:		
a. client identification	✓	
b. analysis file number		
c. analysis title	✓	
d. author(s) identification	✓	
e. description of the purpose of the analysis	✓	
f. discussion of the general method of analysis	✓	
g. identification of input information source	✓	
h. identification of input information status	✓	
i. major assumptions used in performing the analysis	✓	

Date: Dec 3, 1987

3.	(Continued)		
j.	important references, including material properties	✓	
k.	identification of specific versions of codes used		✓
l.	detailed calculation		✓
m.	listing of computer input		✓
n.	microfiche of computer output		✓
o.	summary of results		✓
4.	Record of analysis provided onn CD-28	✓	
5.	All applicable entries on CD-28 correct.	✓	
6.	All referenced NUS internal memos included in analysis file.	✓	
7.	All referenced telecons included in analysis file.	✓	
8.	Separate computer output labeled with analysis file number.		✓
9.	Record of analysis file verification on CD-29.	✓	
10.	All entries on CD-29 completed and correct.	✓	
11.	Item (7) of CD-29 completed and comments numbered	✓	
12.	Verification checklist CD-30 included.	✓	
13.	Computer code used verified per QAI 3.5.		✓
14.	Corrected items crossed out clearly enough to show on Xerox copies.	✓	
15.	List of input information and major assumptions checked for commpleteness.	✓	
16.	Documents Complete (Page Count)	✓	
17.	Documents Legible and Reproducible	✓	
18.	All Documents Identified on Index Received	✓	
19.	Documents Properly Paginated	✓	
20.	Documents Identified to Project/Item	✓	
21.	All Unsatisfactory Conditions Resolved (List)	✓	

Date Dec 3 1987

22. Remarks:

Reviewed by: [signature] Dec 4, 1987

Date

NUS CORPORATION

Page N/A of N/A

DATE 12/3/81

CLIENT NMPC FILE NO. 1961-A382-001 BY D. N. Parkey

SUBJECT Assessment of AMP Terminal Connectors Used At NMP-1 Checked By [illegible]

Assessment of AMP Terminal Connectors Serving a Safety Related Function at NMP-1

Prepared For

Niagara Mohawk Power Corporation

Project 1961

NUS CORPORATION

DATE 12/3/81

CLIENT NMPC FILE NO. 1961-A382-001 BY D. M. [illegible]

SUBJECT Assessment of AMP Terminal Connectors used at NMP-1 Checked By [illegible]

Table of Contents

CLIENT NMPC FILE NO. 1961-A382-001 BY D N. Perkey

SUBJECT Assessment of AMP Terminal Connectors Used at NMP-1 Checked By [signature]

1.0 Client Identification

Niagara Mohawk Power Corporation

2.0 Analysis File Number

1961-A382-001

3.0 Analysis Title

Assessment of AMP Terminal Connectors, Servinging a Safety Related Function, at NMP-1

4.0 Author Identification

D. N. Perkey

5.0 Purpose of Analysis.

The purpose of this analysis is to determine if the design of the AMP Terminal Connectors is adequate to assure that they will operate on demand to meet the system performance requirements under normal and harsh environmental conditions (design basis event) at NMP-1

6.0 Input Information

6.1 Equipment

AMP Ring Tongue Terminal Connectors and Butt Connectors are used in the Common Electrical Equipment system (CEE) (Ref 12.1). Plant Identification numbers have not been assigned to these connectors.

6.2 Materials

The AMP terminal connectors are metallic with a nylon or vinyl insulation covering the terminal barrel (Ref 12.2)

6.3. Safety - Related Function

The AMP Connectors are used in various systems throughout the plant

6.4 Service Conditions

The maximum ambient environment to which AMP Conectors may be subject is: 144°F (Ref 12.3), 0 PSIG, 50 - 90% relative humidity (assumed) and 1×10^4 rad of gamma radiation (assumed). The maximum harsh environment (design basis event) conditions are: 308°F, 35 PSIG, 100% relative humidity (Ref 12.4 and 12.5) and 5×10^7 rad of gamma radiation (Ref 12.6)

CLIENT NMPC FILE NO. 1961 - A382-001 BY D. N. Perkey

SUBJECT Assessment of AMP Terminal Connectors used at NMP-1 Checked By [signature]

7.0 Method of Analysis

AMP was contacted and a list of the materials used in the connectors was obtained. After reviewing the materials list it was decided that a further literature search to determine radiation thresholds, time/temperature aging data, harsh environment effects and cycling was not necessary.

8.0 Major Assumptions

8.1 It is assumed that for the purpose of this analysis, the deterioration of metallic components due to time/temperature effects and radiation exposure is insignificant

8.2 It is assumed that if the insulation on the terminal barrels fails, the connectors will be able to perform their function. This assumption is based on the following:

1. Cables are connected, "Metal to Metal", to the terminal blocks.

2. The terminals on the terminal block are separated by barriers from adjacent terminals. This separation will prevent a metal-to-metal short if the insulation on the connector fails.

CLIENT NMPC FILE NO. 1961-A382-C02 BY D. M[illegible]

SUBJECT Assessment of AMP Terminal Connectors Used at NMP-1 Checked By [illegible]

9.0. Detailed Calculations

Calculations were not performed

10.0 Results

Based on the primarily metallic structure of the AMP connectors degradation due to radiation exposure, time/temperature effects and harsh environment conditions (design basis event) are expected to be minimal during the 40 year life of the plant. Degradation of the insulation on the terminal barrel will not affect the components ability to perform their required functions.

11. Summary

Due to the brevity of this analysis, a summary is not included.

CLIENT NMPC FILE NO. 1961-A382-001 BY [signature]

SUBJECT Assessment of AMP Terminal Connectors used at NMP-1 Checked By [signature]

12.0 References

12.1 NMPC- NMP-1 On-going Qualification assessment Summary, Revision 4, Dated November 5, 1981

12.2 AMP Special Industries, Product Bulletin 101-1, Terminals + Splices

12.3 NMPC Supplied Normal service conditions. Transmittal Memo From Dave Green (NMPC) to Deepak Bhatia (NUS) Dated 3/11/81

12.4 NUS Analysis 1961-SA-A1 NMPC, NMP-1 "Pressure and Temperature Model for Reactor Building" Dated December 9, 1980.

12.5 NUS Analysis 1961-SA-A2- NMPC, NMP-1 "Steam Tunnel/Turbine Building High Energy Line Break Analysis" Dated November 25, 1980.

12.6 NUS Analysis 1961-R-1 - "Radiation Environment Specifications for NMP-1", Dated October 25, 1981.

NUS CORPORATION
CONSULTING DIVISION

RECORD OF SYSTEM/COMPONENT ANALYSES

FILE NO.:	NO. OF PAGES:	NUMBER OF VOLUMES OF COMPUTER OUTPUT:
1961-A382-001	6	N/A

CLIENT:	PROJECT NO.:
NMPC	1961

ANALYSIS TITLE: Assessment of AMP Terminal Connectors, Serving a Safety Related Function, at NMP-1

AUTHOR: D. N. Perkey

PURPOSE OF ANALYSIS: To determine if the design of the AMP Terminal Connectors is adequate to assure they will operate on demand to meet the system performance requirements under normal and harsh environmental conditions

SUMMARY OF ANALYSIS PROCEDURE AND RESULTS:

Based on the design and the materials used in the AMP Connectors it is believed that they will meet performance requirements for the 40 year plant life.

DATE COMPLETED:	VERIFICATION REQUIRED:
12/3/81	☒ YES ☐ NO

ANALYSIS REVIEWED AND ACCEPTED: (DISCIPLINE MANAGER)	DATE:
[signature]	12-6-81

ANALYSIS:	BY: (FILE NO.)	DISCIPLINE MANAGER:	DATE:
☐ SUPERSEDED ☐ SUPPLEMENTED			

NUS 202 10 REVISED 0181
(Formerly CD-28 12/77)

QUALITY ASSURANCE RECORD

NUS CORPORATION
CONSULTING DIVISION

RECORD OF SYSTEM/COMPONENT ANALYSES

FILE NO.: 1961-N007-001	NO. OF PAGES: 43	NUMBER OF VOLUMES OF COMPUTER OUTPUT: NA
CLIENT: NMPC		PROJECT NO.: 1961

ANALYSIS TITLE: ENVIRONMENTAL QUALIFICATION ASSESSMENT OF NAMCO LIMIT SWITCHES SERIES D2400X AND SL3 FOR USE IN NMPC - NMP-1

AUTHOR: [illegible] STEINBERG

PURPOSE OF ANALYSIS: TO DETERMINE IF DESIGN OF NAMCO D2400X AND SL3 SERIES LIMIT SWITCH IS ADEQUATE TO ASSURE SWITCHES WILL WORK ON DEMAND & MEET SYSTEM REQUIREMENTS UNDER NORMAL & HARSH CONDITIONS AND DURING A DBE AT NMP-1

SUMMARY OF ANALYSIS PROCEDURE AND RESULTS:

TEST DATA AS WELL AS ANALYSIS OF MATERIALS USING THE ARRHENIUS THEORY WERE USED TO DETERMINE IF NAMCO SERIES D2400X & SL3 COULD PERFORM THEIR SAFETY RELATED FUNCTION IN NORMAL AND HARSH ENVIRONMENT AT NMP-1. IT WAS CONCLUDED THAT BOTH TYPE SWITCHES COULD WITHSTAND 1.4×10^6 TOTAL INTEGRATED DOSE. IT WAS ALSO CONCLUDED THAT WITH A REGULAR REPLACEMENT PROGRAM OF BUNA-N COMPONENTS THE SWITCHES CAN WITHSTAND A HARSH ENVIRONMENT OF 308°F AND 35PSIG FOR APPROXIMATELY 66 HOURS. BASED ON THE ARRHENIUS THEORY IT WAS CONCLUDED THAT THE LIFE OF BUNA-N COMPONENTS AT NORMAL SERVICE CONDITIONS WAS 12.5 YEARS. NECESSITATING A REGULARLY SCHEDULED REPLACEMENT OF BUNA N COMPONENTS IN THE NAMCO SWITCHES ANALIZED. IT WAS RECOMMENDED THAT SWITCHES 01-01 AND 01-02 BE REPLACED OR SHIELDED FROM RADIATION AND ALL SWITCHES HAVE BUNA-N COMPONENTS REPLACED EVERY 5 YEARS TO BE SAFE AND CONSERVATIVE.

DATE COMPLETED: 11/23/81	VERIFICATION REQUIRED: ☒ YES ☐ NO

ANALYSIS REVIEWED AND ACCEPTED: (DISCIPLINE MANAGER) [signature]	DATE: 11/29/81

ANALYSIS: ☐ SUPERSEDED ☐ SUPPLEMENTED	BY: (FILE NO.)	DISCIPLINE MANAGER:	DATE:

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

FILE NO.:	PAGE 1 OF 2
1961-N007-001	

ANALYSIS TITLE:

ENVIRONMENTAL QUALIFICATION ASSEMENT OF NAMCO LIMIT SWITCHES SERIES D2400X AND SL3 AT NMP-1

AUTHOR:	NO. OF PAGES:	NO. OF VOLUMES OF COMPUTER OUTPUT:
R STEINBERG	43	NA

VERIFICATION SCOPE (CHECK AS APPLICABLE):

- [x] METHOD OF ANALYSIS
- [x] ASSUMPTIONS
- [x] INPUT INFORMATION
- [ ] COMPUTER CODE APPLICATION
- [ ] CHECK OF SAMPLE CALCULATION
- [x] SPOT CHECK OF MATHEMATICS
- [x] REASONABLENESS OF RESULTS
- [ ] COMPLETE CHECK OF MATHEMATICS
- [ ] PARTIAL INDEPENDENT ANALYSIS

BUDGET: (APPROXIMATE)	DESIRED COMPLETION DATE:
1/4 MANDAYS	12/11/81

DESCRIPTION OF VERIFICATION—ACTIVITIES, FINDINGS AND RESOLUTION:

p7 Indicate specific safety related functions on data sheets since there are many.

RESOLUTION: Added TABLE 4 PAGE 32 TO REPORT RJS

NUS 203A 10 REVISED 0181
(Formerly CD-29(1) 12/77)

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

VERIFIER'S SIGNATURE:	DATE: 24 Nov 1981
ACCEPTANCE BY: (DISCIPLINE MANAGER)	DATE: 11/22/81

NUS 2038 10 REVISED 0181

NUS CORPORATION
CONSULTING DIVISION

ANALYSIS VERIFICATION CHECKLIST

ANALYSIS TITLE: ENVIRONMENTAL QUALIFICATION ASSESSMENT OF NAMCO LIMIT SWITCHES SERIES D2400X AND SL3 AT NMP-1

ANALYSIS FILE NUMBER: 1961-N007-001

INDICATE "YES, NO, OR N/A (NOT APPLICABLE)," FOR EACH ITEM AND INCLUDE IN ANALYSIS PACKAGE WITH RECORD OF ANALYSIS VERIFICATION	YES	NO	N/A
METHOD OF ANALYSIS			
IS THE METHOD USED APPROPRIATE CONSIDERING THE PURPOSE AND TYPE OF ANALYSIS AND THE USE AND ACCEPTABILITY OF THE RESULTS (i.e., MARGIN TO LIMITS)?	☑	☐	☐
IS THE METHOD IN ACCORDANCE WITH CODES, STANDARDS, AND REGULATORY REQUIREMENTS?	☑	☐	☐
HAS THE METHOD BEEN EMPLOYED ELSEWHERE IN INDUSTRY OR IN LICENSE APPLICATIONS?	☑	☐	☐
ASSUMPTIONS			
ARE ASSUMPTIONS NECESSARY TO PERFORM THE ANALYSIS ADEQUATELY DESCRIBED AND REASONABLE?	☑	☐	☐
WHERE NECESSARY, ARE THE ASSUMPTIONS IDENTIFIED FOR SUBSEQUENT RE-VERIFICATIONS WHEN THE DETAILED DESIGN ACTIVITIES ARE COMPLETED?	☑	☐	☐
INPUT INFORMATION			
ARE THE INPUTS INTO THE ANALYSIS STATED AND THEIR SOURCE IDENTIFIED?	☑	☐	☐
IS THE INPUT INFORMATION FROM THE LATEST AVAILABLE REVISION TO THE DOCUMENT?	☑	☐	☐
IS THE STATUS (PRELIMINARY, CONCEPTUAL, ETC.) OF THE INPUT SOURCE IDENTIFIED FOR LATER CONFIRMATION OF THE VALIDITY OF THE INPUT?	☑	☐	☐
ARE THE INPUTS SUFFICIENT CONSIDERING THE PURPOSE OF THE ANALYSIS?	☑	☐	☐
COMPUTER CODE APPLICATION			
ARE ALL CODES USED IDENTIFIED ALONG WITH SOURCE, COMPUTER TYPE, INPUTS, AND OUTPUTS?	☐	☐	☑
HAS THE CODE BEING USED BEEN ADEQUATELY VERIFIED?	☐	☐	☑
IS THE CODE SUITABLE FOR THE PRESENT ANALYSIS?	☐	☐	☑
DOES THE COMPUTER MODEL (NODING, TIME STEPS, ETC.) ADEQUATELY REPRESENT THE PHYSICAL SYSTEMS?	☐	☐	☑
REASONABLENESS OF RESULTS			
IS THE MAGNITUDE OF THE RESULT REASONABLE?	☑	☐	☐
ARE THE DIRECTION OF TRENDS REASONABLE?	☑	☐	☐

PREPARED BY: [signature]

DATE: 24 Nov 1987

NUS 204 10 REVISED 0181
(Formerly CD-30 Rev. 1)

FINAL ANALYSIS REVIEW CHECKLIST

Project #/Project Title 1961 Client NMPC

Date: 11/24/81

Analysis File Title: ENVIRONMENTAL QUALIFICATION ASSESSMENT OF NAMCO SERIES D2400X AND SL3 LIMIT SWITCHES AT NMP-1

Analysis File Number: 1961-N007-001

Checklist Item	Yes	N/A
1. Unique Analysis File Number assigned to the file.	✓	
2. Analysis recorded on CD-60	✓	
a. pages numbered	✓	
b. total pages specified	✓	
c. all pages dated	✓	
d. client identified on each page	✓	
e. correct file number on each page	✓	
f. author(s) specified on each page	✓	
g. subject specified on each page	✓	
h. verifier initials on each page	✓	
3. Analysis File includes:		
a. client identification	✓	
b. analysis file number	✓	
c. analysis title	✓	
d. author(s) identification	✓	
e. description of the purpose of the analysis	✓	
f. discussion of the general method of analysis	✓	
g. identification of input information source	✓	
h. identification of input information status	✓	
i. major assumptions used in performing the analysis	✓	

Date: 11/24/87

3.	(Continued)		
	j. important references, including material properties	✓	
	k. identification of specific versions of codes used		✓
	l. detailed calculation	✓	
	m. listing of computer input		✓
	n. microfiche of computer output		✓
	o. summary of results	✓	
4.	Record of analysis provided onn CD-28	✓	
5.	All applicable entries on CD-28 correct.	✓	
6.	All referenced NUS internal memos included in analysis file.	✓	
7.	All referenced telecons included in analysis file.	✓	
8.	Separate computer output labeled with analysis file number.		✓
9.	Record of analysis file verification on CD-29.	✓	
10.	All entries on CD-29 completed and correct.	✓	
11.	Item (7) of CD-29 completed and comments numbered	✓	
12.	Verification checklist CD-30 included.	✓	
13.	Computer code used verified per QAI 3.5.		✓
14.	Corrected items crossed out clearly enough to show on Xerox copies.	✓	
15.	List of input information and major assumptions checked for commpleteness.	✓	
16.	Documents Complete (Page Count)	✓	
17.	Documents Legible and Reproducible	✓	
18.	All Documents Identified on Index Received	✓	
19.	Documents Properly Paginated	✓	
20.	Documents Identified to Project/Item	✓	
21.	All Unsatisfactory Conditions Resolved (List)	✓	

Date 11/24/87

22. Remarks:

Reviewed by: [signature] 24 Nov 87
Date

NUS CORPORATION

Page____ of ____

DATE November 19, 1981

CLIENT NMPC FILE NO. 1961-N007-001 BY [illegible]

SUBJECT ____ Checked By [illegible]

ENVIRONMENTAL QUALIFICATION ASSESSMENT

FOR

NAMCO LIMIT SWITCHES

SERIES

D2400X AND SL3

FOR USE IN

NIAGARA MOHAWK POWER CORPORATION'S

NINE MILE POINT 1

NUCLEAR POWER GENERATING STATION

NUS CORPORATION

2536 COUNTRYSIDE BOULEVARD

CLEARWATER, FL. 33528

NUS CORPORATION

DATE November 19, 1981

CLIENT NMPC FILE NO. 1961-N007-001 BY R. STEINBERG

SUBJECT Environmental Qualification for NAMCO Limit Switches D2400X and SL3 Checked By [signature]

TABLE OF CONTENTS

NUS CORPORATION

DATE November 19, 1981

CLIENT NMPC FILE NO. 1961-N007-00 BY R Steinberg

SUBJECT Environmental Qualification for Namco Limit Switches D2400X and SL3 Checked By [signature]

TABLE of CONTENTS CONTINUED. PAGE

CLIENT NMPC FILE NO. 1961-N007-001 BY R. Steinberg

SUBJECT Environmental Qualification for Namco Limit Switches D2400X and SL3 Checked By [signature]

TABLE OF CONTENTS CONTINUED

NUS CORPORATION

DATE November 19, 1987

CLIENT NMPC FILE NO. 1961-N007-001 BY R. Steinberg

SUBJECT Environmental Qualification for Namco Limit Switches D2400X and SL3 Checked By [signature]

TABLE OF CONTENTS CONTINUED

CLIENT NMPC FILE NO. 1961-N007-001 BY R. Steinberg

SUBJECT Environmental Qualification for Namco Limit Switches D2400X and SL3 Checked By [signature]

1.0 CLIENT IDENTIFICATION

NIAGARA MOHAWK POWER CORPORATION (NMPC)

2.0 ANALYSIS FILE NUMBER

1961-N007-001

3.0 ANALYSIS TITLE

ENVIRONMENTAL QUALIFICATION ASSESSMENT OF NAMCO LIMIT SWITCHES SERIES D2400X AND SL3 FOR USE IN NMPC'S NINE MILE POINT-UNIT 1 NUCLEAR POWER GENERATING STATION.

4.0 AUTHOR IDENTIFICATION

R.J. STEINBERG

5.0 PURPOSE OF ANALYSIS

THE PURPOSE OF THIS ANALYSIS IS TO DETERMINE IF THE DESIGN OF THE NAMCO SERIES D2400X AND SL3 LIMIT SWITCHES IS ADEQUATE TO ASSURE THAT THE SWITCHES WILL OPERATE ON DEMAND, TO MEET THE SYSTEM PERFORMANCE REQUIREMENTS UNDER NORMAL ENVIRONMENTAL CONDITIONS AS WELL AS DURING DESIGN BASIS EVENTS AT NMP-1.

CLIENT NMPC FILE NO. 1961-N007-001 BY R. STEINBERG

SUBJECT ENVIRONMENTAL QUALIFICATION FOR NAMCO LIMIT SWITCHES D2400X AND SL3 Checked By [signature]

6.0 INPUT INFORMATION

6.1 EQUIPMENT IDENTIFICATION

ALL THE NAMCO SWITCHES, BOTH D2400X AND SL3 SERIES, AT NMP-1, THAT ARE WITHIN THE SCOPE OF THIS ANALYSIS (REF. 4) ARE LISTED IN TABLE I.

6.2 MATERIALS.

A LIST OF THE NON METALLIC COMPONENTS USED IN THE D2400X LIMIT SWITCH, OBTAINED FROM THE MANUFACTURER (REF 5), CAN BE FOUND IN TABLE II. A LIST OF THE NON METALLIC COMPONENTS USED IN THE SL3 LIMIT SWITCH, OBTAINED FROM THE MANUFACTURER (REF 5), CAN BE FOUND IN TABLE III.

CLIENT NMPC FILE NO. 1961-N007-001 BY R. STEINBERG

SUBJECT ENVIRONMENTAL QUALIFICATION FOR NAMCO LIMIT SWITCHES D2400X AND SL3 Checked By [signature]

6.3 SAFETY RELATED FUNCTION

GENERALLY INDICATE VALVE POSITION (EITHER OPEN OR CLOSED) FOR VALVES IN ISOLATION SYSTEMS, AND EMERGENCY COOLING SYSTEMS. SEE TABLE 4 FOR COMPLETE FUNCTION BY SWITCH AND LOCATION (REF 15)

6.4 SERVICE CONDITIONS

THE NORMAL SERVICE CONDITIONS AS SPECIFIED BY NMPC (REF 6) FOR ALL OF THE SUBJECT SWITCHES AT NMP-1 ARE LISTED IN TABLE I. HOWEVER THE MAXIMUM LEVEL THAT ANY ONE SWITCH WILL BE SUBJECT TO AT NORMAL SERVICE CONDITIONS ARE AS FOLLOWS.

TEMPERATURE	103°F - 39.4°C
PRESSURE	0 PSIG
RELATIVE HUMIDITY	10-90% ASSUMED
RADIATION	1×10^4 RADS ASSUMED
DURATION	40 YEARS

THE HARSH ENVIRONMENT CONDITIONS TO WHICH THE SUBJECT SWITCHES MAY BE EXPOSED DURING A DESIGN BASIS EVENT (HELB OR LOCA) WERE OBTAINED FROM NUS ANALYSIS 1961-SA-A1 (REF 1), NUS ANALYSIS 1961-SA-A2 (REF 2), AND NUS ANALYSIS 1961-R-1 (REF 3). TEMPERATURE AND PRESSURE PLOTS FOR A DESIGN BASIS EVENT ARE PRESENTED IN FIGURES I THRU VII FOR THE VARIOUS LOCATIONS OF THE SUBJECT SWITCHES

6.4 CONT.

AT NMP-1. (REF 14) A COMPLETE LIST OF HARSH ENVIRONMENT CONDITIONS FOR THE SUBJECT SWITCHES CAN BE FOUND IN TABLE I, HOWEVER THE MAXIMUM LEVEL THAT ANY ONE SWITCH WILL BE SUBJECT TO AT HARSH ENVIRONMENT CONDITIONS ARE AS FOLLOWS.

TEMPERATURE	308°F – 153.3°C
PRESSURE	35 PSIG
RELATIVE HUMIDITY	100 %
RADIATION	5 X 10⁷ RADS
DURATION (REF 14) FIGURES I - VII	< .60 SECONDS AT MAXIMUM CONDITIONS

7.0 METHOD OF ANALYSIS

7.1 MATERIALS

THE MANUFACTURE OF THE NAMCO MODELS D2400X AND SL3 LIMIT SWITCHES WAS CONTACTED AND A LIST OF NON METALLIC COMPONENTS OBTAINED (REF. 5). A LITERATURE SEARCH WAS CONDUCTED TO OBTAIN RADIATION AND TEMPERATURE THRESHOLD LEVELS AND TIME/TEMPERATURE AGING DATA FOR THOSE MATERIALS THAT MAY BE SUBJECT TO DEGRADATION FROM THOSE FACTORS. (TABLES II AND III)

7.2 RADIATION

A LITERATURE SEARCH WAS CONDUCTED TO DETERMINE THE RADIATION THRESHOLD LEVELS FOR THE NON METALLIC MATERIALS USED IN THE NAMCO D2400X AND SL3 LIMIT SWITCHES

7.3 TIME/TEMPERATURE EFFECTS.

THE PRESENT STATE OF THE ART ALLOWS ACCELERATION OF THE AGING EFFECTS OF TEMPERATURE BY SUBJECTING A MATERIAL TO INCREASED TEMPERATURES FOR RELATIVELY SHORT PERIOD OF TIME. FOR MANY NON METALLIC MATERIALS IT IS KNOWN THAT THE DEGRADATION PROCESS CAN BE DEFINED BY A SINGLE TEMPERATURE DEPENDENT REACTION THAT FOLLOWS THE ARRHENIUS EQUATION:

$$K = A \exp -\left(E_a / K_b T \right) \qquad (1)$$

WHERE,

K = REACTION RATE

A = FREQUENCY FACTOR

EXP = EXPONENT TO BASE e

E_a = ACTIVATION ENERGY

K_b = BOLTZMAN'S CONSTANT

T = ABSOLUTE TEMPERATURE

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7.3 CONT.

EQUATION (1) CAN ALSO BE TRANSFORMED INTO A FORM WHICH YEILDS AN EXPECTED LIFE OF THE MATERIAL AT A SPECIFIC TEMPERATURE. THIS FORM IS:

$$\ln \tau_i = E_a/K_b \left(\frac{1}{T_i}\right) + I \qquad (2)$$

WHERE,

LN = NATURAL LOGARITHM

τ_i = EXPECTED LIFE AT TEMPERATURE T_i (HOURS)

T_i = SERVICE TEMPERATURE FOR LIFE τ_i (°K)

I = CONSTANT

EQUATION (2) CAN ALSO BE REPRESENTED IN A LINEAR REGRESSION LINE AS:

$$Y_i = m x_i + I$$

WHERE,

$Y_i = \ln \tau_i$

$x_i = 1/T_i$

$m = E_a/K_b$

I = CONSTANT (INTERCEPT)

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7.3 CONT.

FOR THE PURPOSE OF THIS ANALYSIS THE ARRHENIUS EQUATION IS USED TO CALCULATE THE EXPECTED LIFE OF THE MATERIALS USED IN THE NAMCO D2400X AND SL3 LIMIT SWITCHES. TIME/TEMPERATURE TEST DATA WAS COLLECTED FROM THE AVAILABLE LITERATURE ON EACH TEMPERATURE SENSITIVE MATERIAL, AND THE ACTIVATION ENERGIES AND INTERCEPTS CALCULATED FOR THE SPECIFIED FAILURE CRITERIA (REF. 7, 8, 9, 10, 11, AND 12). THESE ACTIVATION ENERGIES AND INTERCEPTS WERE THEN USED TO CALCULATE THE EXPECTED LIFE OF THE MATERIALS UNDER THE MAXIMUM HARSH ENVIRONMENT TEMPERATURE CONDITIONS. IF THE LIFE CALCULATED FOR ALL THE MATERIALS AT THE MAXIMUM HARSH ENVIRONMENT TEMPERATURES EXCEEDS 40 YEARS, NO FUTHER ANALYSIS WAS DONE BECAUSE THE MAXIMUM HARSH ENVIRONMENT TEMPERATURE ENVELOPES ALL OTHER TEMPERATURE CONDITIONS. IF THE MATERIAL LIFE AS CALCULATED ABOVE DOES NOT EXCEED 40 YEARS THEN THE EXPECTED LIFE AT AMBIENT CONDITIONS WAS ALSO CALCULATED, AND A DETERMINATION OF THE EXPECTED LIFE WAS MADE USING THE COMBINATION OF 40 YEARS AT NORMAL SERVICE CONDITIONS AND THE SPECIFIED DURATION OF A DESIGN BASIS EVENT.

7.4 HARSH ENVIRONMENT – DESIGN BASIS EVENT

THE NAMCO SL3 SERIES LIMIT SWITCH WAS EXPOSED TO DESIGN BASIS EVENT CONDITIONS IN A TEST CONDUCTED ON NAMCO SL3 LIMIT SWITCHES (REF 13). DUE TO SIMILARITY BETWEEN THE SWITCHES IN MATERIALS USED (TABLE II AND III)

7.4 CONT.

THIS SAME TEST WAS USED AS THE DESIGN BASIS EVENT TEST FOR NAMCO D2400X SERIES SWITCHES ALSO.

7.5 CYCLING

AT THIS TIME CYCLING INFORMATION FOR THE NAMCO D2400X AND SL3 SERIES LIMIT SWITCHES HAS NOT BEEN OBTAINED.

8.0 COMPUTER CODES

COMPUTER CODES WERE NOT USED IN THIS ANALYSIS.

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9.0 MAJOR ASSUMPTIONS

9.1 IT IS ASSUMED FOR THE PURPOSE OF THIS ANALYSIS THE DETERIORATION OF METALLIC COMPONENTS DUE TO TIME/TEMPERATURE EFFECTS AND RADIATION EXPOSURE, IS INSIGNIFICANT.

9.2 IT IS ASSUMED THAT THE ORGANIC MATERIALS USED RATHER THAN THE INORGANIC MATERIALS WILL BE THE LIMITING MATERIALS FOR THE TIME/TEMPERATURE EFFECTS AND RADIATION EXPOSURE.

9.3 IT IS ASSUMED THAT BECAUSE OILS AND OTHER LUBRICANTS WILL BE REPLACED ACCORDING TO A REGULAR MAINTAINANCE SCHEDULE THEY ARE NOT CONSIDERED TO BE SUBJECT TO TIME/TEMPERATURE EFFECTS FOR THE 40 YEAR DESIRED LIFE.

9.4 IT IS ASSUMED THAT THE TIME/TEMPERATURE TEST CURVE USED FOR VALOX 420 (A GLASS FILLED POLYESTER REF 8) IS APPLICABLE TO THE GLASS FILLED POLYESTER USED IN THE D2400X AND SL3 SERIES LIMIT SWITCHES. IT IS FUTHER ASSUMED THAT THE RADIATION LEVEL OF GLASS FILLED POLYESTER APPLIES TO THIS PRODUCT.

9.5 IT IS ASSUMED THAT THE TIME/TEMPERATURE TEST CURVE USED FOR DUREZ 152 (A MINERAL FILLED PHENOLIC REF 9) IS APPLICABLE TO THE MINERAL FILLED PHENOLICS USED IN THE D2400X LIMIT SWITCHS. IT IS FUTHER ASSUMED THAT THE RADIATION LEVEL OF MINERAL FILLED PHENOLICS APPLIES TO THIS PRODUCT.

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9.6 IT IS ASSUMED THAT THE TIME/TEMPERATURE TEST CURVE OF G.E. GENAL P4000 (A NYLON FILLED PHENOLIC Ref 9) IS APPLICABLE TO THE NYLON FILLED PHENOLICS USED IN THE D2400X LIMIT SWITCHS. IT IS FUTHER ASSUMED THAT THE RADIATION LEVEL OF NYLON FILLED PHENOLICS APPLIES TO THIS PRODUCT.

9.7. IT IS ASSUMED THAT THE TIME/TEMPERATURE TEST CURVE USED FOR CROSSLINKED PVC INSULATION (REF 10) APPLIES TO THE KURSEAL GASKET USED IN THE D2400X LIMIT SWITCHES AND THE LISTED PVC MATERIAL GASKET IN THE SL3 LIMIT SWITCHES. IT IS FUTHER ASSUMED THAT THE RADIATION LEVEL OF POLYVINYL CHLORIDE APPLIES TO THESE GASKETS.

9.8 IT IS ASSUMED THAT THE TIME/TEMPERATURE TEST CURVE USED FOR NEMA GRADE 5 AND GRADE 9 MELAMINE (REF 11) APPLIES TO THE MELAMINES USED IN BOTH THE D2400X AND SL3 LIMIT SWITCHES. IT IS FUTHER ASSUMED THAT THE RADIATION LEVEL OF MELAMINE FORMALDEHYDE APPLIES TO THE MELAMINE USED IN THESE SWITCHES.

9.9 IT IS ASSUMED THAT THE TIME/TEMPERATURE TEST CURVE USED FOR BUNA-N (REF 7) APPLIES TO NYLON COATED BUNA-N USED IN THE D2400X AND SL3 LIMIT SWITCHES. IT IS FUTHER ASSUMED THAT THE RADIATION LEVEL OF BUNA-N APPLIES TO THE NYLON COATED BUNA-N USED IN THESE SWITCHES

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9.10 IT IS ASSUMED THAT ALTHOUGH RADIATION THRESHOLD LEVELS HAVE BEEN FOUND FOR MOST OF THE OIL AND LUBRICANTS USED IN THE D2400X AND SL3 LIMIT SWITCHES, THEY ARE NOT A LIMITING FACTOR TO QUALIFYING THESE SWITCHES FOR REASONS STATED IN PARAGRAPH 9.3.

9.11. IT IS ASSUMED THAT BECAUSE BOTH THE SL3 AND D2400X LIMIT SWITCHES CONTAIN THE SAME TYPE OF MATERIALS, THEY ARE BOTH SUBJECT TO THE SAME LIMITATIONS IN NORMAL AND HARSH ENVIRONMENT, AND CAN BE CONSIDERED TOGETHER BY SIMILARITY, FOR PURPOSES OF THIS ANALYSIS

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10.0 DETAILED CALCULATIONS

10.1 LIFE CALCULATION FOR GLASS FILLED POLYESTER AT 308°F 153.3°C (MAXIMUM HARSH TEMPERATURE)

308°F = 426.3°K

$$\ln \tau_i = \frac{E_a}{K_b} \left(\frac{1}{T_i} \right) + I$$

$\ln \tau_i$ = Ln Life in Hours

E_a = 1.70 eV (Ref 8)

K_b = 8.617×10^{-5} eV/°K

T_i = 426.3°K

I = −36.5194 (Ref 8)

$$\ln \tau_i = \frac{1.70}{8.617 \times 10^{-5}} \left(\frac{1}{426.3} \right) - 36.5194$$

$\ln \tau_i$ = 9.758

τ_i = 1.7×10^{4} HOURS = 1.975 YEARS

LIFE CALCULATION FOR GLASS FILLED POLYESTER AT 103°F 39.4°C (AMBIENT NORMAL TEMPERATURE)

103°F = 312.4°K

$$\ln \tau_i = \frac{E_a}{K_b} \left(\frac{1}{T_i} \right) + I$$

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10.1 CONT.

LNτi = LN LIFE IN HOURS

$E_a = 1.70\ eV$ (Ref 8)

$K_b = 8.617 \times 10^{-5}\ eV/°K$

$T_i = 312.4°K$

$I = -36.5194$ (Ref 8)

$$LN\tau_i = \frac{1.70}{8.617 \times 10^{-5}} \left(\frac{1}{312.4}\right) - 36.5194$$

$LN\tau_i = 26.63$

$\tau_i = 3.68 \times 10^{11}$ HOURS $= 4.2 \times 10^{7}$ YEARS

10.2 LIFE CALCULATION FOR MINERAL FILLED PHENOLIC AT 308°F 153.3°C (MAXIMUM HARSH TEMPERATURE)

$308°F = 426.3°K$

$$LN\tau_i = E_a/K_b \left(\frac{1}{T_1}\right) + I$$

LNτi = LN LIFE IN HOURS

$E_a = .16733\ eV$ (Ref 9)

$K_b = 8.617 \times 10^{-5}\ eV/°K$

$T_i = 426.3°K$

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10.2 CONT

$$I = -9.9578 \text{ (Ref 9)}$$

$$LN\tau_i = \frac{.6733}{8.617 \times 10^{-5}}\left(\frac{1}{426.3}\right) - 9.9578$$

$$LN\tau_i = 8.37$$

$$\tau_i = 4.32 \times 10^3 \text{ Hours} = .49 \text{ Years}$$

LIFE CALCULATION FOR MINERAL FILLED PHENOLIC AT 103°F 39.4°C (AMBIENT NORMAL TEMPERATURE)

$$103°F = 312.4°K$$

$$LN\tau_i = E_a/K_b\left(\frac{1}{T_i}\right) + I$$

$LN\tau_i$ = ln Life in Hours

$$E_a = .6733 \text{ eV (Ref 9)}$$

$$K_b = 8.617 \times 10^{-5} \text{ eV/°K}$$

$$T_i = 312.4°K$$

$$I = -9.9578 \text{ (Ref 9)}$$

$$LN\tau_i = \frac{.6733}{8.617 \times 10^{-5}}\left(\frac{1}{312.4}\right) - 9.9578$$

$$LN\tau_i = 15.05$$

$$\tau_i = 3.45 \times 10^6 \text{ Hours} = 3.94 \times 10^2 \text{ Years}$$

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10.3 LIFE CALCULATION FOR NYLON FILLED PHENOLIC AT 308°F 153.3°C (MAXIMUM HARSH TEMPERATURE)

$308°F = 426.3°K$

$LN\tau_i = E_a/K_b \left(\frac{1}{T_i}\right) + I$

$LN\tau_i$ = LN LIFE IN HOURS

$E_a = 1.6405\ eV$ (Ref 9)

$K_b = 8.617 \times 10^{-5}\ eV/°K$

$T_i = 426.3°K$

$I = -33.8074$ (Ref 9)

$$LN\tau_i = \frac{1.6405}{8.617 \times 10^{-5}} \left(\frac{1}{426.3}\right) - 33.8074$$

$LN\tau_i = 10.85$

$\tau_i = 5.16 \times 10^4$ HOURS = 5.9 YEARS

LIFE CALCULATION FOR NYLON FILLED PHENOLIC AT 103°F = 39.4°C (AMBIENT NORMAL TEMPERATURE)

$103°F = 312.4°K$

$$LN\tau_i = \frac{E_a}{K_b} \left(\frac{1}{T_i}\right) + I$$

$LN\tau_i$ = LN LIFE IN HOURS

$E_a = 1.6405\ eV$ (Ref 9)

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10.3 CONT

$K_b = 8.617 \times 10^{-5}$ eV/°K

$T_i = 312.4$°K

$I = -33.8074$ (Ref 9)

$$\ln \tau_i = \frac{1.6405}{8.617 \times 10^{-5}} \left(\frac{1}{312.4}\right) - 33.8074$$

$\ln \tau_i = 27.13$

$\tau_i = 6.08 \times 10^{11}$ Hours $= 6.94 \times 10^{7}$ Years

10.4. LIFE CALCULATION FOR KOROSEAL (POLYVINYL CHLORIDE) AT 308°F - 153.3°C (MAXIMUM HARSH TEMPERATURE)

308°F = 426.3°K

$$\ln \tau_i = \frac{E_a}{K_b} \left(\frac{1}{T_i}\right) + I$$

$\ln \tau_i$ = ln life in hours

E_a = .9904 eV (Ref 10)

$K_b = 8.617 \times 10^{-5}$ eV/°K

$T_i = 426.3$°K

$I = -23.0241$ (Ref 10)

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10.4 Cont.

$$\ln \tau_i = \frac{.9904}{8.617\times10^{-5}}\left(\frac{1}{426.3}\right) - 23.0241$$

$$\ln \tau_i = 3.94$$

$$\tau_i = 51.27 \text{ Hours} = 5.8\times10^{-3} \text{ Years}$$

Life calculation for Korseal (Polyvinyl chloride) at 103°F = 39.4°C (Ambient normal temperature)

$$103°F = 312.4°K$$

$$\ln \tau_i = E_a/K_b \left(\frac{1}{T_i}\right) + I$$

$\ln \tau_i$ = Ln life in hours

E_a = .9904 (Ref 10)

K_b = 8.617×10^{-5} eV/°K

T_i = 312.4°K

I = -23.0241 (Ref 10)

$$\ln \tau_i = \frac{.9904}{8.617\times10^{-5}}\left(\frac{1}{312.4}\right) - 23.0241$$

$$\ln \tau_i = 13.76$$

$$\tau_i = 9.527\times10^{5} \text{ Hours} = 1.09\times10^{2} \text{ Years}$$

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10.5 Life calculation for melamine (Formica and/or mineral filled) at 308°F = 153.3°C (maximum harsh temperature)

$308°F = 426.3°K$

$\ln \tau_i = E_a/K_b \left(\frac{1}{T_i}\right) + I$

$\ln \tau_i$ = Ln life in hours

E_a = 1.5709 eV (Ref 11)

K_b = 8.617×10^{-5} eV/°K

T_i = 426.3°K

I = −34.4037 (Ref 11)

$$\ln \tau_i = \frac{1.5709}{8.617 \times 10^{-5}} \left(\frac{1}{426.3}\right) - 34.4037$$

$\ln \tau_i$ = 8.36

$\tau_i = 4.27 \times 10^{3}$ hours $= 4.9 \times 10^{-1}$ years

Life calculation for melamine (Formica and/or mineral filled) at 103°F = 39.4°C (ambient normal temperature)

$103°F = 312.4°K$

$\ln \tau_i = E_a/K_b \left(\frac{1}{T_i}\right) + I$

$\ln \tau_i$ = Ln life in hours

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10.5 CONT

$E_a = 1.5709\ eV$ (REF 11)

$K_b = 8.617 \times 10^{-5}\ eV/{}^oK$

$T_i = 312.4\ {}^oK$

$I = -34.4037$ (REF 11)

$$\ln T_i = \frac{1.5709}{8.617 \times 10^{-5}} \left(\frac{1}{312.4}\right) - 34.4037$$

$\ln T_i = 23.95$

$T_i = 2.52 \times 10^{10}$ HOURS $= 2.88 \times 10^6$ YEARS

10.6 LIFE CALCULATION FOR BUNA-N AND NYLON COATED BUNA-N AT $308^oF = 153.3^oC$ (MAXIMUM HARSH TEMPERATURE)

$308^oF = 426.3\ {}^oK$

$\ln T_i = E_a/K_b \left(\frac{1}{T_i}\right) + I$

$\ln T_i$ = LN LIFE IN HOURS

$E_a = .75065\ eV$ (REF 7)

$K_b = 8.617 \times 10^{-5}\ eV/{}^oK$

$T_i = 426.3\ {}^oK$

$I = -16.2810$ (REF 7)

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10.6 CONT

$$LN\tau_i = \frac{.75065}{8.617\times10^{-5}}\left(\frac{1}{426.3}\right) - 16.2810$$

$$LN\tau_i = 4.15$$

$$\tau_i = 63.66 \text{ HOURS} = 7.27\times10^{-3} \text{ YEARS}$$

LIFE CALCULATION FOR BUNA-N AND NYLON COATED BUNA-N AT 103°F = 39.4°C (AMBIENT NORMAL TEMPERATURE)

$$103°F = 312.4°K$$

$$LN\tau_i = E_a/K_b\left(\frac{1}{T_i}\right) + I$$

$LN\tau_i$ = LN LIFE IN HOURS

E_a = .75065 eV (Ref 7)

K_b = 8.617×10^{-5} eV/°K

T_i = 312.4°K

I = −16.2810 (Ref 7)

$$LN\tau_i = \frac{.75065}{8.617\times10^{-5}}\left(\frac{1}{312.4}\right) - 16.2810$$

$$LN\tau_i = 11.60$$

$$\tau_i = 1.095\times10^{5} \text{ HOURS} = 12.5 \text{ YEARS}$$

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10.7 IT HAS BEEN DETERMINED BY THE PREVIOUS CALCULATIONS THAT BUNA-N IS THE MOST AGE SENSITIVE MATERIAL USED IN THE SUBJECT SWITCHES. THE FOLLOWING CALCULATION DETERMINES THE LOSS OF LIFE FOR BUNA-N SHOULD IT BE EXPOSED TO MAXIMUM HARSH TEMPERATURE CONDITIONS DURING ITS NORMAL SERVICE LIFE OF 10.5 YEARS AT NORMAL SERVICE TEMPERATURES

$$\tau_2 = \tau_1 \exp\left[\frac{E_a}{K_b}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)\right] \qquad (4)$$

WHERE

τ_1 = TIME AT T_1

τ_2 = EQUIVALENT TIME AT T_2

E_a = ACTIVATION ENERGY (eV)

K_b = BOLTZMAN'S CONSTANT (8.617×10^{-5} eV/°K)

T_1 = HARSH ENVIRONMENT TEMPERATURE (°K)

T_2 = NORMAL SERVICE TEMPERATURE (°K)

WHERE

τ_1 = 1 MINUTE – (REF 14) FIGURES I – VIII

E_a = .75065 eV (REF 7)

K_b = 8.617×10^{-5} eV/°K

T_1 = 308°F = 153.3°C = 426.3°K

T_2 = 103°F = 39.4°C = 312.4°K

$$\tau_2 = \frac{1}{60}\ \text{HR} \exp\left[\frac{.75065}{8.617 \times 10^{-5}}\left(\frac{1}{312.4} - \frac{1}{426.3}\right)\right]$$

τ_2 = 28.68 HOURS = 1.20 DAYS

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11.0. RESULTS

11.1 RADIATION

AS INDICATED IN TABLES II AND III THE MOST RADIATION SENSITIVE MATERIALS USED IN BOTH THE D2400X AND SL3 SERIES NAMCO LIMIT SWITCHES ARE BUNA-N AND NYLON COATED BUNA-N AND MELAMINE. BUNA-N CAN WITHSTAND A RADIATION LEVEL OF 1.4×10^6 RADS (REF 7) AND MELAMINE CAN WITHSTAND A RADIATION LEVEL OF BETWEEN 10^6 TO 10^7 RADS (REF 11)

11.2 TIME/TEMPERATURE EFFECTS.

IT HAS BEEN DETERMINED BY THE LIFE CALCULATIONS OF SECTION 10, THAT BUNA-N IS THE MOST TIME/TEMPERATURE SENSITIVE MATERIAL USED IN BOTH THE D2400X AND SL3 SERIES LIMIT SWITCHES. USING THE ARRHENIUS EQUATION IT WAS CALCULATED THAT THE EXPECTED LIFE OF BUNA-N UNDER NORMAL AMBIENT CONDITIONS OF 103°F IS 12.5 YEARS. AT THE MAXIMUM HARSH TEMPERATURE OF 308°F THE EXPECTED LIFE WAS CALCULATED TO BE 65.66 HOURS.

11.3 HARSH ENVIRONMENT

THE NAMCO SL3 LIMIT SWITCH WAS SUBJECTED TO A TEMPERATURE OF 340°F AT 103 PSIG FOR

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11.3 CONT.

FOR 3 HOURS. THE TEMPERATURE AND PRESSURE WERE THEN REDUCED TO 320°F AND 75 PSIG, RESPECTIVELY, AND MAINTAINED FOR AN ADDITIONAL 3 HOURS. THEN THE TEST CONDITIONS WERE REDUCED TO 250°F AND 16 PSIG FOR 18 HOURS, AFTER WHICH THE TEST WAS TERMINATED. THIS TEST WAS CONDUCTED IN A STEAM ENVIRONMENT. (Ref 13) A PROFILE OF THIS TEST IS SHOWN IN FIGURE VIII, OF THIS ANALYSIS. THE SWITCHES FUNCTIONED NORMALLY THROUGHOUT THE 24 HOUR TEST.

11.4 CYCLING

CYCLING DATA WAS NOT OBTAINED

12.0 SUMMARY OF RESULTS AND CONCLUSIONS

12.1 RADIATION

THE RESULTS OF THE LITERATURE SEARCH ON THE MATERIALS USED IN BOTH THE D2400X AND SL3 LIMIT SWITCHES, INDICATE THAT WITH THE EXCEPTION OF THE SWITCHES IN THE REACTOR ISOLATION WITH NUMBERS 01-01 AND 01-02, BOTH OF WHICH ARE SL3 SERIES SWITCHES, ALL SWITCHES CAN WITHSTAND THE MAXIMUM HARSH ENVIRONMENT RADIATION LEVEL OF $<1 \times 10^6$ RADS. THE TWO SWITCHES IN REACTOR ISOLATION (01-01 AND 01-02) WILL BE EXPOSED TO 5×10^7 RADS, A LEVEL IN EXCESS OF THE THRESHOLD

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12.1 CONT.

Level of most of the known materials in the switches. (Tables I and III)

12.2 Time/Temperature effects

Based on an analysis of the materials used in the D2400X and SL3 series switches, using the Arrhenius theory it has been determined that Buna-N is the most time/temperature sensitive material. At ambient conditions the switches have a life of 12.5 years, and at maximum harsh temperatures their life is 63.66 hours. If a design basis event should occur during the 12.5 year normal temperature life, the resultant loss to normal life would be 1.20 days. In the absense of a regular replacement of Buna-N components, the switches cannot be expected to perform their safety related function during an end of life LOCA or HELB

12.3 Harsh environment.

Based on the design basis test (Ref 13) the SL3 switches are qualified for a harsh environment of 340°F at 103 PSIG pressure. Based on the similarity between the SL3 and D2400X, the D2400X should also be qualified for these levels. These levels are in excess of the maximum harsh environment conditions of 308°F and 35 PSIG pressure.

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12.4 Recommendations

It is recommended that type SL3 switches numbered 01-01 and 01-02 located in reactor isolation, either be replaced or sheilded from the source of radiation. These switches contain Buna-N with a radiation threshold of 1.4x10[6] rads and the maximum radiation dose in this area is 5x10[7] rads.

It is recommended that Buna-N components of all switches be replaced on a regularly scheduled basis. The maximum life of Buna-N at normal service temperatures is calculated to be approximatly 12.5 years. These components should be replaced approximately every five (5) years to be safe and conservative.

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13.0 References

1. NUS Analysis 1961-SA-A1 — NMPC, NMP-1 "Pressure and Temperature Model for Reactor Building" Dated 12/9/80

2. NUS Analysis 1961-SA-A2 — NMPC, NMP-1 "Steam Tunnel/Turbine Building High Energy Line Analysis" Dated 11/25/80

3. NUS Analysis 1961-R-1 - "Radiation Environment Specifications for NMP-1" Dated 10/25/81

4. NMPC-NMP-1 Ongoing Qualification Assessment Summary, Revision 4 Dated 11/5/81

5. NAMCO Letter from J. Bendokaitis to Deepak Bahtia, NUS Dated 5/8/81

6. NMPC Supplied Normal Service Conditions. Memo from Dave Green (NMPC) to Deepak Bahtia (NUS) Dated 3/11/81

7. NUS Analysis NUS-LA-A-1 "Determination of Aging Parameters of Acrylonitrile Rubber" Dated 11/23/81

8. NUS Analysis NUS-LA-P-2 "Determination of Aging Parameters of Polyester (Glass Filled)" Dated 11/14/81

9. NUS Analysis NUS-LA-P-6 "Determination of Aging Parameters of Phenolic" Dated 11/23/81

10. NUS Analysis NUS-LA-P-1 "Determination of Aging Parameters of Polyvinyl Chloride" Dated 11/18/81

CLIENT NMPC FILE NO. 1961-N007-001 BY R. Steinberg

SUBJECT Environmental Qualification for NAMCO Limit Switches D2400X and SL3 Checked By [signature]

13.0 Continued

11 NUS Analysis NUS-LA-M-1 "Determination of Aging Parameters of Melamine Formaldehyde" Dated 11/15/81

12 NUS Analysis NUS-LA-L-1 "Determination of Aging Parameters for Lubricants" Dated 11/9/81 (Draft)

13 BWR Equipment Qualification Summary Report Number QSR-014-A-01 Dated 10/16/80

14 NMPC Response to NRC Safety Evaluation Report of 6/8/81 for NMP-1 Dated 9/8/81

15 Internal Correspondence S. Gazda (NUS) to A. Canepa (NUS) CD-ENG-926 Dated 11/23/81 NMPC SER Response Project 1961 Qualified Components - Safety Function Identification

DATE 11/19/81

207-001 By R STEINBERG

MANT OF RIES Checked By [signature]

EQUIPMENT IDENTIFICATION CONDITIONS (REF 1-2-3)					
SYSTEM	I.D. NUMBER	RH	PEAK Radiation (RAD)	DURATION	FIGURE NO.
CID	201-10	70	< 1x10⁶ RAD		FIG V
	83.1-10		"		"
	83.1-12		"		"
	80-16		"		FIG IV
CID	201-32	70	< 1x10⁶ RAD		FIG II
	201.2-03		"		"
	201.2-32		"		"
CIT	201-08	70	< 1x10⁶ RAD		FIG V
	201.2-06		"		"
	201.2-33		"		"
	201-16		"		"
RI	01-05	70	< 1x10⁶ RAD		FIG I
	01-06		"		"
RI	39-05	70	< 1x10⁶ RAD		FIG III
	39-06		"		"
RI	01-01	70	5x10⁷ RAD		FIG VI, VII
	01-02		"		"
RI	01-03	70	< 1x10⁶ RAD		FIG I
	01-04		"		"

DATE 11/19/81

27-001 By R STEINBERG

...ENT FOR Checked By [signature]
...ERIES

COMPONENT MATERIAL (REF 5)	MANUFACTURER RATING	REFERENCE
G.P HYDROCARBON GREASE AND OIL	NOT AVAILABLE	See SECTION 9:3
POLYESTER GLASS FILLED	140°C m?4	REF 8
PHENOLIC MINERAL FILLED	MAX TEMP 16?	REF 9
PHENOLIC NYLON FILLED	NOT AVAILAI4	REF 9
BUNA-N	NO- AVAILA?	REF 7
KOROSEAL (PVC)	:105°C im1	REF 10
FORMICA MELAMINE	NOT AVAILAI7	REF 11
BUNA-N NYLON COATED	NOT AVAIL?	REF 7

DATE 11/19/81

07-001 By R. STEINBERG

...NT FOR Checked By [signature]
SERIES

COMPONENT MATERIAL (REF 5)	MANUFACTURER	
	RATING	REFERENCE
MELAMINE MINERAL FILLED	NOT AVAILABLE	REF 11
POLYESTER GLASS FILLED	140°C	REF 8
LUBRICO M-55 GREASE	NOT AVAILABLE	SEE SECTION 9.3
NYE 181 OIL	-40-275°F	SEE SECTION 9.3
BUNA-N	NOT AVAIL.	REF 7
POLYVINYL CHLORIDE	105°C	REF 10
BUNA-N COATED NYLON	NOT AVAIL.	REF 7

DATE 11/19/81

27-001 By R STEINBERG

UT FOR Checked By [signature]
ERIES

EQUIPMENT Identification (15)

SYSTEM	I. D. NUMBER	Model N
CID	201-32	D24001
	201.2-03	" Bleed
	201.2.32	"
	80.16	" AY
	201-10	" T AND PURGE
	83.1-10	" TANK
	83.1-12	" LECTOR TANK
CIT	201-8	D2400 L
	201.2-06	" Bleed
	201.2-33	"
	201-16	" URGE
RI	01-05	D2400.
	01-06	"
	01-03	SL3C -
	01-04	"
	39-05	SL3 - Aux main Condenser. SOV opens
	39-06	SL3 - L

Fig. 4-1

LIMITING TRANSIENT TEMPEI ATURE AND PRESSURE IN STEAM TUNNEL

FIGURE I
(Ref. 14)

PAGE 36 OF 43
DATE [illegible]
FILE NO. [illegible]
BY R. Steinberg
CHECKED BY [illegible]

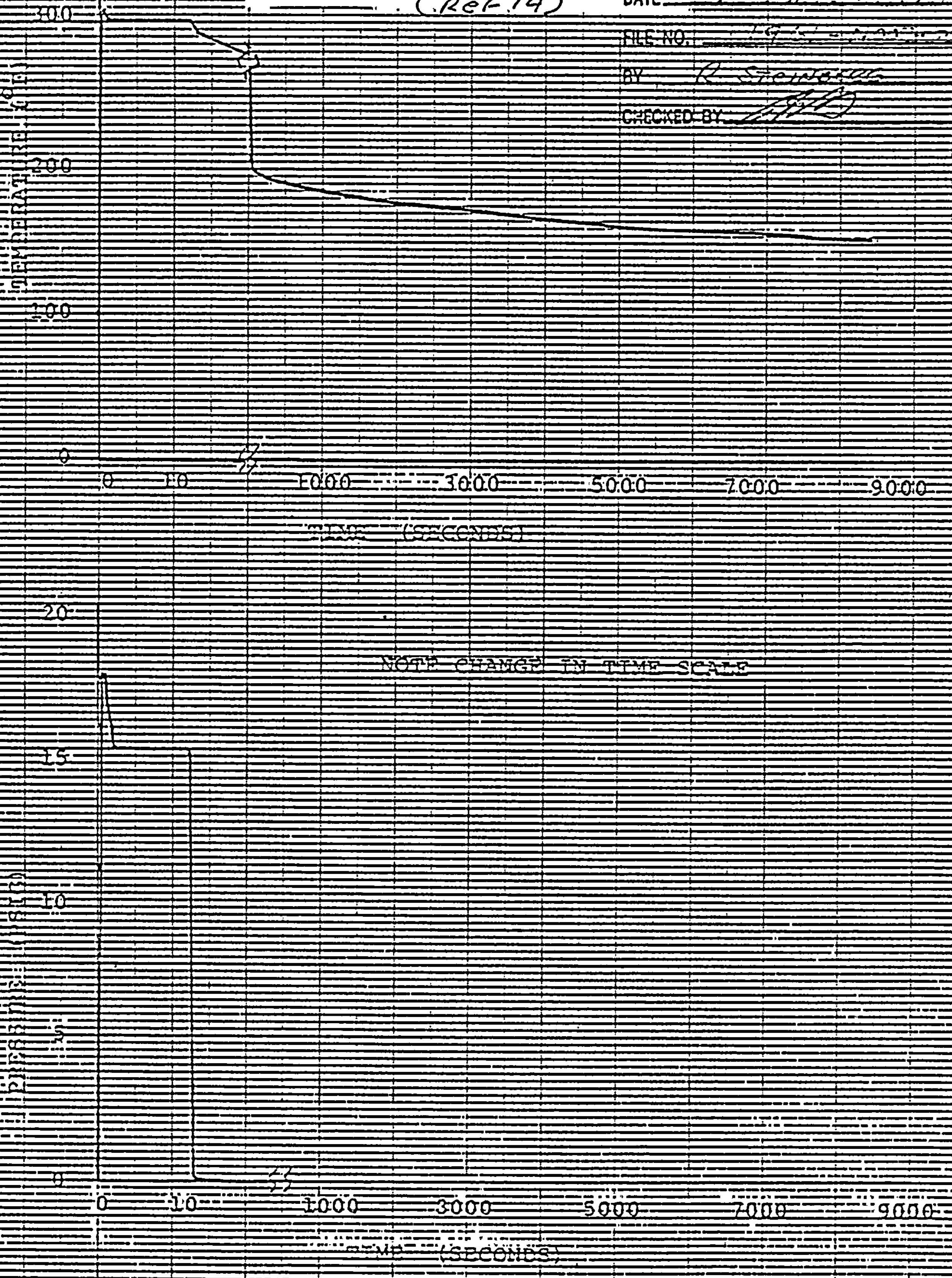


Fig. 4-6

(Ref 14)

LIMITING TRANSIENT TEMPERATURE AND PRESSURE IN EMERGENCY CONDENSER ISOLATION VALVE CUBICLE

FIGURE II

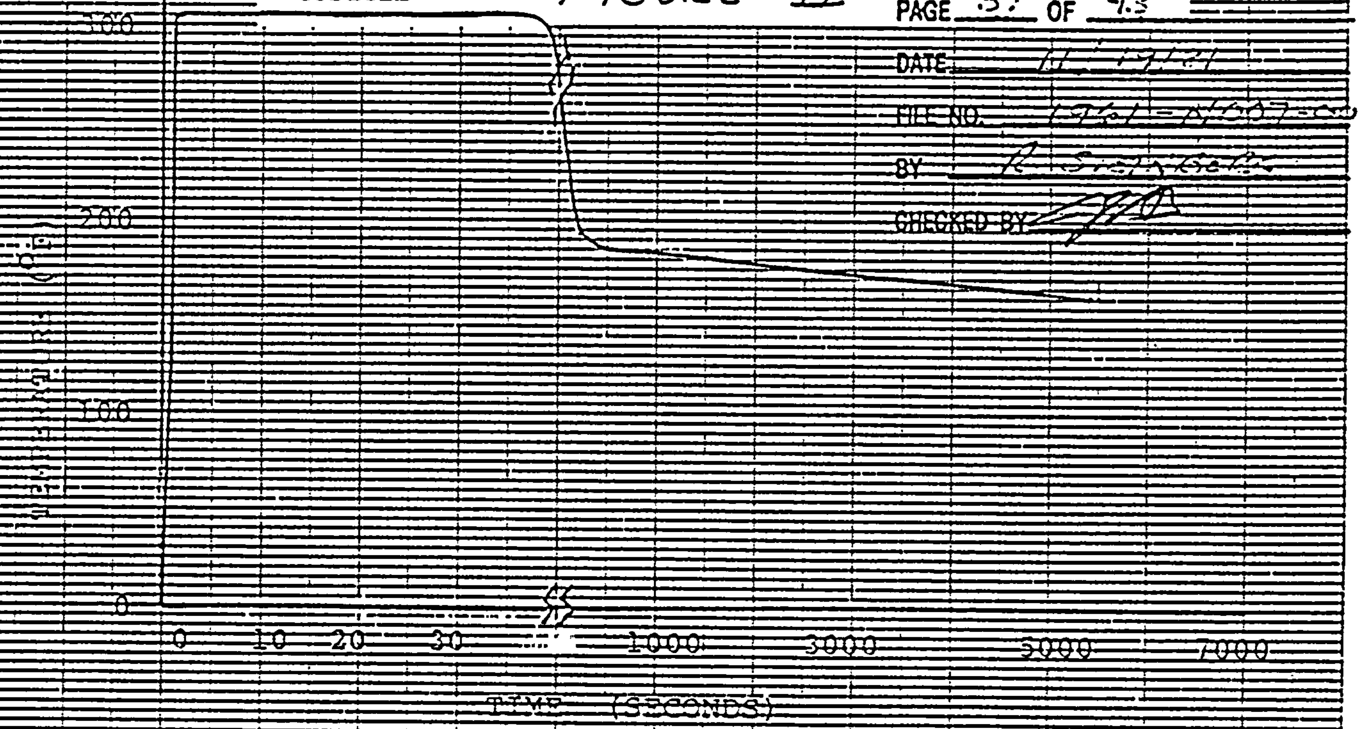
PAGE 37 OF 73

DATE [illegible]

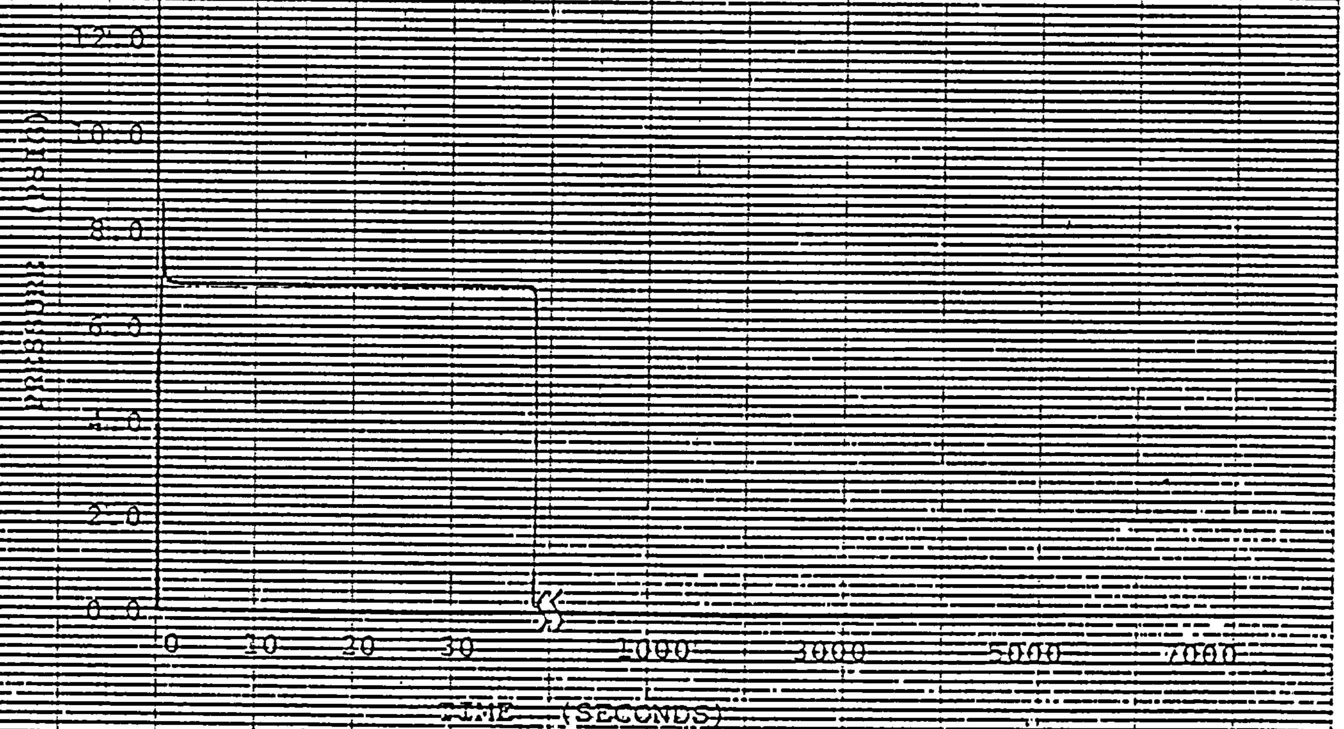
FILE NO. [illegible]

BY [illegible]

CHECKED BY [illegible]

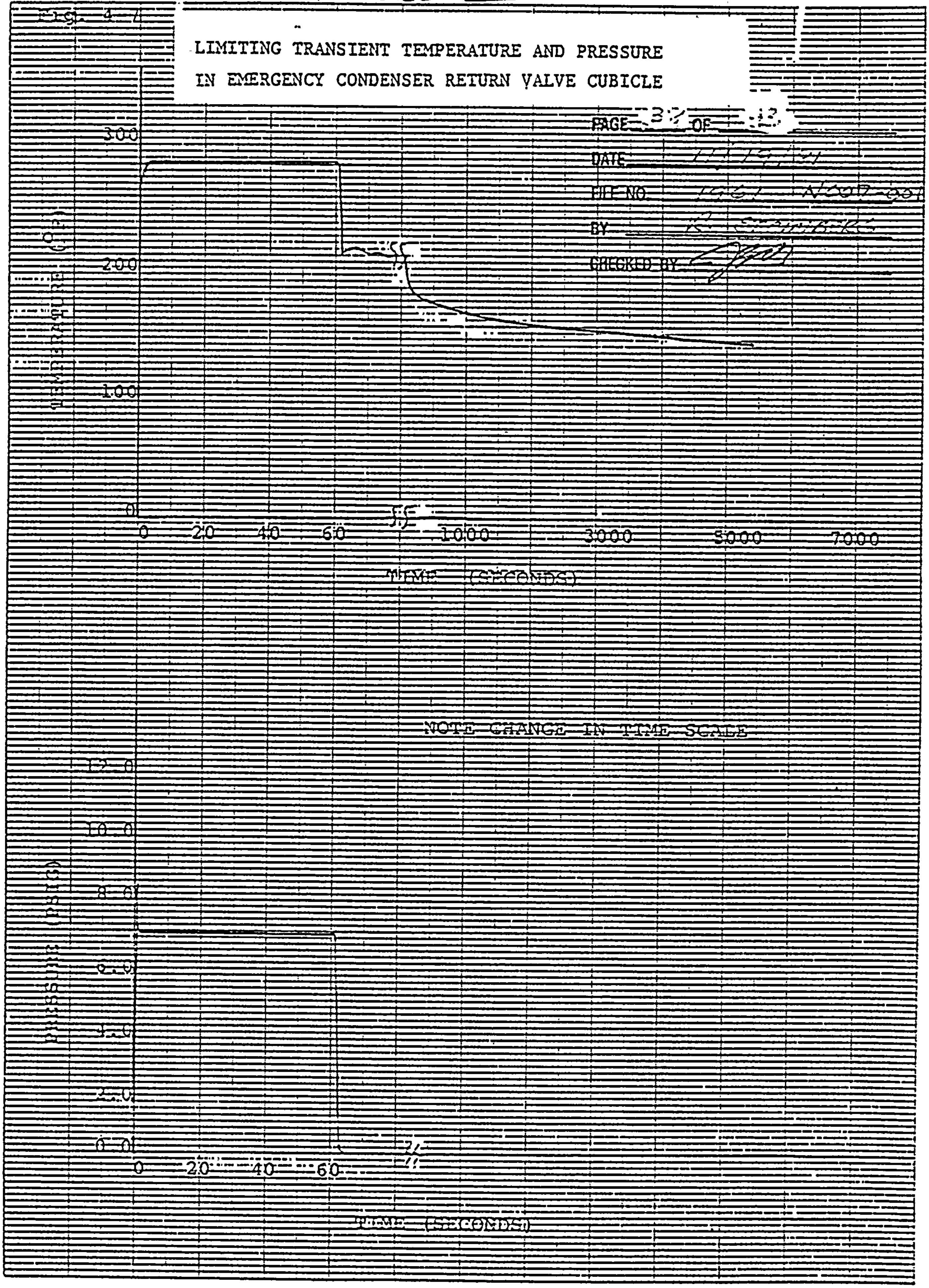


NOTE CHANGE IN TIME SCALE



(Ref 14)

FIGURE III



46 1320

K&E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

(Ref 14)

FIGURE IV

LIMITING TEMPERATURE AND PRESSURE IN OPEN FLOOR AREAS NOT NEAR BREAK LOCATIONS

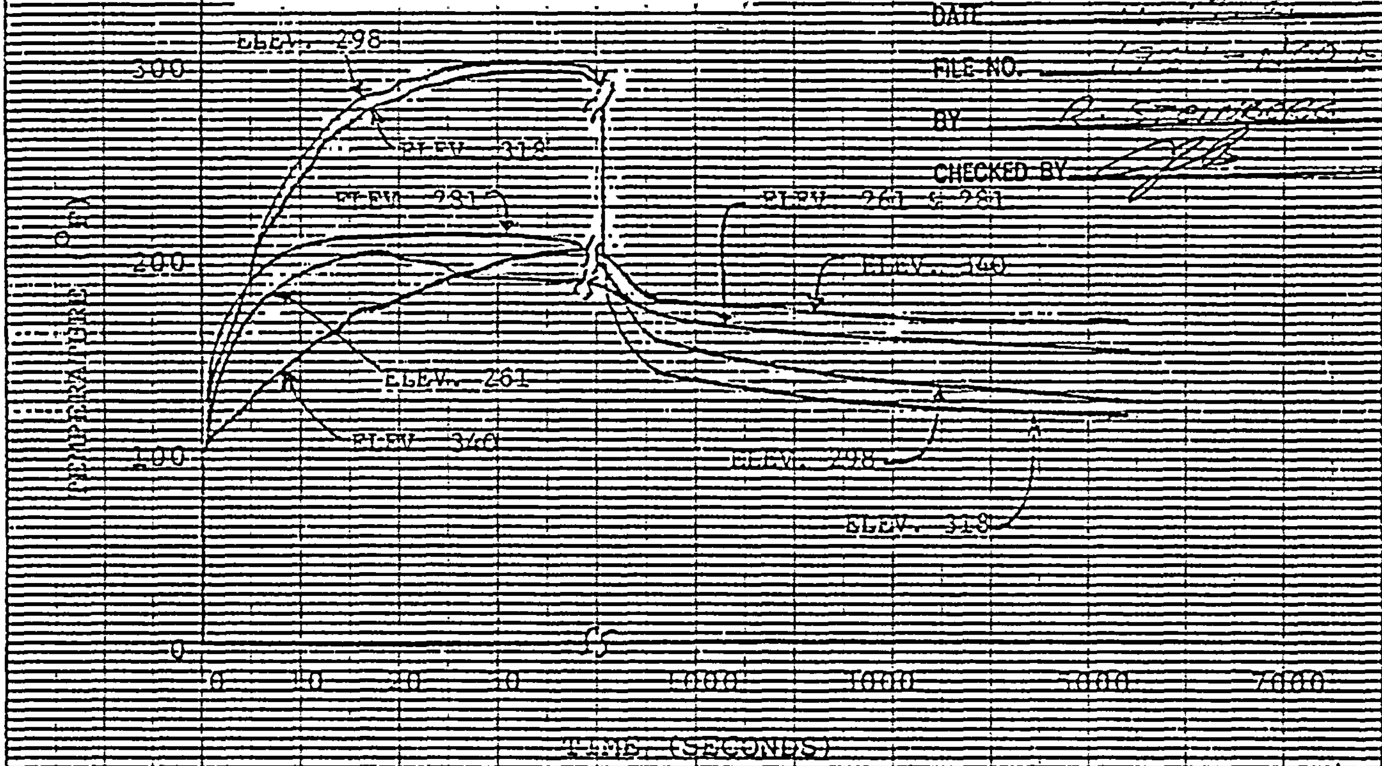
PAGE 39 OF 43

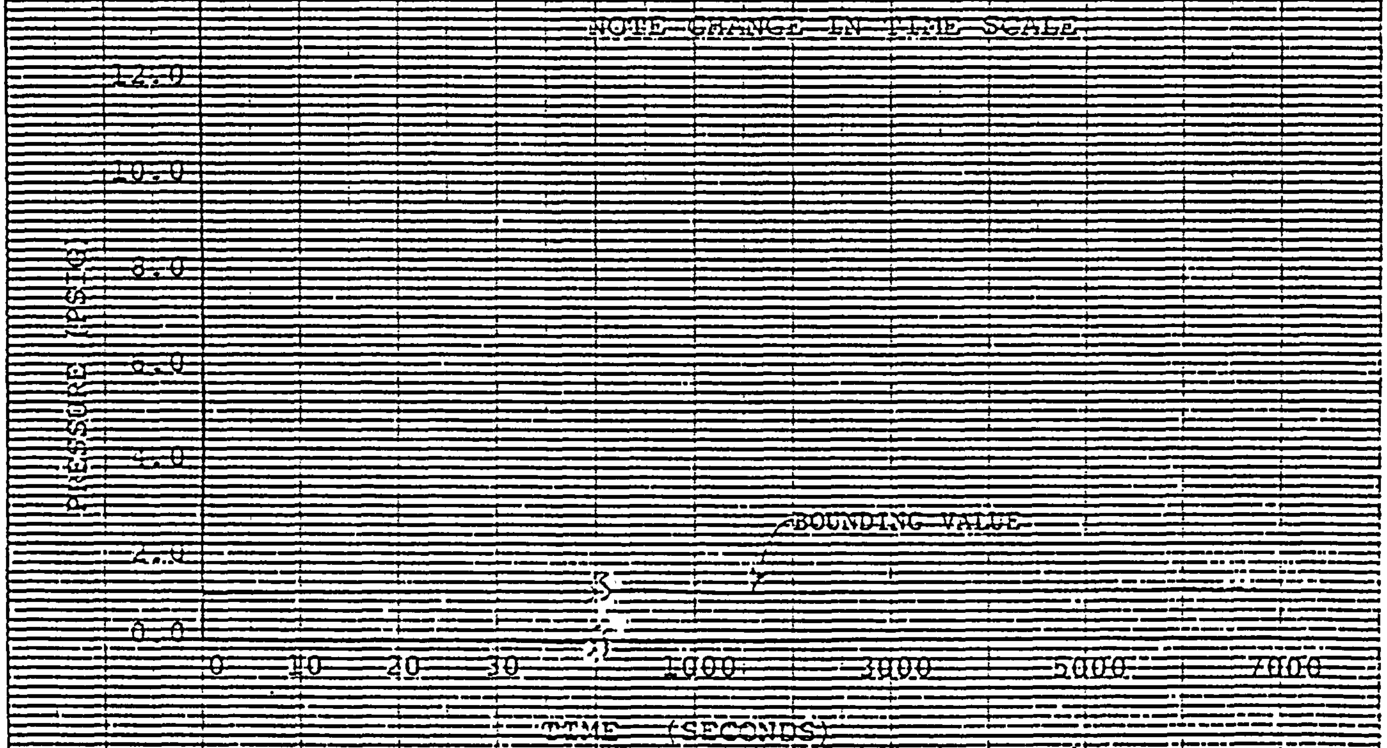
DATE

FILE NO.

BY

CHECKED BY





46 1320

K&E 10 X 10 TO 1/2 INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

(REF 14)

FIGURE V

Fig. 4-11

LIMITING TEMPERATURE AND PRESSURE IN OPEN FLOOR AREAS NOT NEAR BREAK LOCATIONS

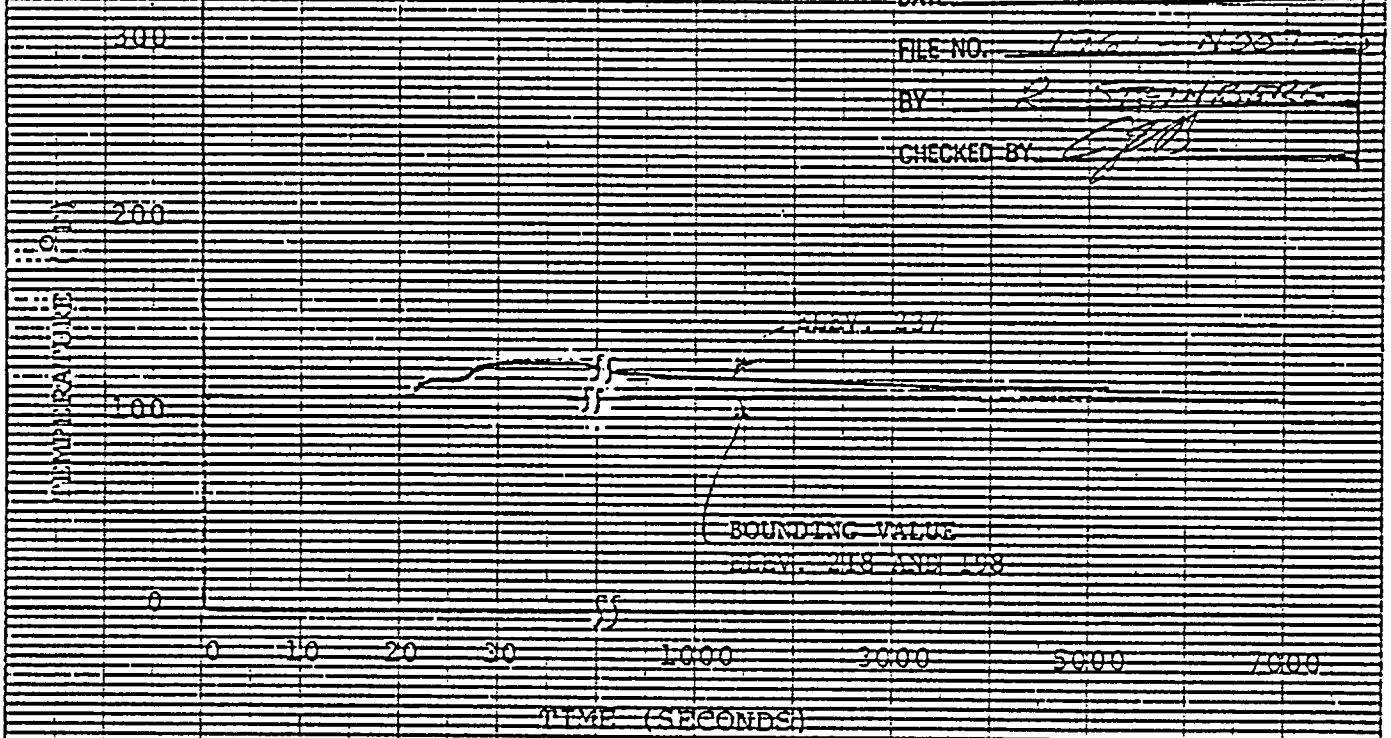
PAGE [illegible] OF [illegible]

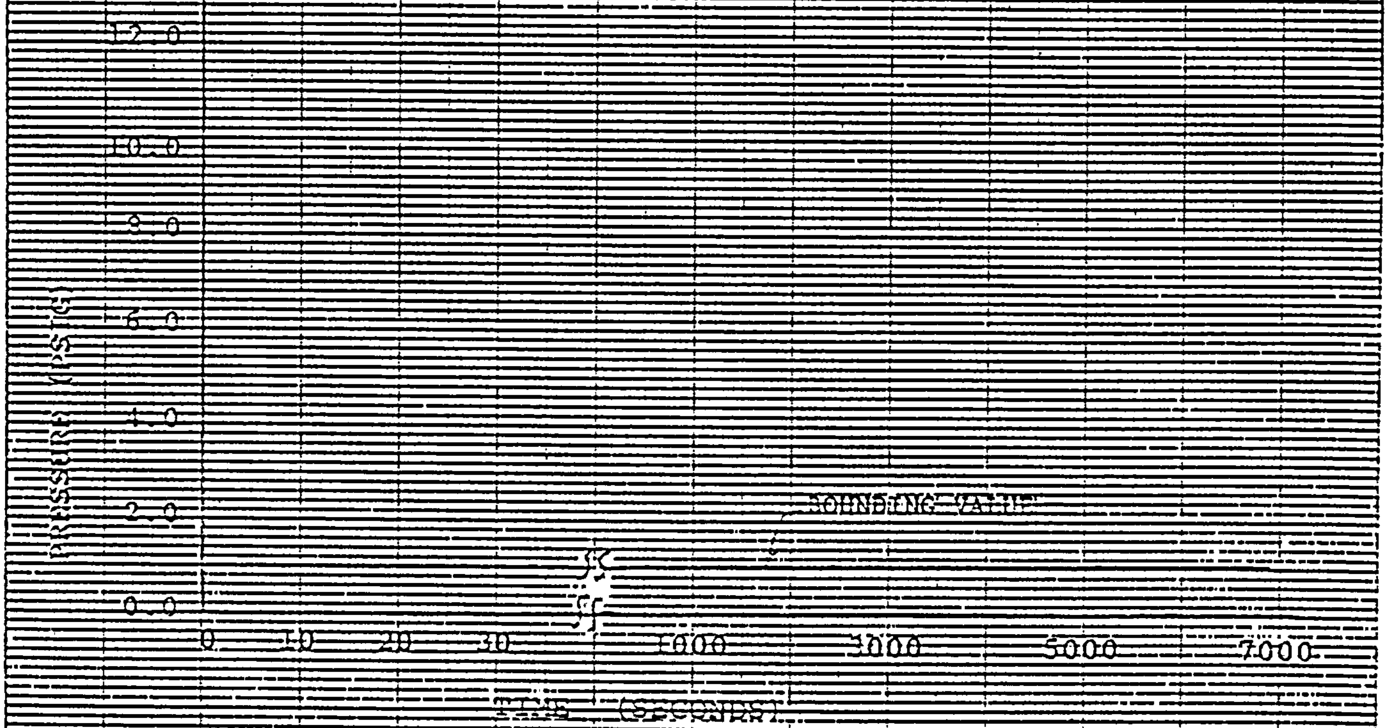
DATE [illegible]

FILE NO. [illegible]

BY [illegible]

CHECKED BY [illegible]

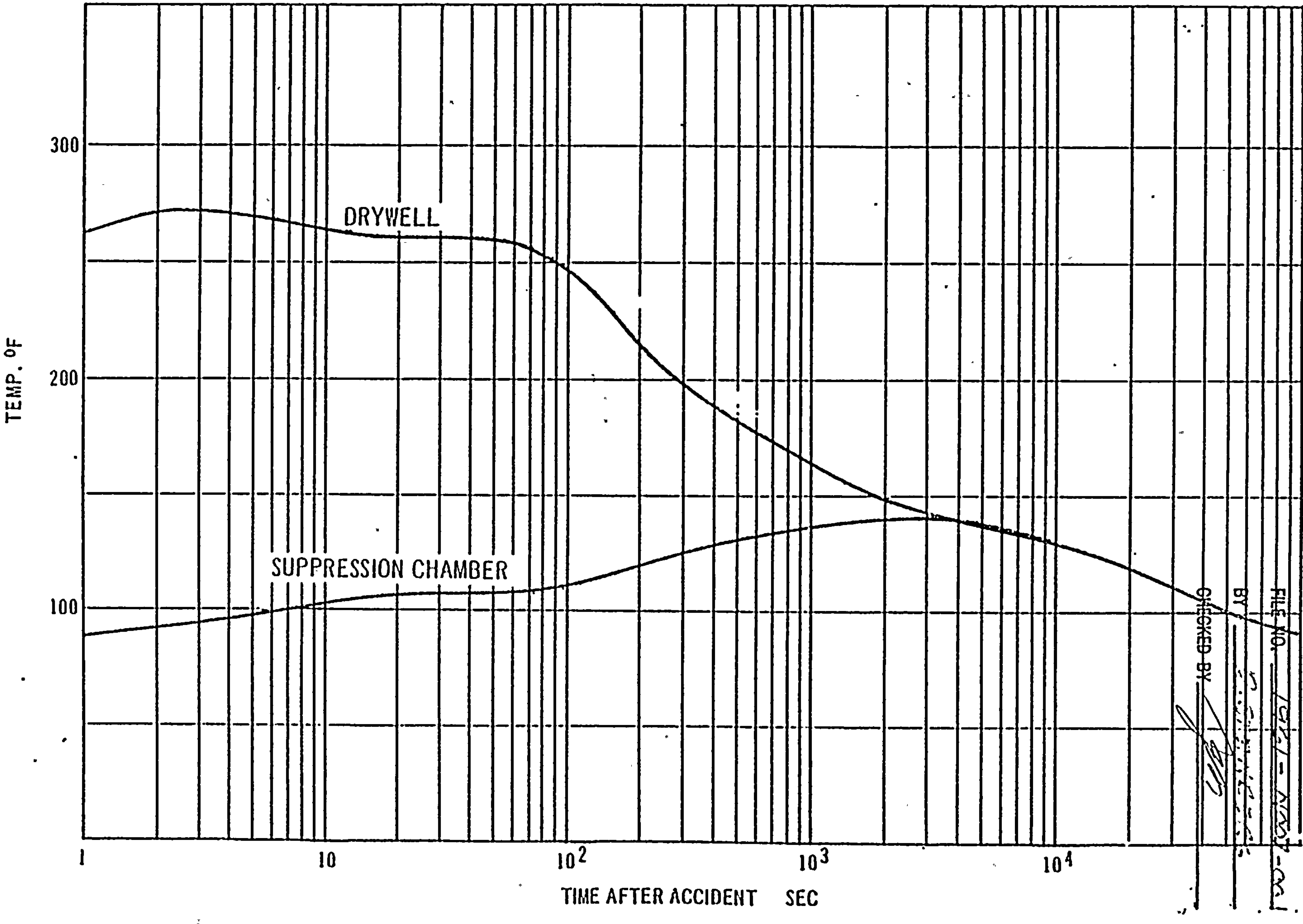




46 1320

FIGURE 4-12A

LOSS OF COOLANT ACCIDENT
CONTAINMENT TEMPERATURE – WITH CORE SPRAY
STRETCH POWER

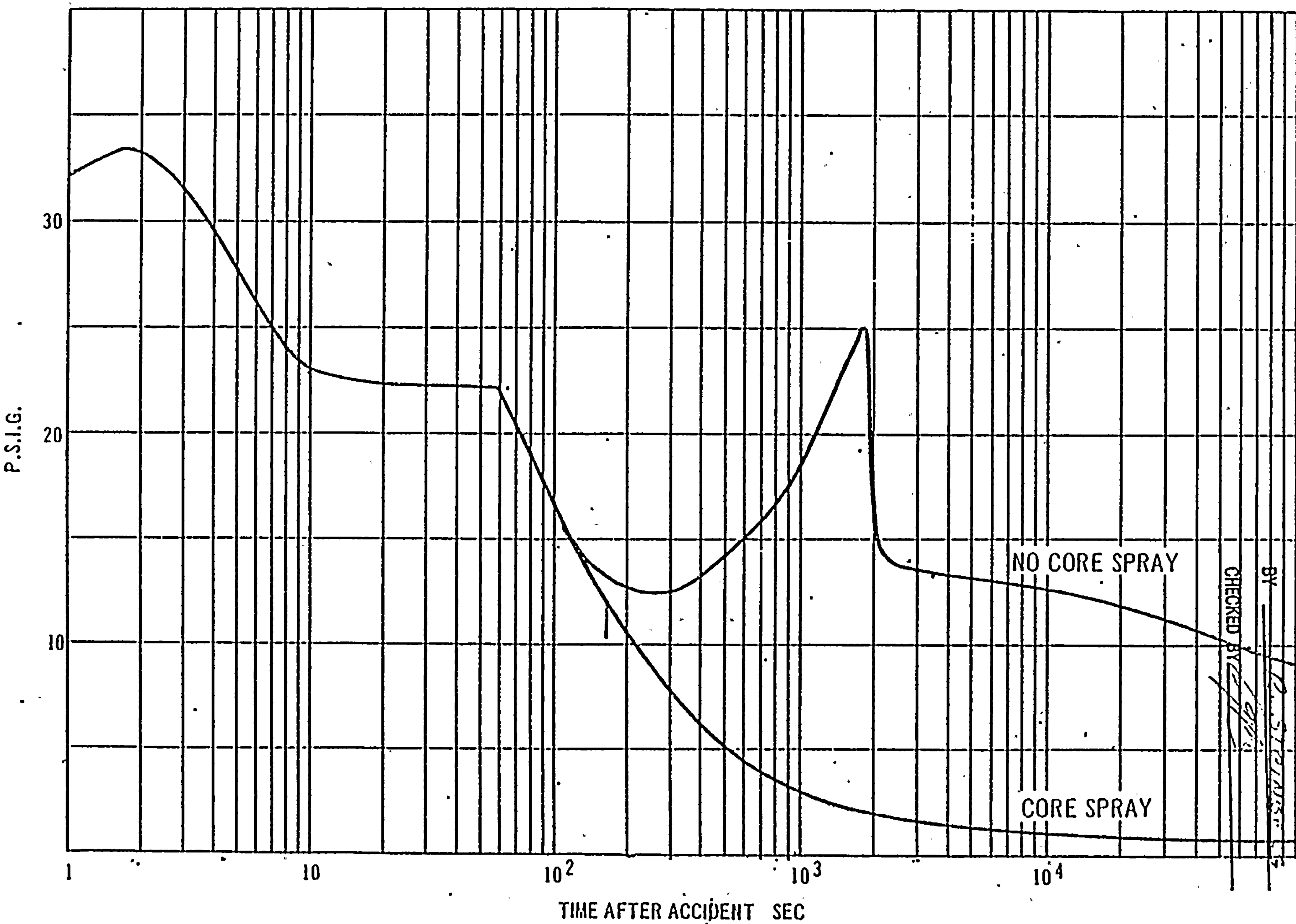


(Ref 14)
FIGURE VI

PAGE 41 OF 43
DATE 11/19/81
FILE NO. [illegible]
BY [illegible]
CHECKED BY [illegible]

FIGURE 4-12B

LOSS OF COOLANT ACCIDENT
DRYWELL PRESSURE
STRETCH POWER



(Ref 14)
Figure VII

PAGE 42 OF 43
DATE 11/19/81
FILE NO. 1961-N007-031
BY
CHECKED BY

REPORT NO. QSR 014-A (Ref 13) PAGE 3 OF 4

FIGURE VIII

PAGE 43 OF 43

[SEIS]MIC QUALIFICATION NONE IDENTIFIED

DATE 11/19/81

FILE NO. 1961-N007-001

BY R. STEINBERG

CHECKED BY [illegible signature]

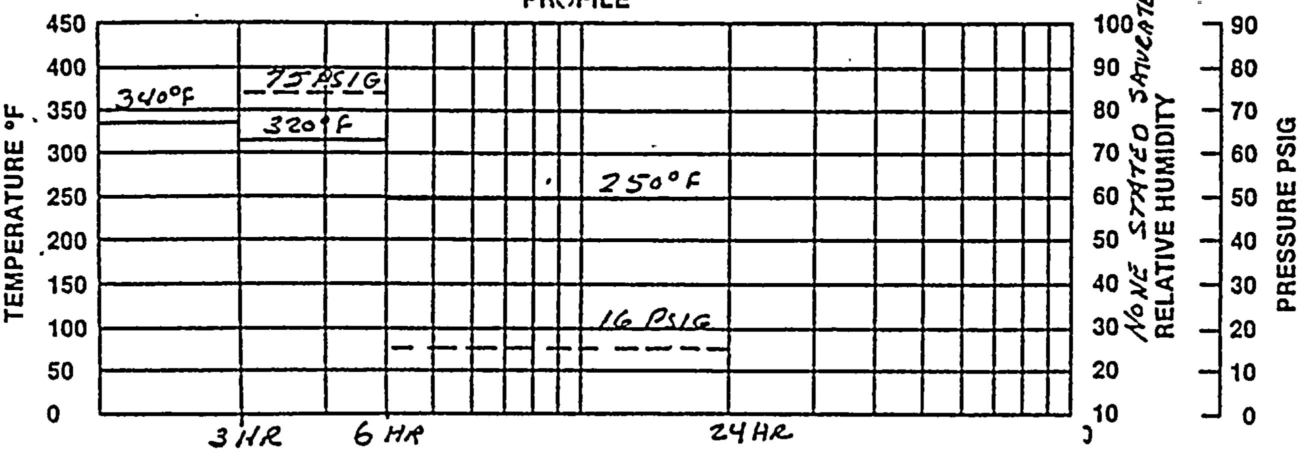
LOW LEVEL SINE SWEEP ☐	SINE DWELL ☐	SINE BEAT ☐
RANGE ____ TO ____ Hz	ACCEL. ____ g's	ACCEL. ____ g's
RATE ____ OCT/MIN.	FREQ. ____ Hz	FREQ. ____ Hz
ACCEL. ____ g's	____ Hz ____ Hz	____ Hz ____ Hz
SING. AXIS ☐	____ Hz ____ Hz	____ Hz ____ HZ
BI-AXIAL ☐	DURATION ____ SEC	OSC./BEAT ____
EQUIP OPER? YES ☐ NO ☐	SING. AXIS ☐	SING. AXIS ☐
	BI-AXIAL ☐	BI-AXIAL ☐
	EQUIP OPER? YES ☐ NO ☐	EQUIP OPER? YES ☐ NO ☐
☐ SEE COMMENT PAGE ____	☐ SEE COMMENT PAGE ____	☐ SEE COMMENT PAGE ____

RANDOM MULTIFREQUENCY ☐	TIME HISTORY ☐	COMPLEX WAVE ☐
RANGE ____ TO ____ Hz	ACCEL. ____ g's	ZPA ____ g's
ZPA ____ g's	DURATION ____ SEC	INPUT DAMPING ____ %
DURATION ____ SEC	NO. OBE'S ____	OUTPUT DAMPING ____ %
DAMPING ____ %	NO. SSE'S ____	NO. OBE'S ____
NO. OBE'S ____	SING. AXIS ☐	NO. SSE'S ____
NO. SSE'S ____	BI-AXIAL ☐	SING AXIS ☐
SING. AXIS ☐ BI-AXIAL ☐	EQUIP OPER? YES ☐ NO ☐	BI-AXIAL ☐
EQUIP OPER? YES ☐ NO ☐		EQUIP OPER? YES ☐ NO ☐
☐ SEE COMMENT PAGE ____	☐ SEE COMMENT PAGE ____	☐ SEE COMMENT PAGE ____

LOCA, MSLB, HELB, RECIRCULATION AREA SEE 4-① & 4-② CONTINUED ☐

103 PSIG

PROFILE



TIME SCALE

CHEMICAL SPRAY		KEY TO PROFILE CHART
NONE ☒	RATE ____ GPM/FT^2	——— TEMP.
CONTENT ____	DURATION ____ SEC	- - - - - PRESSURE
pH ____	EQUIP. OPER? YES ☐ NO ☐	········· RELATIVE HUMIDITY
		—◆—◆— INDICATES EQUIP. CYCLING

WH 1183 Rev. 2 9/4/80

NUS CORPORATION
CONSULTING DIVISION

RECORD OF SYSTEM/COMPONENT ANALYSES

FILE NO.:	NO. OF PAGES:	NUMBER OF VOLUMES OF COMPUTER OUTPUT:
1961-R369-001-R1	30	N/A

CLIENT:	PROJECT NO.:
Niagara Mohawk Power Corporation	1961

ANALYSIS TITLE: Environmental Qualification of Rosemount 510 DU Trip Units.

AUTHOR: M. A. Ippolito

PURPOSE OF ANALYSIS: The purpose of this analysis is to determine if the design of the Rosemount 510 DU Trip Unit is adequate to assure that they will operate on demand during normal and harsh environment conditions.

SUMMARY OF ANALYSIS PROCEDURE AND RESULTS:

Analysis of tests conducted by Rosemount were used to qualify the 510 DU Trip Units for a 40 year life and also for radiation and harsh environment.

DATE COMPLETED:	VERIFICATION REQUIRED:
2/25/82	☑ YES ☐ NO

ANALYSIS REVIEWED AND ACCEPTED: (DISCIPLINE MANAGER)	DATE:
[signature]	2-25-82

ANALYSIS:	BY: (FILE NO.)	DISCIPLINE MANAGER:	DATE:
☐ SUPERSEDED ☐ SUPPLEMENTED			

NUS 202 10 REVISED 0181
(Formerly CD-28 12/77)

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

FILE NO.: 1961-R369-001-R1

PAGE 1 OF 2

ANALYSIS TITLE:
Environmental Qualification of Rosemount 510DU Trip Units

AUTHOR:	NO. OF PAGES:	NO. OF VOLUMES OF COMPUTER OUTPUT:
M. A. Ippolito	30	N/A

VERIFICATION SCOPE (CHECK AS APPLICABLE):

- [x] METHOD OF ANALYSIS
- [x] ASSUMPTIONS
- [x] INPUT INFORMATION
- [ ] COMPUTER CODE APPLICATION
- [ ] CHECK OF SAMPLE CALCULATION
- [x] SPOT CHECK OF MATHEMATICS
- [x] REASONABLENESS OF RESULTS
- [ ] COMPLETE CHECK OF MATHEMATICS
- [ ] PARTIAL INDEPENDENT ANALYSIS

BUDGET: (APPROXIMATE) 1/4 MANDAYS

DESIRED COMPLETION DATE: ASAP

DESCRIPTION OF VERIFICATION—ACTIVITIES, FINDINGS AND RESOLUTION:

NONE

NUS 203A 10 REVISED 0181
(Formerly CD-29(1) 12/77)

VERIFIER'S SIGNATURE: [signature]	DATE: 2/25/82
ACCEPTANCE BY: (DISCIPLINE MANAGER) [signature]	DATE: 2-25-82

NUS CORPORATION
CONSULTING DIVISION

ANALYSIS VERIFICATION CHECKLIST

ANALYSIS TITLE: Environmental Qualification of Rosemount 5200U Trip Units

ANALYSIS FILE NUMBER: 1961-R369-001-R1

INDICATE "YES, NO, OR N/A (NOT APPLICABLE)," FOR EACH ITEM AND INCLUDE IN ANALYSIS PACKAGE WITH RECORD OF ANALYSIS VERIFICATION	YES	NO	N/A
METHOD OF ANALYSIS			
IS THE METHOD USED APPROPRIATE CONSIDERING THE PURPOSE AND TYPE OF ANALYSIS AND THE USE AND ACCEPTABILITY OF THE RESULTS (i.e., MARGIN TO LIMITS)?	[X]	[ ]	[ ]
IS THE METHOD IN ACCORDANCE WITH CODES, STANDARDS, AND REGULATORY REQUIREMENTS?	[X]	[ ]	[ ]
HAS THE METHOD BEEN EMPLOYED ELSEWHERE IN INDUSTRY OR IN LICENSE APPLICATIONS?	[X]	[ ]	[ ]
ASSUMPTIONS			
ARE ASSUMPTIONS NECESSARY TO PERFORM THE ANALYSIS ADEQUATELY DESCRIBED AND REASONABLE?	[X]	[ ]	[ ]
WHERE NECESSARY, ARE THE ASSUMPTIONS IDENTIFIED FOR SUBSEQUENT RE-VERIFICATIONS WHEN THE DETAILED DESIGN ACTIVITIES ARE COMPLETED?	[X]	[ ]	[ ]
INPUT INFORMATION			
ARE THE INPUTS INTO THE ANALYSIS STATED AND THEIR SOURCE IDENTIFIED?	[X]	[ ]	[ ]
IS THE INPUT INFORMATION FROM THE LATEST AVAILABLE REVISION TO THE DOCUMENT?	[X]	[ ]	[ ]
IS THE STATUS (PRELIMINARY, CONCEPTUAL, ETC.) OF THE INPUT SOURCE IDENTIFIED FOR LATER CONFIRMATION OF THE VALIDITY OF THE INPUT?	[X]	[ ]	[ ]
ARE THE INPUTS SUFFICIENT CONSIDERING THE PURPOSE OF THE ANALYSIS?	[X]	[ ]	[ ]
COMPUTER CODE APPLICATION			
ARE ALL CODES USED IDENTIFIED ALONG WITH SOURCE, COMPUTER TYPE, INPUTS, AND OUTPUTS?	[ ]	[ ]	[X]
HAS THE CODE BEING USED BEEN ADEQUATELY VERIFIED?	[ ]	[ ]	[X]
IS THE CODE SUITABLE FOR THE PRESENT ANALYSIS?	[ ]	[ ]	[X]
DOES THE COMPUTER MODEL (NODING, TIME STEPS, ETC.) ADEQUATELY REPRESENT THE PHYSICAL SYSTEMS?	[ ]	[ ]	[X]
REASONABLENESS OF RESULTS			
IS THE MAGNITUDE OF THE RESULT REASONABLE?	[X]	[ ]	[ ]
ARE THE DIRECTION OF TRENDS REASONABLE?	[X]	[ ]	[ ]

PREPARED BY: R. J. Stiling **DATE:** 2/25/82

NUS 204 10 REVISED 0181
(Formerly CD-30 Rev. 1)

FINAL ANALYSIS REVIEW CHECKLIST

Project #/Project Title   Client

Date: 2/25/82

Analysis File Title: Environmental Qualification of Rosemount 5100U Trip Units

Analysis File Number: 1961-R369-001-R1

Checklist Item		Yes	N/A
1.	Unique Analysis File Number assigned to the file.	X	
2.	Analysis recorded on CD-60	X	
	a. pages numbered	X	
	b. total pages specified	X	
	c. all pages dated	X	
	d. client identified on each page	X	
	e. correct file number on each page	X	
	f. author(s) specified on each page	X	
	g. subject specified on each page	X	
	h. verifier initials on each page	X	
3.	Analysis File includes:		
	a. client identification	X	
	b. analysis file number	X	
	c. analysis title	X	
	d. author(s) identification	X	
	e. description of the purpose of the analysis	X	
	f. discussion of the general method of analysis	X	
	g. identification of input information source	X	
	h. identification of input information status	X	
	i. major assumptions used in performing the analysis	X	

Date: 2/25/82

3. (Continued)

j.	important references, including material properties	X	
k.	identification of specific versions of codes used	X	
l.	detailed calculation	X	
m.	listing of computer input		X
n.	microfiche of computer output		X
o.	summary of results	X	

4.	Record of analysis provided onn CD-28	X	
5.	All applicable entries on CD-28 correct.	X	
6.	All referenced NUS internal memos included in analysis file.		X
7.	All referenced telecons included in analysis file.		X
8.	Separate computer output labeled with analysis file number.		X
9.	Record of analysis file verification on CD-29.	X	
10.	All entries on CD-29 completed and correct.	X	
11.	Item (7) of CD-29 completed and comments numbered	X	
12.	Verification checklist CD-30 included.	X	
13.	Computer code used verified per QAI 3.5.		X
14.	Corrected items crossed out clearly enough to show on Xerox copies.	X	
15.	List of input information and major assumptions checked for commpleteness.	X	
16.	Documents Complete (Page Count)	X	
17.	Documents Legible and Reproducible	X	
18.	All Documents Identified on Index Received	X	
19.	Documents Properly Paginated	X	
20.	Documents Identified to Project/Item	X	
21.	All Unsatisfactory Conditions Resolved (List)	X	

22. Remarks: None

Reviewed by: [signature] 2/25/82
Date

NUS CORPORATION

DATE 2/25/82.

CLIENT NMPC FILE NO. 1961-R369-001-R1 BY M. A. Ippolito

SUBJECT Analysis of Rosemount 510 DU Transmitter Checked By [illegible]

Environmental Qualification of Rosemount 510.DU Trip Units For Use in Niagara Mohawk Corporation's Nine Mile Point - Unit 1 Nuclear Power Generating Station

CLIENT NMPC FILE NO. 1961-R369-001-R1 BY M. A. Ippolito
SUBJECT Analysis of Rosemount 510 DU Trip Unit Checked By [signature]

Table of Contents

CLIENT NMPC FILE NO. 1961-R369-001-R1 BY M.A. Appolito

SUBJECT Analysis of Rosemount 510 DU Trip Units Checked By [initials]

Table of Contents (Cont'd.)

List of Tables

CLIENT NMPC FILE NO. 1961-R369-001-R1 BY M-A-Ippolito

SUBJECT Analysis of Rosemount 510 DU Trip Units Checked By [signature]

List of Tables (Cont'd)

Appendices

1.0 Client Identification

Niagara Mohawk Power Corporation

2.0 Analysis File Number

NUS-1961-R369-001-R1

3.0 Analysis Title

Environmental Qualification of Rosemount 5100U Trip Units

4.0 Author Identification

M. A. Ippolito

5.0 Purpose of Analysis

The purpose of this analysis is to determine if the design of Rosemount 5100U Trip Units is adequate to assure that they will operate on demand to meet system performance requirements under normal and harsh environmental conditions at NMP 1.

CLIENT NMPC FILE NO. 1961-R369-001-R5 BY M. A. Ippolito

SUBJECT Analysis of Rosemount 510 DU Trip Units Checked By RS

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6.0 Input Information

6.1 Equipment Identification

The equipment to be qualified consists of Rosemount 510 DU Trip Units used at NMP-1 in the following systems. (Ref. 12.7)

System	I.D. NO.	Equipment Description	Serial No.
AI	01-24(A-H)	Master	UNKNOWN
AI	201.2-476A	Master	809
AI	201.2-476B	Master	9285
AI	201.2-476C	Master	9286
AI	201.2-476D	Master	5755
AI	36-06A	Master	5058
AI	36-06B	Master	5056
AI	36-06C	Master	5053
AI	36-06D	Master	5049
RVI	36-03A	Master	9076
RVI	36-03B	Master	9077
RVI	36-03C	Master	4848
RVI	36-03D	Master	9078
RVI	36-03A	Slave	2853
RVI	36-03B	Slave	2868
RVI	36-03C	Slave	2850
RVI	36-03D	Slave	2852
RVI	36-04A	Master	5164
RVI	36-04B	Master	5163
RVI	36-04C	Master	5165
RVI	36-04D	Master	5162
RVI	36-08A	Master	9288
RVI	36-08B	Master	4208
RVI	36-08C	Master	4205
RVI	36-08D	Master	9287
RVI	36-08A	SLAVE	2878

CLIENT NMPC FILE NO. 1961-R369-001-R1 BY M.Q. Ippolito
SUBJECT Analysis of Rosemount 510 DU Trip Units Checked By. [illegible]

System	I.D. No.	Equipment Description	Serial no.
RVI	36-08B	Slave	2856
RVI	36-08C	Slave	2860
RVI	36-08D	Slave	2876
RVI	36-05A	Master	5045
RVI	36-05B	Master	9539
RVI	36-05C	Master	9075
RVI	36-05D	Master	5044
RVI	36-07A	Master	4206
RVI	36-07B	Master	4209
RVI	36-07C	Master	4207
RVI	36-07D	Master	4204
RVI	36-07A	Slave	2839
RVI	36-07B	Slave	2841
RVI	36-07C	Slave	2844
RVI	36-07D	Slave	2869

6.2 Materials

The equipment will be qualified based on tests conducted by Rosemount. Therefore, this analysis will be based on the Rosemount tests rather than an individual material breakdown.

6.3 Safety Related Function

I.D. NO. 201.2-476 (A-D), System: AI, Type: Master

Initiates Containment Spray, Core Spray, ADS, Drywell Isolation on High Drywell Pressure (C-18022-C, 2) (Ref 12.4)

CLIENT NMPC FILE NO. 1961-R369-001-R7 BY M.A. [illegible]
SUBJECT Analysis of Rosemount 510 DU Trip Units Checked By [illegible]

I.d. NO.: 36-06 (A-D), System: AI, Type: Master

Initiates RPS, Emergency Condenser Isolation On High Flow. (C-18017-C) (Ref. 12.4)

I.d. No.: 01-26 (A-H), System AI, Type: Master

Steam Line Flow Detection, Initiates RPS On High Flow (C-18006-C) (Ref 12.4)

I.d. NO.: 36-04 (A-D), System: RVI, Type: Master

Initiates RPS, Closes Main Steam Isolation Valve on Reactor Low Level. (C-18015-C) (12.4)

I.d. NO.: 36-05 (A-D), System: RVI, Type: Master

Initiates RPS, Auto Depressurizes On Reactor Low-Low Level (C-18015-C) (Ref. 12.4)

I.d. NO.: 36-03 (A-D), System: RVI, Type: Master + Slave

Initiates RPS, Scram Reactor/Trip Turbine Stop Valves On Reactor High or Low Level (C-18015-C) (Ref. 12.4)

I.d. NO.: 36-07 (A-D), System: RVI, Type: Master Slave

Initiates RPS, Scram Reactor/Trip Turbine Stop Valves on Reactor High Pressure. (C-18015-C) (Ref 12.

CLIENT NMPC FILE NO. 1961-R369-001-R1 BY M.A. Esposito

SUBJECT Analysis of Rosemount 510 DU Trip Units Checked By [signature]

I.d. NO.: 36-08 (A-D), System: RVI, Type: Master Slave

Initiates RPS, Actuates Emergency Cooling On Reactor High Pressure (C-18025-C) (Ref. 12.4)

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SUBJECT Analysis of Rosemount 510DU Triplets Checked By [illegible]

6.4 Service Conditions

6.4.1 Normal Service Conditions

The following conditions are the normal service conditions expected at NMP-1.

- Temperature — 103 °F (Ref 12.5)
- Pressure — 0 psig
- Relative Humidity — 50-90% (assumed)
- Radiation — 7×10^4 rads (assumed)
- Operational Cycling — (To be specified by NMPC) (1 cycle/year assumed)

6.4.2 Harsh Environment Conditions

The following harsh environment conditions are the peak conditions obtained by NUS from NMPC (Ref 12.3)

- Temperature — 212 °F
- Pressure — 1 psig
- Relative Humidity — 100%
- Radiation — 8.3×10^4 rads (Ref 12.6)

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SUBJECT Analysis of Rosemount 510 DU Trip Units Checked By [signature]

o Duration 1 hour

o Operational Cycling 1 trip (assumed)

7.0 Method of Analysis

7.1 Materials

Time/Temperature aging of the subject equipment will be qualified by analysis of a test conducted by Rosemount. Analysis of the time/temperature effects on the individual materials will not be addressed.

7.2 Radiation

Radiation qualification will be based on a test conducted by Rosemount. The radiation effect on the individual materials will not be addressed.

7.3 Time Temperature Effects

The present state of the art allows acceleration of the aging effects of temperature by subjecting a material or component to increased temperatures for a relatively short duration. It is known that the degradation process can be defined by a single temperature-dependent reaction that follows the Arrhenius equation:

$$K = Ae^{-(E_a/k_B T)} \qquad (1)$$

Where,

K = Reaction rate
A = Frequency factor
e = Exponent to base e
Ea = Activation energy
K_B = Boltzmann's Constant
T = Absolute temperature

Equation (1) can also be expressed in a form which yields an expected lifetime of the material at a specific temperature. This form is:

$$\ln(t_i) = E_a/k_B (1/T_i) + I \qquad (2)$$

Where,

ln = Natural logarithm
t_i = Expected life at temperature T_i (hours)
T_i = Service temperature (°K)
I = Constant (intercept)

Equation (2) can also be represented in a linear regression line as:

$$Y_i = M x_i + I \qquad (3)$$

Where,

$Y_i = \ln(t_i)$

$X_i = 1/T_i$
$M = E_a/K_B$
I = Constant (Intercept)

For the purpose of this analysis, Equation (2) was used to calculate the expected life of the component trip unit. The activation energy and intercept were calculated based on tests conducted by Rosemount. The activation energy and intercept were then used to calculate the expected life of the 510DU Trip Unit under the maximum harsh environment temperature conditions. If the life of the 510DU Trip Unit calculated at the harsh environment temperature exceeded 40 years, no further analysis was done because the maximum harsh environment temperature envelopes all other temperature conditions. If the expected life did not exceed 40 years, then the expected life at ambient conditions was also calculated and a determination of the expected life was made using the combination of 40 years at normal service conditions and the specified duration of a design basis event. Comparison will also be made to the method Rosemount used.

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SUBJECT Analysis of Rosemount 5100U Trip Units Checked By RB

7.4 Harsh Environment

For each temperature and relative humidity condition, 510 DU trip units were placed in the humidity chamber, and the temperature and humidity adjusted to the test level (Ref. 12.1) Tests were conducted for 12.5 hours for each of the following conditions:

Temperature	Relative Humidity
40°F	10%
40°F	60%
120°F	10%
120°F	60%

The trip point was readjusted and the following tests were run for 12.5 hours each:

Temperature	Relative Humidity
40°F	20%
40°F	90%
156°F	20%
156°F	99%

The chamber was then increased to 171°F for one hour. No pressure conditions were mentioned and is assumed that the tests were run at normal atmospheric pressure. The unit was then subjected to and passed

CLIENT NMPC FILE NO. 1961-R369-001-R1 BY M. A. Ippolito

SUBJECT Analysis of Rosemount 510 DU Trip Units Checked By

the acceptance criteria specified by Rosemount. Two 510 DU Trip Units were also subjected to better than 3000 hours at 212°F during the aging tests without failure.

7.4.1 Radiation

The test units were placed in a cesium-137 gamma ray test chamber, and the exposure rate was set a 1.1 R/hr. The units were exposed to the radiation for 1.5 hours, rotated 180° and exposed for another 1.5 hours. The dosage rate was increased to 10^4 rads/hour and the units were operated until a total of 1.9×10^5 R was achieved. Testing was done at 70-80°F, 20-90% relate humidity and 14.7 psia (Ref 12.1) The unit successfully completed the acceptance test specified by Rosemount after being exposed to the radiation.

7.5 Operational Cycling

There was no operational cycling conducted. Based on operating experience and the design of the 510 DU Trip Units, it is felt that the 510 DU Trip Units are capable of functioning for an assumed 40 cycles in a 40 year life and 1 cycle during a Harsh environment conditions.

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SUBJECT Analysis of Rosemount 510 DU Trip Unit Checked By [initials]

8.0 Major Assumptions

- It is assumed that the 510DU Trip Units will be cycled once every year plus once during a LOCA.
- It is assumed that the meters on the 510 DU Trip Units are not required to perform the safety function and are therefore exempted from this analysis.

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SUBJECT Analysis of Rosemount 510DU Trip Units Checked By RJS

9.0 Detailed Calculations and Analysis

Four Master Trip Units with Analog Output# were installed in temperature chambers; two units at 212°F and two units at 250°F (Ref. 12.2).
The two units at 212°F were tested for 3124 hours each, without failure.
The two units at 250°F were tested until the following number of failures occured-
Unit 1 - The first failure occured after 748 hours. At this time the trip point adjustment potentiometer had to be replaced because the trip point was intermittent. The second failure occured after an additional 894 hours, at which time a fuse had to be replaced because it was open circuit.
Unit 2 - The first failure occured after 594 hours at which time a fuse had to be replaced because it was open circuit. The second failure occured after an additional 164 hours, at which time the trip adjustment potentiometer and the reset differential potentiometer had to be replaced because the trip point was intermittent. (Note: The reset differential potentiometer was replaced first but it did not correct the operation of the unit. Next, the trip point adjustment potentiometer was replaced and the unit functioned properly. Therefore the replacement of the reset differential potentiometer was not necessary.). The third

failure occurred after an additional 894 hours, at which time a fuse had to be replaced because it was open circuit. The method Rosemount used to determine the expected life is as follows: For the units that were subjected to the 250°F temperature, Rosemount took the total number of hours the two units operated (3276), and divided it by the total number of failures (5), for an average mean time to failure of 655 hours. The units at 212°F were aged for 3124 hours each. Using these two data points (212°F, 3124 hours and 250°F, 655 hours), a line was drawn and extrapolated to 95°F (see fig 1 Apdx A), which gave an expected life of 168 years. This, also, provided an expected life of 101.67 years at 103°F the specified ambient at NMP-1. It is felt, however, that a better approach would be to use the method outlined in section 7.3 and to use the number of hours to the first failure (594) for the unit tested at 250°F. Using these two points (212°F, 3124 hours and 250°F, 594 hours), and linear regression the activation energy is determined to be 0.996 eV and the intercept is a −22.9425. Thus, providing the following equation:

$$\ln(t_i) = \frac{0.996\ eV}{8.617 \times 10^{-5}}(1/T_i) - 22.9425 \quad (4)$$

Substituting the harsh environment temperature 212°F (373°K) into equation (4) the expected

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SUBJECT Analysis of Rosemount 510 DU Trip Unit Checked By: [signature]

life is 3.1199×10^3 hours $\times \frac{1 \text{ year}}{8760 \text{ hours}} = 0.3561$ years.

Since the life expectancy is less than 40 years, the expected life at the ambient temperature of 103°F (312.44°K) will be calculated. Substituting 312.44°K into equation (4), the expected life at ambient is 1.266×10^6 hours $\times \frac{1 \text{ year}}{8760 \text{ hours}} = 144.5284$ years.**

To determine if the unit can function during a LOCA after being aged 40 years the following method method will be used:

1.) Subtract 40 from 144.5284 which leaves 104.5284 years.

2.) Using the following form of the Arrhenius equation, determine the life at 212°F:

$$t_2/t_1 = \exp[(E_a/k_B)(1/T_2 - 1/T_1)] \qquad (5)$$

where,

t_2 = expected life left at 103°F (104.5284 yrs)

T_2 = ambient temperature 103°F (312.44°K)

T_1 = harsh environment temperature 212°F (373°K)

t_1 = life left at 212°F (yrs)

E_a = activation energy (0.996 eV)

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

Substituting into equation (5) and solving for t_1

$$t_1 = 104.5284 \exp\left[\left(\frac{0.996}{8.617 \times 10^{-5}}\right)(1/373 - 1/312.44)\right]$$

$$t_1 = 0.25745 \text{ years} \times \frac{8760 \text{ hrs}}{1 \text{ year}} = 2255.26 \text{ hours}.$$

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SUBJECT Analysis of Rosemount 510 DU Trip Units Checked By

Since the Trip Units have a life greater than 2200 hours left at 212°F after being aged for 40 years at an ambient condition of 103°F, and since the harsh environment specification is for only 1 hour at 212°F, it is suggested that the 510 DU Trip Units are qualified for a 40 year life plus a LOCA.

To substantiate this even further, a very conservative activation energy of 0.800 eV will be used with the best data point (212°F, 3124 hours), and the Arrhenius Theory to calculate the life expectancy using equation (5)

$$t_2/t_1 = \exp[(E_a/K_B)(1/T_2 - 1/T_1)] \qquad (5)$$

Where,

t_2 = expected life at 103°F (hours)
T_2 = Ambient temperature 103°F (312.44 °K)
T_1 = Aging temperature 212°F (373 °K)
t_1 = time at aging temperature (3124 hours)
E_a = Activation energy 0.800 eV
K_b = Boltzmann's Constant (8.617×10^{-5} eV/°K)

Substituting these values in Equation (5) and solving for t_2:

$$t_2 = 3124 \cdot \exp[(0.800/8.617 \times 10^{-5})(1/312.44 - 1/373)] \qquad (6)$$

$$t_2 = 3.89 \times 10^5 \text{ hours} \times 1\text{ year}/8760\text{ hours} = 44.4 \text{ years.}$$

Using the same methodology discussed

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SUBJECT Analysis of Rosemount 510 DU Trip Units Checked By [signature]

in section 7.3 and used above, 40 years is subtracted from the 44.4 years leaving 4.4 years. Again refering to equation (5):

$$t_2/t_1 = \exp\left[[E_a/k_B](1/T_2 - 1/T_1)\right] \quad (5)$$

Where,

t_2 = life left at 103°F (4.4 years)
T_2 = ambient temperature 103°F (312.44°K)
T_1 = harsh environment temperature (212°F) (373°K)
t_1 = life left at 212°F
E_a = Activation energy 0.800 eV
k_B = Boltzmann's Constant 8.617×10^{-5} eV/°K

Substituting into equation (5) and solving for t_2:

$$t_2 = 4.4 \exp\left[(0.800/8.617 \times 10^{-5})(1/373 - 1/312.44)\right] \quad (7)$$

t_2 = 0.03534 years × 8760 hrs/year = 309.56 hours.

Again, since the Trip Units have a life greater than 300 hours left at 212°F after being aged for 40 years at ambient condition of 103°F, and since the harsh environment specification is for only 1 hour at 212°F, and since 0.800 eV is considered to be a very conservative energy, it is suggested that 510DU Trip Units are qualified for a 40 year life.

* Master Trip Units with analog output were used for the aging test because they contain the same parts as a master trip unit without analog output and Slave Trip Units, only more of them. It should further be noted that the panel meters were removed from the Trip Units because testing previously completed by Rosemount indicated they would not withstand temperatures above 200°F. However, since the meters do not affect the performance of the safety function, they are exempted from this analysis.

** The fact that the "better approach" gives a greater life than the Rosemount approach, (144.53 vs. 101.67 yrs) simply means that the "better approach" is a more realistic way to interpret the test data but not necessarily a more conservative approach. A lower activation energy and a larger (-) intercept is what determines a more conservative approach. The activation energy for the Rosemount approach is 0.9374 eV and the intercept is -21.1116. The activation energy for the "better approach" is 0.996 eV and the intercept is -22.9425.

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SUBJECT Analysis of Rosemount 510 DU Trip Units Checked By [signature]

Table I
Expected Life Of 510DU Trip Units At 103 °F

Table	Ea (eV)	I (Constant)	t (Hours)	t (years)
II	0.9374	-21.1176	8.9075×10^{5}	101.67
III	0.996	-22.9425	1.266×10^{6}	144.53*

Table II (Rosemount Approach)

Time (hrs)	Temp °F
3124	212
655	250

Table III (NUS Procedure)

Time (hours)	Temp °F
3124	212
594	250

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10.0 Results

10.1 Radiation

The Rosemount 510DU Trip Units have been successfully tested to 1.9×10^5 rads of gamma radiation (Ref 12.1). Since the Rosemount 510DU Trip Units used at NMP-1 will only experience a maximum total integrated dose of 8.3×10^4 rads (Ref 12.6) during a 40 year life plus 1 hour LOCA, it is suggested that they are qualified for radiation exposure.

10.2 Time/Temperature Effects

Based on NUS analysis of Rosemount test data, the Rosemount 510DU Trip Units have an expected life greater than 40 years at 103 °F plus a life greater than 2200 hours for a 212 °F LOCA. Using a conservative activation energy of 0.800 eV, the 510DU Trip Units have an expected life of 40 years at 103 °F plus life greater than 300 hours for a 212 °F LOCA. Based on this NUS Analysis of the Rosemount tests, it is suggested that the 510DU Trip Units are qualified for a 40 year life.

10.3 Harsh Environment

Two 510DU Trip Units were aged for 3124 hours at 212°F without failure (Ref 12.2). Furthermore, a 510DU Trip Unit was successfully tested at 171°F and 99% relative humidity for 1 hour (Ref 12.1). The 510DU Trip Units are only required to function for 1 hour during a harsh environment and will experience a 212°F temperature for less than a minute. Therefore, using a combination of the two above-mentioned tests, it is suggested that the Rosemount 5100U Trip Units are qualified for the expected harsh environment.

10.4 Cycling

Based on operating experience and the design of the 5100U Trip Units, it is felt that they are capable of functioning for an assumed 40 cycles in a 40 year life plus an assumed 1 cycle during LOCA.

11.0 Summary of Results / Conclusions

Based on this analysis the 510DU Trip Units are qualified. However, the following recommendations are suggested.

1.0 They should be put on a periodic maintenance checklist.

2.0 The meters should be investigated as to their requirement for qualification.

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SUBJECT Analysis of Rosemount 510 DU Trip Units Checked By [signature]

12.0 References

12.1 Rosemount Report 3768B, Revision A "Qualification Test Summary for the Trip/Calibration System Rosemount Model 510 DU" dtd 3/10/76

12.2 Rosemount Report 127770 Revision A "Qualified Life Test Report For Rosemount Model 510 DU Trip/Calibration System" dtd 12/19/77.

12.3 NUS Analysis File, NUS-1961-SA-A1, "NMPC's Nine Mile Point Unit 1 HELB Pressure and Temperature Model-Reactor Building", dated 12/9/80

12.4 Memo CO-ENG-926, From S. Gazda (NUS) To A. Canepa (NUS), "NMPC SER Response, Project 1961, Qualified Components Safety Function Identification," dated 11/23/81

12.5 Memo Dave Green (NMPC) To Deepak Bhatia (NUS), "NMPC Supplied Normal Service Conditions" dated 3/11/81

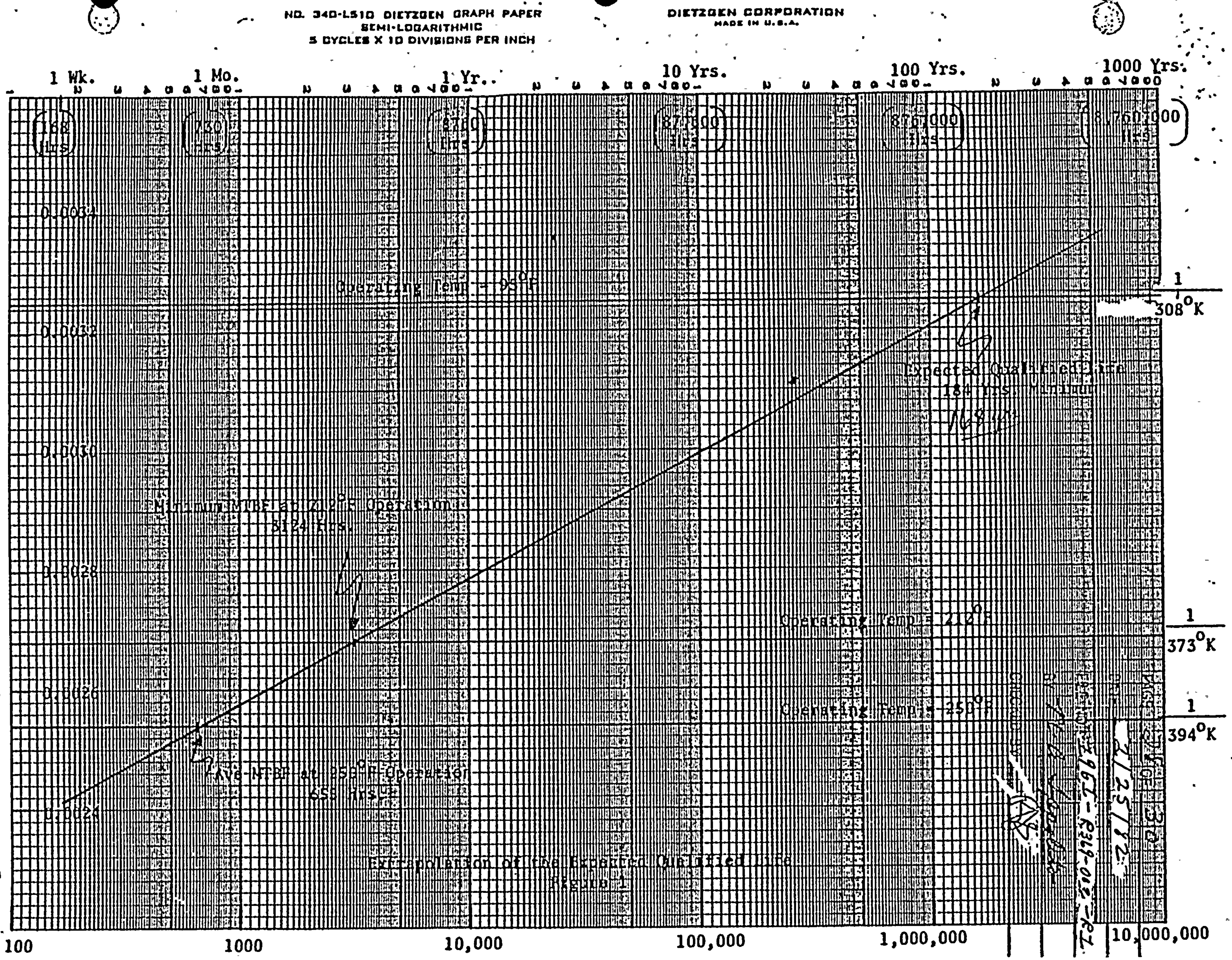
12.6 Memo No CO-ENG-847, S. Gazda (NUS) to A. Canepa (NUS), "Radiation Environmental Specification Review Rosemount 510 DU Trip Units." dated 11/23/81

12.7 "Niagara Mohawk Power Corporation's Nine Mile Point 1 On-Going Qualification Assessment Summary" Rev , dtd 11/5/81

CLIENT NMPC FILE NO 1961-R369-001-R1 BY M.A. Ippolito
SUBJECT Analysis of 510 DU Trip Units Checked By [illegible]

Appendix A

Rosemount Time/Temperature Extrapolation For 510 DU Trip Units



Extrapolation of the Expected Qualified Life
Figure 1

CLIENT NMPC FILE NO. 1961-R364-002-R1 BY M. A. Appelitz
SUBJECT Analysis of Rosemount 510 DU Trip Unit Checked By RJS

Appendix B

Harsh Environment Profile for Rosemount 510 DU Trip Units at NMP-1.

FIGURE 2 ELEV. 281

PAGE 30 OF 30

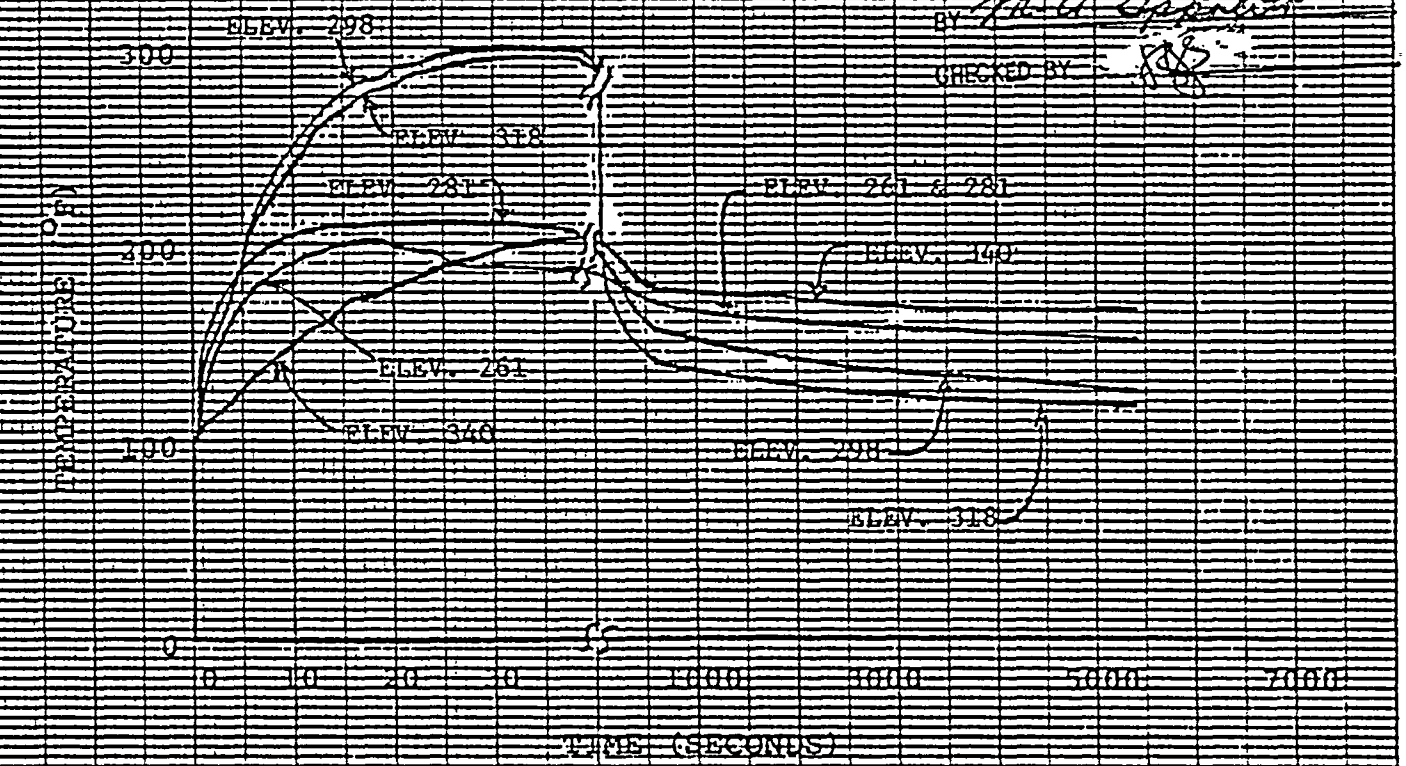
LIMITING TEMPERATURE AND PRESSURE IN OPEN FLOOR AREAS NOT NEAR BREAK LOCATIONS

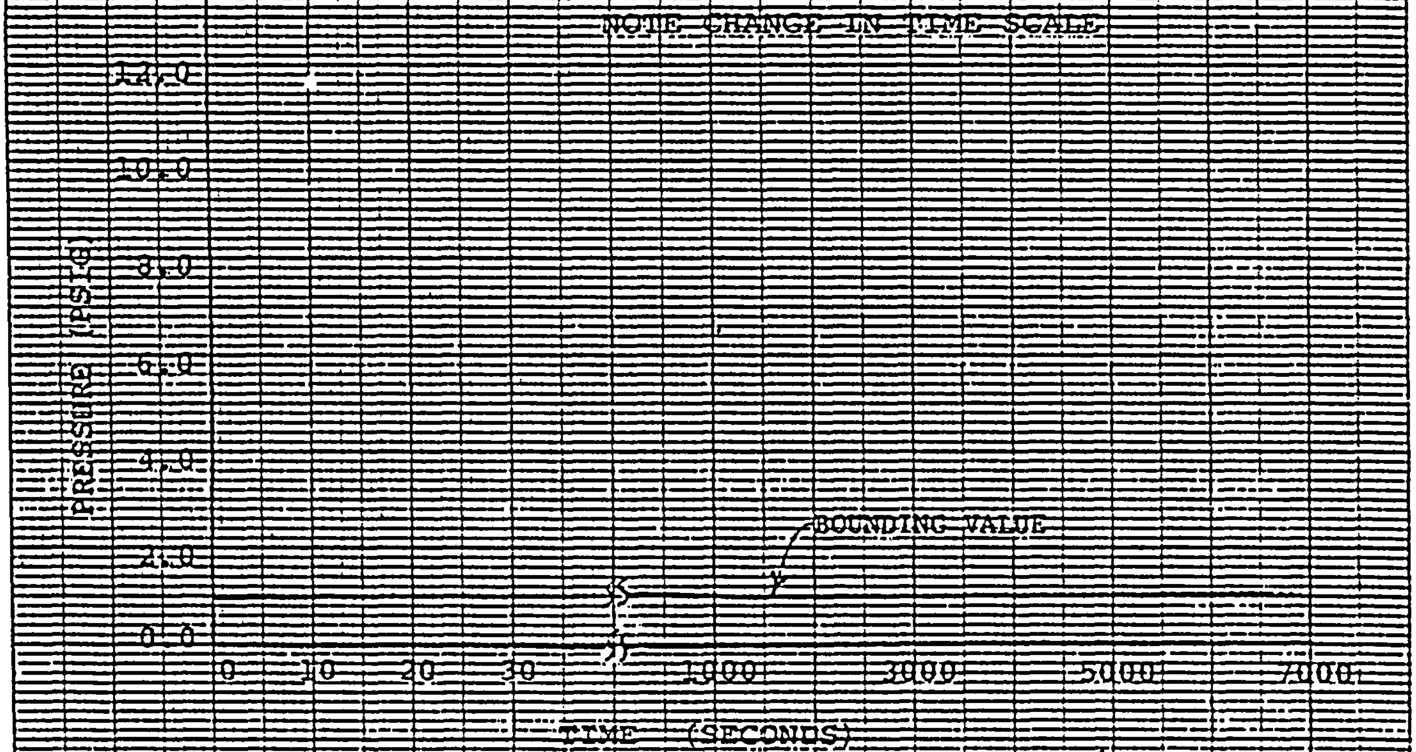
DATE 2/25/82

FILE NO. 1961-R369-001-R1

BY M. A. Sparks

CHECKED BY





(Rek 72.3)

2

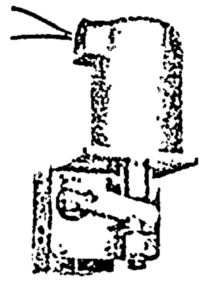
SERIES 500 & SERIES 500HP

2-WAY ROTARY SHAFT TYPE SOLENOID VALVES

QUALITY ASSURANCE

BULLETIN SERIES 500 500HP

Issue 5



DIRECT & SEMI-DIRECT OPERATED

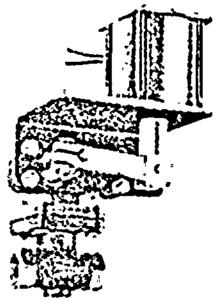
for

— #6 Fuel Oil, Viscous & Unclean Liquids, Sea Water

— Corrosive Liquids & Gases, De-Ionized Water

— Steam, Edible & Sterile Liquids, Cryogenics

— Air, Water, Light Oils, Fuel Gases, Solvents



FEATURES

ROTARY SHAFT TYPE, with ROTARY TEFLON SHAFT SEAL

Higher pressures can be handled because of the mechanical advantage in opening the valve.

Greater shut-off reliability is achieved because: (1) pressure and flow (above the seat) tend to close the valve and hold it closed, and (2) the rotary shaft type mechanical advantage allows a stronger direct-closure internal spring, an optional external spring, and/or optional gravity-weight on the lever to be installed.

Fluid media is contained in a separate lower unit, away from the magnetic solenoid plunger, and away from the coil -- corrosive fluids are handled safely; hot fluids do not appreciably affect the coil, therefore fewer inadvertent shut-downs occur as a result of coil failure; no chance of fuel gases, other flammable or explosive fluids escaping into the coil enclosure due to solenoid-core tube breakage; viscous or dirty liquids cannot foul the solenoid plunger (core).

Manual opening and manual closing is provided by the external lever - in case of emergency, for trial operation, etc.

Visual valve position indication is provided by the position of the inherent external lever.

NO MINIMUM PRESSURE or MINIMUM FLOW REQUIREMENT

Opens and closes fully down to 0 PSI.

Positive, quick action at all pressures - no floating-piston or diaphragm flutter due to water hammer, back pressure surges, or suction effects (solid connection between solenoid and piston).

NO AUXILIARY AIR or PILOT SUPPLY NEEDED - ALL ELECTRIC

Eliminates dependence on two media for operating continuity; eliminates clutter and costly installation of air lines and accessories; eliminates worry of frozen or plugged air lines; eliminates dependence on steady air pressure for constant speed of operation - all-electric Rotary Shaft type solenoid valves operate at essentially the same speed regardless of line pressure.

HEAVY-WALLED VALVE BODY

Higher static pressure ratings, greater strength.

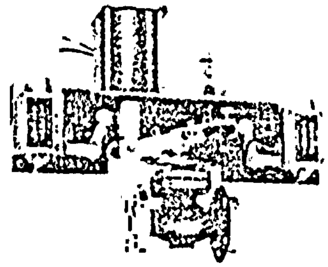
Prevents permanent leakage due to distortion of valve body and seat when installed with oversize wrenches.

HEAVY DUTY PILOT SWITCH PROVISION

Contactor-type heavy-duty limit switch(es) can be mounted readily to indicate valve position remotely or to actuate an alarm or relay.

CLOSELY GUIDED VALVE INTERNAL PARTS

Eliminates sticking; consistent, lasting tight shut-off.



ROTARY SHAFT TYPE

All valves in this bulletin are of the ROTARY SHAFT TYPE. They are basically lift, globe-style valves; however the linear, lifting action of the solenoid plunger is transmitted thru a mechanical advantage by way of an external lever and ROTARY shaft seal unit, and then is converted back into a linear action to lift the valve piston (plug) and disc off the seat.

Compared with "direct-lift" packless type solenoid valves, which are truly suitable only for general purpose fluids and general purpose applications, many more fluids and greater ranges of pressures and temperatures can be suitably handled with the Laurence ROTARY SHAFT type solenoid valves; in addition greater versatility and adaptability with respect to variations and options are afforded.

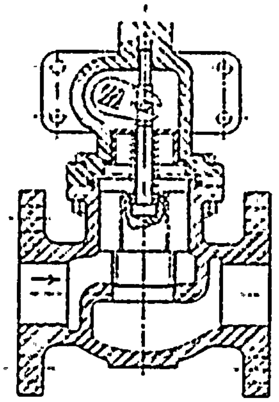
Pneumatic-, motor-, and solenoid-operated reciprocating-stem valves (where the packing is drawn back and forth with each stroke) normally require packing gland maintenance, which is virtually eliminated by the slight, closely guided ROTARY motion (20-30° arc) of the shaft seal unit on a Laurence ROTARY SHAFT type solenoid valve.

NORMALLY CLOSED - ENERGIZE TO OPEN

- Valve closed in the normal position (de-energized)
  - Opens upon energization of the solenoid (current on)
    - Fails closed upon loss of current.

NORMALLY OPEN - ENERGIZE TO CLOSE

- Valve open in the normal position (de-energized)
  - Closes upon energization of solenoid (current on)
    - Fails open upon loss of current.



SERIES 500—DIRECT OPERATED

SERIES 500 are pure Direct Operated valves; (referring to the internal construction) wherein the solenoid lifts the full-area valve disc off the seat against the full static line pressure without the aid of an internal pilot and without a minimum pressure or flow requirement.

The valve opens and closes fully down to 0 PSI differential and both opening and closing are instantaneous. Closing speed is essentially independent of fluid viscosity, line pressure, or pressure drop across the valve.

SERIES 500HP—SEMI-DIRECT OPERATED (NOT SHOWN)

SERIES 500HP are Semi-Direct Operated valves for liquid service only at higher pressures than Series 500. The solenoid with the aid of a pressure assist lifts the full-area disc off the seat against the full static line pressure.

However because of a solid connection between the valve disc and the solenoid, valve action is quick and positive and no minimum pressure or flow is required, and the valve acts as a pure Direct Operated valve at low pressures.

Viscous or unclean liquids can be handled safely because the diameter of the first-stage port is 25-50% of the diameter of the main port rather than being a needle-sized bleed orifice.

124 N. SUMMIT ST.,
P.O. BOX 187,
TENAFLY, N.J. 07670 USA

R. G. LAURENCE CO., INC.

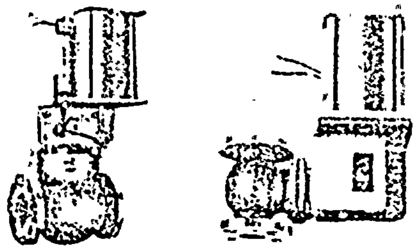
AREA CODE 201
568-5471

2

BULLETIN SERIES 500 500HP

Issue 5

Laurence



VALVE BODY		INNER PARTS	DISC	Normally Closed (Energize to open): NEMA 1 General Purpose, NEMA 2 Driptight, NEMA 3 Weatherproof, NEMA 4 Watertight, NEMA 12 Dusttight Solenoid Enclosure	Normally Closed (Energize to open): Class 1, Groups A, B, C, & D Division I Explosion Proof Solenoid Enclosure ① FM	Normally Open (Energize to close): NEMA 1 General Purpose, NEMA 2 Driptight, NEMA 3 Weatherproof, NEMA 4 Watertight, NEMA 12 Dusttight Solenoid Enclosure	Normally Open (Energize to close): Class 1, Groups A, B, C, & D Division I Explosion Proof Solenoid Enclosure ① FM
				SERIES 500 CATALOG NUMBER PREFIXES			
Bronze	ASTM B-62	Brass & Stainless Steel	Regrinding	500WA	520	510WA	530
			Resilient	501WA	521	511WA	531
Bronze	B-62	Stainless Steel	Regrinding	502WA	522	512WA	532
			Resilient	502GWA	522G	512GWA	532G
Naval Bronze	B-61	Monel	Regrinding	502NBMWA	522NBM	512NBMWA	532NBM
			Resilient	502NBMGWA	522NBMG	512NBMGWA	532NBMG
Steel	A216 WCB	Stainless Steel	Regrinding	509WA	529	519WA	539
			Resilient	509GWA	529G	519GWA	539G
Stainless Steel Type 304	A351 CF8	Stainless Steel Type 303/304	Regrinding	506WA	526	516WA	536
			Resilient	506GWA	526G	516GWA	536G
Stainless Steel Type 316	A351 CF8M	Stainless Steel Type 316	Regrinding	507WA	527	517WA	537
			Resilient	507GWA	527G	517GWA	537G
Stainless Steel Alloy-20	A351 CN7M	Stainless Steel Alloy-20	Regrinding	508WA	528	518WA	538
			Resilient	508GWA	528G	518GWA	538G
Monel	FED QQ-N -288	Monel	Regrinding	508MWA	528M	518MWA	538M
			Resilient	508MGWA	528MG	518MGWA	538MG

FOR SERIES 500HP, ADD "HP" TO APPLICABLE SERIES 500 PREFIX ABOVE

VALVE BODIES - Globe type (standard). Angle type bodies are also available in some sizes - consult factory.

INNER PARTS - means ALL parts coming in contact with the fluid. (solenoid magnetic parts are not wetted by the fluid.)

REGRINDING DISC - a closely guided, rounded metal disc, lapped-in for tight shut off.

RESILIENT DISC - Buna, TFE, Class-filled TFE, Viton.

SEAT - Integral (standard). Inserted and stellite-faced seats are also available.

BODY-BONNET FLANGE O-RING SEAL - Buna, TFE, Viton, metal.

ROTARY SHAFT SEAL - Teflon (standard). Also Buna, Viton, and metal.

OPTIONAL FEATURES

POSITION SWITCH(ES) - Heavy duty, SPDT or DPDT, for remote indication of valve position or to actuate an alarm or relay; contacts rated up to 20 amps @ 115/60 AC or 10 amps @ 125 DC; for valve closed and/or valve open. Add "PS" to suffix on Page 3.

EXTERNAL LINKAGE COVER - To discourage tampering with, or tieing-up of the valve mechanism, and/or to prevent direct contact with the weather or corrosive ambient. Add "LC" to suffix on Page 3. Optionally available with Lexan window.

TERMINAL BLOCK - For making solenoid connections within the solenoid enclosure. Add "TB" to suffix on Page 3.

LEVER LOCKING DEVICE - To hold or lock valve in actuated or manually-overrided position. Add "LD" to suffix on Page 3.

GRAVITY-OPERATED - With a weight on external lever to assist return to normal or fail-safe position - for additional reliability from gravity. Maximum pressure capability may differ - consult factory. Add "W" to suffix on Page 3.

OVERLOAD RELAY - To prevent coil burnout should the valve not actuate when energized for any reason. Recommended with viscous or unclean liquids, or when abnormal pressure surges or voltage dips can be expected. Separate unit for panel mounting.

MATERIALS TRACEABILITY, RADIATION-RESISTING COILS & SEALS SHOCK & VIBRATION-RESISTANT CONSTRUCTIONS & CERTIFICATIONS.

SOLENOID ENCLOSURES - standard with ½" NPT conduit connection (except size T9 - 3/4" NPT, size T10 - 1").

① MOST LAURENCE EXPLOSION PROOF ENCLOSURES ARE FM APPROVED FOR CLASS 1 GROUPS A, B, C & D, DIVISION I.
Consult factory for CLASS 1 GROUP C areas and solenoid size T10.

SOLENOID COILS	Safe Ambient Temp.	Safe Fluid Temp.
Class F insulation (std.)	130F ②	300F ④
Class H insulation	215F ③	550F ④

However the safe temperatures for a specific application depend on an overall consideration of the actual max. ambient and fluid temperatures, the temperature rise of the coil to be used, range of applied voltage and nature of hazardous area, if any - consult factory for the safe temps. for your application. Also, higher temperatures can be handled in some cases.

② - based on fluid temperature of 130F or less.
③ - based on fluid temperature of 215F or less.
④ - based on ambient temperature of 40C (104F).

Standard coils are waterproofing-varnish dipped, vacuum impregnated and baked. Molded Class F or Class H coils for greater resistance to moisture, fungus and physical damage are available. Standard coils are for continuous duty (24-hour continuous energization, with maximum steady state coil temperature within rating of class of insulating materials used).

STANDARD VOLTAGES
A.C. - 110-120/60, 110-120/50, 220-240/60, 220-240/50, 440-480/60 Volts/Hz.
D.C. - 125 or 250 volts.
Other voltages/frequencies, special electrical characteristics can be furnished (pressure listings may differ) - consult factory.

MOUNTING - All valves must be mounted with the solenoid in a vertical, upright position. Horizontal pipe mounting is standard and should be utilized whenever possible. For vertical pipe mounting add "V" to prefix above and specify whether flow is upward or downward; resilient valve disc is recommended. For limited headroom, add "Z" to horizontal pipe mounting prefix above for inverted valve body.

CATALOG NUMBER SUFFIXES — A. C. VOLTAGES

CATALOG NUMBER SUFFIX	PIPE SIZE	CLASS & TYPE END CONNECTIONS	MAXIMUM OPENING DIFFERENTIAL PRESSURE SERIES 500	MAXIMUM OPENING DIFFERENTIAL PRESSURE SERIES 500 HP	SOLENOID SIZE	Cv FLOW RATING
09	1/4"	300 Screwed	150 PSI	—	CI	1.4
092		600 Screwed	600	—	DI	1.4
16	1/2"	300 Screwed	265	—	DI	1.4
17		600 Screwed	500	—	EI	1.4
20	1/2"	300 Screwed	115	—	DI	2.3
21		300 Screwed	225	—	EI	2.3
22	1/2"	300 Screwed	20	—	CI	3.0
24		300 Screwed	85	—	DI	3.0
26		300 Screwed	150	—	EI	3.0
262		300 Screwed	300	—	T7	3.0
288	1/2"	150 Flanged	85	—	DI	3.0
29		150 Flanged	150	—	EI	3.0
292		150 Flanged	275	—	T7	3.0
31	1/2"	300 Flanged	150	—	EI	3.0
312		300 Flanged	300	—	T7	3.0
34	3/4"	300 Screwed	5	—	CI	6.8
36		300 Screwed	30	175	DI	6.8
38		300 Screwed	75	325	EI	6.8
381		600 Screwed	135	600	T7	6.8
398	3/4"	150 Flanged	30	175	DI	6.8
40		150 Flanged	75	275	EI	6.8
41		150 Flanged	135	—	T7	6.8
413	3/4"	300 Flanged	75	325	EI	6.8
414		300 Flanged	135	600	T7	6.8
42	1"	300 Screwed	12	50	DI	10
44		300 Screwed	30	110	EI	10
45		300 Screwed	75	250	T7	10
47	1"	150 Flanged	12	40	DI	10
49		150 Flanged	30	90	EI	10
50		150 Flanged	75	250	T7	10
509	1"	300 Flanged	30	90	EI	10
51		300 Flanged	75	250	T7	10
56	1-1/4"	300 Screwed	8	25	DI	15.5
58		300 Screwed	20	70	EI	15.5
59		300 Screwed	45	175	T7	15.5
61	1-1/4"	150 Flanged	8	25	DI	15.5
63		150 Flanged	20	70	EI	15.5
64		150 Flanged	45	175	T7	15.5
65	1-1/4"	300 Flanged	45	175	T7	15.5
71	1-1/2"	250 Screwed	12	50	EI	22.5
72		250 Screwed	25	125	T7	22.5
75	1-1/2"	150 Flanged	12	50	EI	22.5
76		150 Flanged	25	125	T7	22.5
77	1-1/2"	300 Flanged	25	125	T7	22.5
82	2"	250 Screwed	4	40	EI	40
83		250 Screwed	10	110	T7	40
85	2"	150 Flanged	4	40	EI	40
86		150 Flanged	10	110	T7	40
87	2"	300 Flanged	10	110	T7	40
88		300 Flanged	18	175	T9	40
89	2-1/2"	250 Screwed	6	20	T7	63
90		250 Screwed	12	75	T9	63
92	2-1/2"	150 Flanged	6	20	T7	63
93		150 Flanged	12	75	T9	63
94	2-1/2"	300 Flanged	10	75	T9	63
96	3"	150 Flanged	5	75	T9	90
962		150 Flanged	10	100	T10	90
97	3"	300 Flanged	5	75	T9	96
972		300 Flanged	10	100	T10	96
98	4"	150 Flanged	3	50	T9	160
982		150 Flanged	6	100	T10	160
99	4"	300 Flanged	3	50	T9	175
992		300 Flanged	6	100	T10	175

SEE PAGE 4 for listings for D.C. voltages.
SEE PAGE 5 for A.C. dimensions.

TO SPECIFY A CATALOG NUMBER - Combine the catalog number prefix from Page 2 with the catalog number suffix from above; e.g. 500WA24, 500WA24SW, 500WA24PST8, etc.

PRESSURES -

The listings shown are intended to indicate our current maximum standard capability. The pressure "rating" of a given suffix number will depend on an overall consideration of the actual pressure range, actual temperature range, materials selection, ambient temperature range (for DC voltages), viscosity range, and other specifics for a particular application. In other words, all valves with the same suffix number are not necessarily "rated" at the maximum opening differential pressure figure shown. Therefore ALWAYS ADVISE or SPECIFY YOUR ACTUAL pressure and temperature conditions and consult factory for the pressure rating for your application.

The figures shown represent the maximum differential pressure the valve can be opened against (max. inlet pressure minus the min. outlet pressure when the valve is closed). A higher inlet pressure can be handled if a corresponding higher downstream pressure exists when the valve is closed. All valves will hold closed at emergency pressures greatly exceeding the figures shown because the line pressure and flow are above the seat, tending to close the valve. However, in a few cases, the safe operating pressure is limited by the pressure-temperature tables of ANSI B16.5, B16.15, or B16.24 (in these cases figures are based on -20 to +100 F fluid temperature).

All pressures are based on a valve being furnished with a continuous duty coil (rated for 24-hour, continuous energization or frequent cycling).

FOR HIGHER PRESSURES - Consult factory for specials, or:
- Specify a Fractional (reduced) Port Size, where flow rate is of secondary importance.
- See Bulletin Series 700 and 1100 for Manually Reset Direct Operated Rotary Shaft type solenoid valves.
- See Bulletin Series 600 for higher-pressure Semi-Direct Operated Rotary Shaft type solenoid valves.

TEMPERATURES - Standard maximum fluid temperature: 550F
Standard minimum fluid temperature: -50F,
although variations are made in the standard construction for temperatures within this range. Therefore, ALWAYS SPECIFY YOUR ACTUAL TEMPERATURE CONDITIONS. Valves for higher temperatures and cryogenics are available - consult factory.

PORT SIZES - All valves have full diameter ports except suffixes 16, 17, 20 & 21.

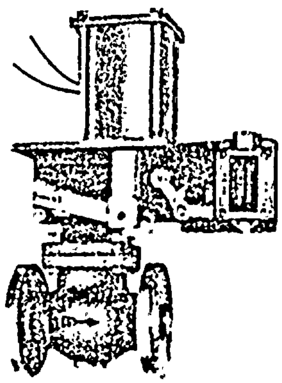
TYPE CONNECTIONS -
Bronze & Naval Bronze bodies: Class 250 Screwed, Class 150 & 300 Flanged, flat face (FF).
Stainless Steel, Steel, Monel bodies: Class 300 & 600 Screwed, Class 150 & 300 flanged, raised face (RF).
Butt-weld or socket-weld connections are also available. Add "BW" or "SW" to screwed-ends suffix up to 1½" pipe size and to flanged-ends suffix 1½" to 6" pipe size.
Class 600 flanged, silver-brazing ends (female socket or union), and MIL-F-20042 flanged ends are also available - consult factory.

STAINLESS STEEL, STEEL & MONEL VALVES - Screwed ends are standard up to 1½" pipe size only. Stainless steel type 304 body is standard for all screwed-ends steel body valves.

SOLENOID SIZE - is for comparison purposes, factory application, and pricing of options. It need not be specified.

CURRENT DRAW - Inrush and holding currents depend on valve size, solenoid size, ambient temperature (DC voltages), voltage/frequency and other electrical characteristics of the coil selected. Consult factory for specific data.

C_v FLOW FACTORS - are approximate for estimating only. See Page 4 for flow formulas.



Laurence

BULLETIN SERIES 500 500HP

Issue 5

CATALOG NUMBER SUFFIXES —— *D. C. VOLTAGES*

CATALOG NUMBER SUFFIX	PIPE SIZE	CLASS & TYPE END CONNECTIONS	MAXIMUM OPENING DIFFERENTIAL PRESSURE SERIES 500	MAXIMUM OPENING DIFFERENTIAL PRESSURE SERIES 500 HP	SOLENOID SIZE	C_v FLOW RATING
09DC	1/4"	300 Screwed	75 PSI	—	C	1.4
092DC		300 Screwed	300	—	D	1.4
16DC	1/2"	300 Screwed	175	—	D	1.4
17DC		600 Screwed	350	—	E	1.4
20DC	1/2"	300 Screwed	75	—	D	2.3
21DC		300 Screwed	175	—	E	2.3
22DC	1/2"	300 Screwed	10	—	C	3.0
24DC		300 Screwed	40	—	D	3.0
26DC		300 Screwed	75	—	E	3.0
262DC		600 Screwed	350	—	T7DC	3.0
288DC	1/2"	150 Flanged	40	—	D	3.0
29DC		150 Flanged	75	—	E	3.0
292DC		150 Flanged	275	—	T7DC	3.0
31DC	1/2"	300 Flanged	75	—	E	3.0
312DC		300 Flanged	350	—	T7DC	3.0
36DC	3/4"	300 Screwed	8	50	D	6.8
38DC		300 Screwed	35	165	E	6.8
381DC		300 Screwed	160	600	T7DC	6.8
398DC	3/4"	150 Flanged	8	50	D	6.8
40DC		150 Flanged	35	165	E	6.8
41DC		150 Flanged	160	275	T7DC	6.8
413DC	3/4"	300 Flanged	35	165	E	6.8
414DC		300 Flanged	160	600	T7DC	6.8
42DC	1"	300 Screwed	5	15	D	10
44DC		300 Screwed	12	40	E	10
45DC		300 Screwed	75	250	T7DC	10
47DC	1"	150 Flanged	5	12	D	10
49DC		150 Flanged	12	35	E	10
50DC		150 Flanged	75	250	T7DC	10
509DC	1"	300 Flanged	12	35	E	10
51DC		300 Flanged	75	250	T7DC	10
56DC	1-1/4"	300 Screwed	—	10	D	15.5
58DC		300 Screwed	5	25	E	15.5
59DC		300 Screwed	45	175	T7DC	15.5
61DC	1-1/4"	150 Flanged	—	10	D	15.5
63DC		150 Flanged	5	25	E	15.5
64DC		150 Flanged	45	175	T7DC	15.5
65DC	1-1/4"	300 Flanged	45	175	T7DC	15.5
71DC	1-1/2"	250 Screwed	2	10	E	22.5
72DC		250 Screwed	25	125	T7DC	22.5
75DC	1-1/2"	150 Flanged	2	10	E	22.5
76DC		150 Flanged	25	125	T7DC	22.5
77DC	1-1/2"	300 Flanged	25	125	T7DC	22.5
83DC	2"	250 Screwed	10	110	T7DC	40
86DC	2"	150 Flanged	10	110	T7DC	40
87DC	2"	300 Flanged	10	110	T7DC	40
88DC		300 Flanged	18	175	T9DC	40
89DC	2-1/2"	250 Screwed	6	20	T7DC	63
90DC		250 Screwed	12	75	T9DC	63
92DC	2-1/2"	150 Flanged	6	20	T7DC	63
93DC		150 Flanged	12	75	T9DC	63
94DC	2-1/2"	300 Flanged	10	75	T9DC	63
96DC	3"	150 Flanged	5	75	T9DC	90
962DC		150 Flanged	10	100	T10DC	90
97DC	3"	300 Flanged	5	75	T9DC	96
972DC		300 Flanged	10	100	T10DC	96
98DC	4"	150 Flanged	3	50	T9DC	160
982DC		150 Flanged	6	100	T10DC	160
99DC	4"	300 Flanged	3	50	T9DC	175
992DC		300 Flanged	6	100	T10DC	175

SEE PAGE 3 for listings for A.C. VOLTAGES
SEE PAGE 6 for D.C. dimensions.

TO SPECIFY A CATALOG NUMBER - Combine the catalog number prefix from Page 2 with the catalog number suffix from above; e.g. 500WA24DC, 500WA24DCSW, 500WA24DCPSTB, etc.

NOTE: The opening pressure capability of a solenoid valve with a D.C.-voltage coil is significantly dependent on ambient temperature. Therefore, ALWAYS ADVISE or SPECIFY YOUR ACTUAL ambient temperature range. The figures shown are based on 40C (104F).

FOR NORMALLY OPEN VALVES (D.C. ONLY) - Some suffixes have a much higher differential pressure capability using an alternate construction along with the inlet pressure being applied underneath the valve seat (high holding power of D.C. solenoid holds the valve closed, pressure tends to open the valve). Consult factory for details.

SEE PAGE 3 FOR ADDITIONAL NOTES CONCERNING:

- PRESSURES
- TEMPERATURES
- PORT SIZES
- TYPE CONNECTIONS
- SOLENOID SIZE
- CURRENT DRAW
- C_v FLOW RATINGS
- STAINLESS STEEL, STEEL, & MONEL VALVES

C_v FLOW FACTOR FORMULAS (Approx., for estimating only.)

FOR LIGHT LIQUIDS:

$$\text{pressure drop (PSI)} = \left(\frac{\text{GPM}}{C_v}\right)^2 \left(\text{specific gravity}\right)$$

where specific gravity of water = 1.0

FOR AIR, GASES:

$$\text{pressure drop (PSI)} = \left(\frac{(460 + {}^\circ F)\ (\text{spec. grav.})}{\text{inlet gauge pressure} + 15}\right)\left(\frac{\text{SCFH}}{1360 \times C_v}\right)^2$$

where specific gravity of air = 1.0

FOR STEAM:

$$\text{pressure drop (PSI)} = \left(\begin{matrix}\text{specific volume} \\ (\text{ft}^3/\text{lb})\end{matrix}\right)\left(\frac{\text{lb/hr}}{63 \times C_v}\right)^2$$

ORDERING DATA

Full Catalog Number (prefix + suffix + option adders)

Pipe Size & C_v

Max. Opening Differential Pressure, and Max. Inlet Pressure (ACTUAL)

Liquid or Gas Handled

Viscosity, Specific Gravity, Concentration, Clean?

Fluid & Ambient Temperatures (ACTUAL)

Flow Rate & Max. Allowable Pressure Drop, if important

Valve Body, Inner Parts & Disc materials desired

Class & Type of end connections

For Horizontal or Vertical Pipe Mounting?

Type of Solenoid Enclosure (if explosion proof, specify Class & Group and/or nature of hazard)

Voltage & Frequency

Max. Time On and Frequency of Operation

Solenoid Insulation Class

Summary of Application and/or Sketch of System

Optional or Special Features

For your convenience, use OUR Solenoid Valve Data Sheet for compiling the above information, to save time in:

- Writing a specification
  - Requesting price & delivery
    - Requesting additional literature or a complete catalog

QUALITY ASSURANCE
RECORD

NUS CORPORATION
CONSULTING DIVISION

RECORD OF SYSTEM/COMPONENT ANALYSES

FILE NO.:	NO. OF PAGES:	NUMBER OF VOLUMES OF COMPUTER OUTPUT:
1961-A499-001	21	NA

CLIENT:	PROJECT NO.:
NIAGARA MOHAWK POWER CORPORATION	1961

ANALYSIS TITLE: Environmental Qualification Analysis for ASCO Solenoid Valves model 8300 series.

AUTHOR: Kwan C Wong

PURPOSE OF ANALYSIS: To determine if the design of the solenoid valve is adequate to assure that the valves will operate on demand to meet the system performance requirement under normal and harsh environment conditions and during design basis events at NMP-1

SUMMARY OF ANALYSIS PROCEDURE AND RESULTS:

Literature search was conducted to obtain time/temperature data and radiation threshold level for the non-metallic components contained in the subject equipment. Arrhenius Theory was used to calculate the life of the non-metallic components from available time/temperature data. A valve similar to the subject equipments was tested under harsh environment conditions.

The subject equipment cannot be qualified for 40 years of service life. Recommend the subject equipments be replaced with qualified equipments

DATE COMPLETED:	VERIFICATION REQUIRED:
11/20/81	☒ YES ☐ NO

ANALYSIS REVIEWED AND ACCEPTED: (DISCIPLINE MANAGER)	DATE:
[signature]	11/29/81

ANALYSIS:	BY: (FILE NO.)	DISCIPLINE MANAGER:	DATE:
☐ SUPERSEDED ☐ SUPPLEMENTED			

NUS 202 10 REVISED 0181
(Formerly CD-28 12/77)

NUS CORPORATION
CONSULTING DIVISION

ANALYSIS VERIFICATION CHECKLIST

ANALYSIS TITLE: Environmental Qualification Analysis for ASCO solenoid Valves, B300 series

ANALYSIS FILE NUMBER: 1961-A499-001

INDICATE "YES, NO, OR N/A (NOT APPLICABLE)," FOR EACH ITEM AND INCLUDE IN ANALYSIS PACKAGE WITH RECORD OF ANALYSIS VERIFICATION	YES	NO	N/A
METHOD OF ANALYSIS			
IS THE METHOD USED APPROPRIATE CONSIDERING THE PURPOSE AND TYPE OF ANALYSIS AND THE USE AND ACCEPTABILITY OF THE RESULTS (i.e., MARGIN TO LIMITS)?	✓	☐	☐
IS THE METHOD IN ACCORDANCE WITH CODES, STANDARDS, AND REGULATORY REQUIREMENTS?	✓	☐	☐
HAS THE METHOD BEEN EMPLOYED ELSEWHERE IN INDUSTRY OR IN LICENSE APPLICATIONS?	✓	☐	☐
ASSUMPTIONS			
ARE ASSUMPTIONS NECESSARY TO PERFORM THE ANALYSIS ADEQUATELY DESCRIBED AND REASONABLE?	✓	☐	☐
WHERE NECESSARY, ARE THE ASSUMPTIONS IDENTIFIED FOR SUBSEQUENT RE-VERIFICATIONS WHEN THE DETAILED DESIGN ACTIVITIES ARE COMPLETED?	✓	☐	☐
INPUT INFORMATION			
ARE THE INPUTS INTO THE ANALYSIS STATED AND THEIR SOURCE IDENTIFIED?	✓	☐	☐
IS THE INPUT INFORMATION FROM THE LATEST AVAILABLE REVISION TO THE DOCUMENT?	✓	☐	☐
IS THE STATUS (PRELIMINARY, CONCEPTUAL, ETC.) OF THE INPUT SOURCE IDENTIFIED FOR LATER CONFIRMATION OF THE VALIDITY OF THE INPUT?	✓	☐	☐
ARE THE INPUTS SUFFICIENT CONSIDERING THE PURPOSE OF THE ANALYSIS?	✓	☐	☐
COMPUTER CODE APPLICATION			
ARE ALL CODES USED IDENTIFIED ALONG WITH SOURCE, COMPUTER TYPE, INPUTS, AND OUTPUTS?	☐	☐	✓
HAS THE CODE BEING USED BEEN ADEQUATELY VERIFIED?	☐	☐	✓
IS THE CODE SUITABLE FOR THE PRESENT ANALYSIS?	☐	☐	✓
DOES THE COMPUTER MODEL (NODING, TIME STEPS, ETC.) ADEQUATELY REPRESENT THE PHYSICAL SYSTEMS?	☐	☐	✓
REASONABLENESS OF RESULTS			
IS THE MAGNITUDE OF THE RESULT REASONABLE?	✓	☐	☐
ARE THE DIRECTION OF TRENDS REASONABLE?	✓	☐	☐

PREPARED BY: E. J. Brown (signature)

DATE: 24 Nov 1987

NUS 204 10 REVISED 0181
(Formerly CD-30 Rev. 1)

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

FILE NO.: 1961-A499-001	PAGE 1 OF 2

ANALYSIS TITLE: Environmental Qualification Analysis for ASCO Solenoid Valves, 8300 series

AUTHOR:	NO. OF PAGES:	NO. OF VOLUMES OF COMPUTER OUTPUT:
Kwan C Wong	21	NA

VERIFICATION SCOPE (CHECK AS APPLICABLE):

- [x] METHOD OF ANALYSIS
- [x] ASSUMPTIONS
- [x] INPUT INFORMATION
- [ ] COMPUTER CODE APPLICATION
- [ ] CHECK OF SAMPLE CALCULATION
- [x] SPOT CHECK OF MATHEMATICS
- [x] REASONABLENESS OF RESULTS
- [ ] COMPLETE CHECK OF MATHEMATICS
- [ ] PARTIAL INDEPENDENT ANALYSIS

BUDGET: (APPROXIMATE) 1/4 MANDAYS	DESIRED COMPLETION DATE: 11/28/81

DESCRIPTION OF VERIFICATION—ACTIVITIES, FINDINGS AND RESOLUTION:

11.1 & 18 – Some applications cannot tolerate minimum leakages – no action necessary since replacement is recommended. [initials]

NUS 203A 10 REVISED 0181
(Formerly CD-29(1) 12/77)

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

VERIFIER'S SIGNATURE:	DATE: 24 Nov 81
ACCEPTANCE BY: (DISCIPLINE MANAGER) C. H. Hooks	DATE: 11/29/81

FINAL ANALYSIS REVIEW CHECKLIST

Project #/Project Title 1961   Client NMPC

Date: 11/20/81

Analysis File Title: Environmental Qualification Analysis for ASCO Solenoid Valve, 8300 Series

Analysis File Number: 1961-A499-001

Checklist Item	Yes	N/A
1. Unique Analysis File Number assigned to the file.	✓	
2. Analysis recorded on CD-60	✓	
a. pages numbered	✓	
b. total pages specified	✓	
c. all pages dated	✓	
d. client identified on each page	✓	
e. correct file number on each page	✓	
f. author(s) specified on each page	✓	
g. subject specified on each page	✓	
h. verifier initials on each page	✓	
3. Analysis File includes:		
a. client identification	✓	
b. analysis file number	✓	
c. analysis title	✓	
d. author(s) identification	✓	
e. description of the purpose of the analysis	✓	
f. discussion of the general method of analysis	✓	
g. identification of input information source	✓	
h. identification of input information status	✓	
i. major assumptions used in performing the analysis	✓	

Date: 11/20/81

3. (Continued)

	j. important references, including material properties	✓	
	k. identification of specific versions of codes used	✓	
	l. detailed calculation	✓	
	m. listing of computer input		✓
	n. microfiche of computer output		✓
	o. summary of results	✓	
4.	Record of analysis provided onn CD-28	✓	
5.	All applicable entries on CD-28 correct.	✓	
6.	All referenced NUS internal memos included in analysis file.	✓	
7.	All referenced telecons included in analysis file.	✓	
8.	Separate computer output labeled with analysis file number.		✓
9.	Record of analysis file verification on CD-29.	✓	
10.	All entries on CD-29 completed and correct.	✓	
11.	Item (7) of CD-29 completed and comments numbered	✓	
12.	Verification checklist CD-30 included.	✓	
13.	Computer code used verified per QAI 3.5.		✓
14.	Corrected items crossed out clearly enough to show on Xerox copies.	✓	
15.	List of input information and major assumptions checked for commpleteness.	✓	
16.	Documents Complete (Page Count)	✓	
17.	Documents Legible and Reproducible	✓	
18.	All Documents Identified on Index Received	✓	
19.	Documents Properly Paginated	✓	
20.	Documents Identified to Project/Item	✓	
21.	All Unsatisfactory Conditions Resolved (List)	✓	

Date 11/20/81

22. Remarks:

Reviewed by: [signature] 24 Nov 81

Date

CLIENT NMPC FILE NO. 1961-A499-001 BY Kwan C Wong

SUBJECT Environmental Qualification Analysis Checked By [signature]

ENVIROMENTAL QUALIFICATION ANALYSIS

FOR

ASCO WPLB 8300 872F

ASCO WPLB 8300 868F

SOLENOID VALVES

FOR USE IN

NIAGARA MOHAWK POWER CORPORATION'S

NINE MILE POINT - UNIT ONE

NUCLEAR POWER GENERATING STATION

PROJECT 1961

Prepared by: [signature]

Approved by: [signature]

NUS CORPORATION

DATE 11/20/81

CLIENT NMPC FILE NO. 1961-A499-001 BY Kwan C Wong

SUBJECT Environmental Qualification Analysis Checked By [signature]

TABLE OF CONTENT

CLIENT NMPC FILE NO. 1961-A499-001 BY Kwan C Wong

SUBJECT Enviromental Qualification Analysis Checked By [signature]

NUS CORPORATION

DATE 11/20/81

CLIENT NMPC FILE NO. 1961-AAPP-001 BY Kwan C. Wong

SUBJECT Environmental Qualification Analysis Checked By [signature]

TABLES AND FIGURES

CLIENT NMPC FILE NO. 1961-A499-001 BY Kwan C Wong

SUBJECT Environment Qualification Analysis Checked By [signature]

1.0 CLIENT IDENTIFICATION

Niagara Mohawk Power Corporation (NMPC), Nine Mile Point Nuclear Power Plant, Unit 1 (NMP-1)

2.0 ANALYSIS FILE NUMBER

1961-A499-001

3.0 ANALYSIS TITLE

Enviromental Qualification Analysis for ASCO solenoid valve, 8300 series.

4.0 AUTHOR IDENTIFICATION

Kwan C Wong

5.0 PURPOSE OF ANALYSIS

The purpose of this analysis is to determine if the design of the ASCO solenoid valve, 8300 series, is adequate to assure that the subject equipment will operate on demand to meet the system performance requirements under normal and harsh enviromental conditions and during design basis events at NMP-1.

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6.0 INPUT INFORMATION

6.1. Equipment Identification (Ref 13.1)

System	Plant I.D. No	Model No
CID	201.2-03	WPLB 8300 B72F
CID	201.2-32	WPLB 8300 B72F
CIT	68-08C	WPLB 8300 B68F
CIT	68-09C	WPLB 8300 B68F
CIT	68-10C	WPLB 8300 B68F

CLIENT NMPC FILE NO. 1961-A499-001 BY Kwan C Wong

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6.2 Materials

The ASCO solenoid valves contain a class "B" coil, stainless steel disc and seat, and Buna-N O-rings. (Ref 13.2)

6.3 Safety-Related Function

The safety-related function for WPLB 8300 B72F is to provide containment isolation (Drywell) for N_2 make-up and bleed. The safety-related function for WPLB 8300 868F is to provide containment isolation (Torus) for vacuum relief system. (Ref 13.3)

6.4 Service Conditions

Service conditions that the subject equipments are subject to are presented in Table 6-1. The normal service conditions are specified by NMPC (Ref 13.4). The harsh environment conditions are obtained from NUS analyses (Ref 13.5, 13.6)

7.0 METHOD OF ANALYSIS

7.1 Materials

The manufacturer of the subject equipments was contacted and a list of the non-metallic components used in the subject equipments was obtained. A literature search was then conducted to obtain time-temperature aging data, maximum temperature level and radiation threshold level for the non-metallic materials.

TABLE 6-1

Service Conditions for ASCO 8300 series
Solenoid Valves Serving
a Safety-Related Function at NMP-1

Model	System	Plant I.D. No	Normal Service Conditions: Temp °F	Press Psig	R.H. %	Radiation rads	Maximum Harsh Environment Condition: Temp °F	Press psig	R.H. %	Radiation rads	Duration hr
WPLB 8300 B72F	CID	201.2-03 201.2-32	103	0	50-90	1×10^4	305	9	100	$<1 \times 10^6$	1
WPLB 8300 B68F	CIT	68-08C 68-09C 68-10C	103	0	50-90	1×10^4	126	1	100	$<1 \times 10^6$	1

FIG 6-1

DATE 11/20/81

Fig. 4-6

REF 13.5

FILE NO. 1961-A199-001

LIMITING TRANSIENT TEMPERATUTE AND PRESSURE IN EMERGENCY CONDENSER ISOLATION VALVE CUBICLE

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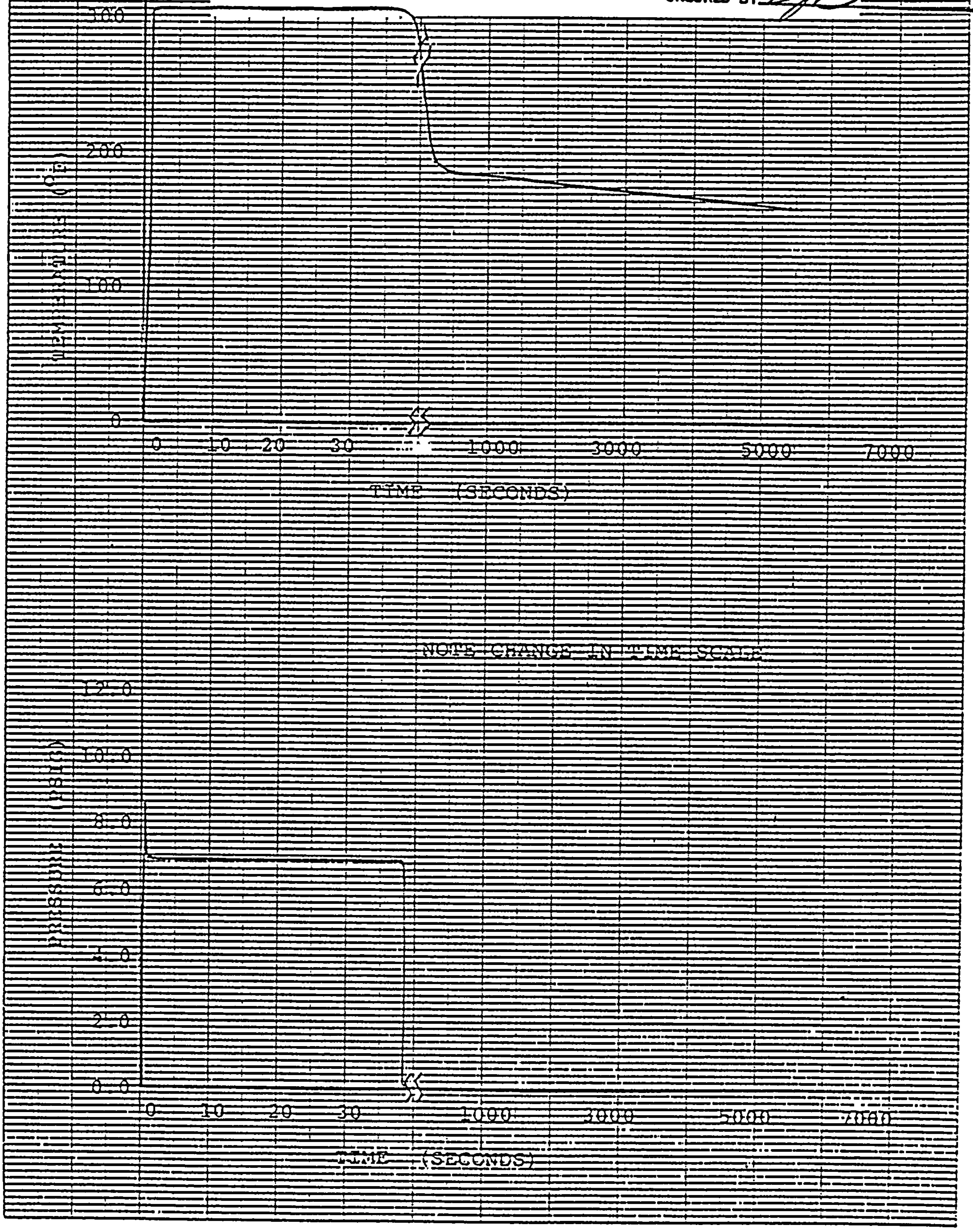

46 1320

FIG 6-2

DATE 11/20/81

FILE NO. 1961-A499-001

REF 13.5

LIMITING TEMPERATURE AND PRESSURE IN OPEN FLOOR AREAS NOT NEAR BREAK LOCATIONS

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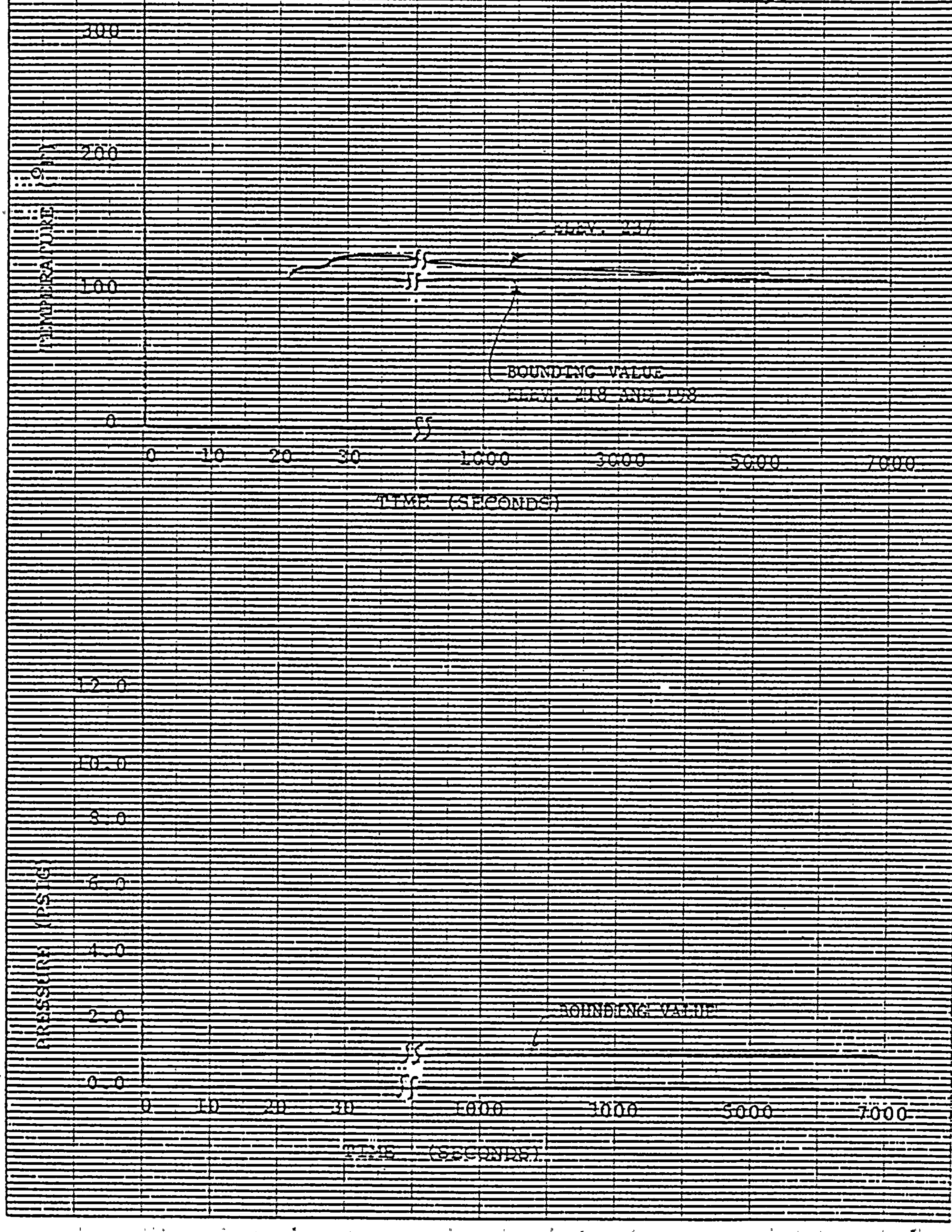

46 1320

K&E 10 X 10 TO 1/2 INCH 7 X 10 INCHES KEUFFEL & ESSER CO.

CLIENT NNPC   FILE NO. 1961-A499-001   BY Kwon C Wong

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7.2 Radiation

A literature search was conducted and the manufacturer was contacted to determine the radiation threshold level for the non-metallic materials used in the component.

7.3 Time/Temperature Effects

The present state of the art allows acceleration of the aging effects of temperature by subjecting a material to increased temperatures for a relatively short duration. For many non-metallic materials, it is known that the degradation process can be defined by a single temperature-dependent reaction that follows the Arrhenius equation:

$$K = A \exp[-E_a/(K_b T)] \quad (1)$$

Where,

K = Reaction Rate
A = Frequency Factor
exp = Exponent to base e
K_b = Boltzman's Constant
T = Absolute Temperature

Equation (1) can also be expressed in a form which yields an expected lifetime of the material at a specific temperature. This form is:

$$\ln t_i = E_a/(K_b T_i) + I \quad (2)$$

Where,

ln = Natural Logarithm
t_i = Expected Life at Temperature T_i (hr)
T_i = Service Temperature for Life t_i (K)
I = Constant

Equation (2) can also be represented in a linear regression line as:

$$Y_i = M X_i + I \qquad (3)$$

Where,

$Y_i = \ln t_i$
$X_i = 1/T_i$
$M = E_a/K_b$
I = Constant (Intercept)

For the purpose of this analysis, Equation (2) was used to calculate the expected life of the materials used in the subject equipment. Time/temperature test data were collected from the available literature on each temperature sensitive material, and the activation energies and intercepts calculated for the specified failure criteria.

These activation energies and intercepts were then used to calculate the expected life of the materials (equation 2) under the maximum harsh environment temperature conditions. If the life calculated for all materials at harsh environment conditions exceeded 40 years, no further analysis was necessary because the maximum harsh environment temperature envelopes all other temperature conditions. If the material life as calculated did not exceed 40 years, then the expected life at ambient conditions was also calculated. A determination of the expected life was made using the combination of the calculated life at normal service conditions and the specified duration of a design basis event. The thermal degradation equivalency where a

CLIENT NMPC FILE NO. 1961-AA99-001 BY Kwan C Wong

SUBJECT Environmental Qualification Analysis Checked By

material is exposed to a shorter test duration can be determined by the transformed Arrhenius Theory as follows:

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

where

t_1 = Test Time at Temperature T_1
t_2 = Equivalency Time at Temperature T_2
E_a = Activation Energy
K_b = Boltzmann's Constant
T_1 = Test Temperature
T_2 = Qualification Temperature

7.4 Harsh Environment

The test specimen was a 8300 B68F solenoid valve with a class "A" coil. The tested equipment was cycled 200 times and irradiated to 3×10^7 rads prior to the harsh environment test. The following test profile was conducted at 100% R.H. (Ref 13.7):

340 °F / 65 psig – 2 min
340 °F / 45 psig – 3 hr
320 °F / 45 psig – 3 hr
250 °F / 25 psig – 90 hr

7.5 Cycling

The tested equipment was energized 200 times with 106 VDC. (Ref 13.7)

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8.0 MAJOR ASSUMPTIONS

- It is assumed that for the purpose of this analysis, the deterioration of metallic components due to time/temperature effects and radiation exposure is insignificant.

- It is assumed that the organic materials used rather than the inorganic materials will be the limiting materials for time/temperature effects and radiation exposure.

- It is assumed that the time/temperature data obtained by the leakage test, where Buna-N O-rings are subjected to 1500 psi for three-1-minute cycles, were applicable to the Buna-N O-ring contained in the subject equipment.

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9.0 DETAILED CALCULATION

9.1 Buna-N O-ring (Ref 13.8)

Activation Energy for Buna-N O-ring = 0.75065 eV

Intercept of the regression curve = −16.2810

The life calculation equation for Buna-N O-ring is

$$\ln t_i = 8711.2572\left(\frac{1}{T_i}\right) - 16.2810$$

For a maximum harsh environment temperature of 305°F (152°C) in the CID system, the life calculation for Buna-N O-ring is as follows:

$$\ln t_i = 8711.2572\left(\frac{1}{425}\right) - 16.2810$$

$$t_i = 67.77 \text{ hr}$$

For a maximum harsh environment temperature of 126°F (52.56°C) in the CIT system, the life calculation for Buna-N O-ring is as follows:

$$\ln t_i = 8711.2572\left(\frac{1}{325.56}\right) - 16.2810$$

$$t_i = 35481.35 \text{ hr} = 4.05 \text{ yrs}$$

For a normal service environment temperature of 103°F (39.78°C) in both CIT and CID systems, the life calculation for Buna-N O-ring is as follows:

$$\ln t_i = 8711.2572\left(\frac{1}{312.78}\right) - 16.2810$$

$$t_i = 105880.72 \text{ hr} = 12.09 \text{ yr}$$

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Equivalent life at normal service conditions (103°F) based on 1 hour duration at maximum service environment condition (305°F) in CID system.

$$t_2 = 1 \exp\left[8711.2572\left(\frac{1}{312.78} - \frac{1}{425}\right)\right]$$

$$= 1562.42 \text{ hr}$$

Equivalent life at normal service conditions (103°F) based on 1 hour duration at maximum service environment condition (126°F) in CIT system.

$$t_2 = 1 \exp\left[8711.2572\left(\frac{1}{312.78} - \frac{1}{325.56}\right)\right]$$

$$= 2.98 \text{ hr}$$

Expected life of Buna-N O-ring using the combination of the calculated life at normal service conditions and the equivalent life based on 1 hour at maximum service environment condition in CID system

$$t = 105880.72 - 1562.42 \text{ hr}$$

$$= 104318.3 \text{ hr}$$

$$= 11.91 \text{ yr}$$

CLIENT NMPC FILE NO. 1961-AA99-001 BY Kwan C. Wong

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9.2 Class "H" Coil (Ref 13.9)

Solenoid valve was tested at 268°F for 12 days to simulate 40 years at 140°F by 10°C rule. The 10°C rule states that the specific reaction rate doubles for each 10-degree (°C or K) rise in temperature. The life calculation equation using the 10°C rule is

$$t_2 = t_1 \, 2^{\frac{T_2 - T_1}{10}}$$

where,

t_1 = Test Time at Temperature T_1

t_2 = Equivalent Time at Temperature T_2

T_1 = Test Temperature

T_2 = Qualification Temperature.

Equivalent life at normal service conditions (103°F) by 10°C rule

$$t = 12 \cdot 24 \cdot 2^{\frac{268-103}{1.8 \cdot 10}}$$

$= 165513.76$ hr

$= 18.89$ years

Equivalent life at normal service conditions by 10°C rule, based on 1 hour at maximum environment condition

$$t = 1 \cdot 2^{\frac{305-103}{1.8 \cdot 10}}$$

$= 2389.05$ hr

Expected life using the combination of calculated life at normal service conditions and equivalent life based on 1 hour at maximum service conditions:

$t = 165513.76 - 2389.05$ hr

$= 163124.71$ hr

$= 18.62$ yrs.

10.0 RESULTS

10.1 Radiation

According to reference 13.8, the radiation threshold damage for Buna-N is 1.4×10^6 rads.
The solenoid valve 8300B68F was irradiated to 4×10^6 rads without malfunction and only minimum leakage. The valve was also exposed to 3×10^7 rads without malfunction but with erratic leakage. (Ref 13.7.)

10.2 Time / Temperature Effects

10.2.1 Buna-N O-ring

Buna-N O-ring has an calculated expected life of 67.77 hours at 305°F in the CID system, 4.05 years at 126°F in the CIT system, and 12.09 years at 103°F in both CID and CIT systems. The expected life calculated, using normal service conditions and equivalent life based on one hour at maximum temperature, is 11.91 years.

10.2.2 Coil

No life expectancy data of the class "B" coil used in the subject equipment is available. The class "B" coil has a thermal rating of 130°C.

ASCO uses class "H" coils in the NP series solenoid valves which has been tested at 268°F for 12 days to simulate 4.4 years at 140°F, by 10°C rule. The expected life calculated by 10°C rule, using normal service

CLIENT NMPC FILE NO. 1961-A479-001 BY Kwan C Wong

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conditions and equivalent life based on one hour at maximum temperature, is 18.62 years. The class "H" coil has a thermal rating of 180°C.

10.3 Harsh Environment

The tested equipment was subjected to 340°F, 65 psig for 2 minutes; 340°F, 45 psig for 3 hours; 320°F, 45 psig for 3 hours; and 250°F, 25 psig for 90 hours. The relative humidity was 100% in the test chamber. The valve was operated after 6 hours of testing with no malfunction and only minimum leakage. The valve was also operated at the end of the test with no malfunction but with erratic leakage.

10.4 Cycling

The tested equipment was energized 200 times with 106 VDC. At the end of the cycling test, the tested equipment was operated without malfunction. ASCO recommended 1,000,000 cycles for the subject equipment. (Ref 13.10)

11.0 SUMMARY OF RESULTS / CONCLUSION

11.1 Radiation

The radiation threshold level for Buna-N is 1.4×10^6 rads. The solenoid valve 8300 368F was also irradiated to 4×10^6 rads without malfunction and only minimum leakage. Since both of these radiation doses exceed the total integrated dose the subject equipment is expected to receive in 40 years of normal

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service conditions and one design basis event, the subject equipment can be qualified for a service life of 40 years, based on radiation only.

11.2 Time/Temperature Effect

11.2.1 Buna-N O-ring

The Buna-N O-ring has an calculated expected life of 11.91 years, based on normal service conditions and one hour maximum service conditions. Therefore, the Buna-N O-ring cannot be qualified for a service life of 40 years, base on Time/Temperature effect.

11.2.2 Coil

No life expectancy data of the class "B" coil used in the subject equipment is available. The class "H" coil has an calculated expected life of 18.62 years, based on normal service conditions and one hour maximum service conditions. Since class "H" coil has a higher thermal rating than the class "B" coil, the class "B" coil will have a shorter expected life. Therefore, the class "B" coil cannot be qualified for a service life of 40 years.

11.3 Harsh Environment

The tested equipment was tested at 320°F/45 psig or higher for 6 hours and 250°F/25 psig for 90 hours. The tested equipment was operated without malfunction and only minimum leakage after 6 hours of testing.

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The tested equipment was operated at the end of the test without malfunction but with erratic leakage. The test environments exceeded the harsh environment requirement specified in Table 6-1. The subject equipment can be qualified to operate at harsh environment only if the fluid supply can handle the amount of leakage that can develop.

11.4 Cycling

The tested equipment was operated without malfunction after it was energized 200 times at 106 VDC. ASCO recommended 1,000,000 cycles for the subject equipment. Since no operational cycling requirement has been specified, no conclusion can be drawn for the cycling qualification of the subject equipment.

12.0 RECOMMENDATION

- Subject equipments be replaced with qualified equipments

Since there is no data available for the life of the class "B" coil, it is not possible to set up a maintenance program to replace the coil. Therefore, the subject equipment should be replaced.

CLIENT NMPC FILE NO. 1961-A099-001 BY Kwon C Wong

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13.0 REFERENCES

13.1 Niagara Mohawk Power Corporation, Nine Mile Point 1, on-going Qualification Assesment Summary, Rev. 4, dated 11/5/81

13.2 ASCO Catalog No 30A

13.3 Memo from SJ Gazda (NUS) to AP Canepa (NUS), CD-ENG-926, dated 11/23/81

13.4 NMPC letter from D. Green to DH Bhatia (NUS), dated 3/11/81

13.5 NUS Analysis 1961-SA-A1, Niagara Mohawk Power Corporation, Nine Mile Point 1, HELB Pressure and Temperature Model — Reactor Building, dated 12/9/81

13.6 NUS Analysis 1961-R-1, Niagara Mohawk Power Corporation, Radiation Environment Specification For NMP-1, dated 10/25/81

13.7 Environmental Testing of MSS/RV Air Control Valves, Report No 101.2401.0359; GE Report No. 126-62, dated 1/15/75

13.8 NUS Generic Analysis, NUS-LA-A-1, Material Analysis for Acrylonitrile-Rubber; 11/23/81

13.9 ASCO letter from FW Madehose to DH Bhatia (NUS), dated 7/27/81

13.10 Contact Report, Ralph Ellis (ASCO)/MA Ippolito (NUS), dated 9/29/81

SUBJECT:

Preliminary Evaluation of "LS", "HS", "CMC", "PT", and "Series 2" Type Switches Under Electrical Aging, Environmental Aging and Seismic Vibration Tests.

PURPOSE:

Provide information concerning switch performance during electrical aging, environmental aging and seismic vibration to demonstrate a switch capability under the applicable portions of IEEE323 and IEEE344.

CONCLUSIONS:

The "LS", "HS", "CMC", "PT", and "Series 2" switches demonstrated their abilities to perform their intended switch function throughout the selected tests. It is the intention of this report to provide information concerning switch performance in the areas of Electrical, Environmental, and Seismic Vibration testing. Product acceptance or suitability must be established by customer review of this information in conjunction with his application requirements.

MICRO SWITCH ENGINEERING TEST LABORATORY

TEST BY ______

APPROVED BY *Virgil Hoerather*

K. E. ...

DATE *24 Feb. 1977*

TEST SEQUENCE

1. Basic Measurements
2. Electrical Life (Initial Aging)
3. Environmental Aging
4. Basic Measurements
5. Electrical Life (Extended Aging)
6. Basic Measurements
7. Seismic Vibration
8. Electrical Life (Function Verification)
9. Basic Measurements

TEST DATA:

This test was initiated on 19 August 1975 by R.P. Hadley. One of each of the following Catalog Listings was received for testing.

Catalog Listing	Date Code
LSA2B-1D	7524
LSD1A	7534
LSQ051	7533
PTP22BB	7519
PTH2214CCC	7519
2C203 with 2D9	7527
2C206 with 2D33	7532
911BGD011MC with 2 PTCC	7440
910CGF511 with 4 PTCC	7542
1HS1	7531

GENERAL ENGINEERING COMMENTS:

These tests were initiated because of a variety of customer requests for "Qualification" to IEEE 323 or IEEE 344.

Qualification or acceptance under these specifications is a function of individual customer requirements. Obviously we would not have specific information available under such a wide variety of possible test conditions. The Evaluation Laboratory (MICRO SWITCH) was asked to conduct tests that would show switch capabilities under simulated IEEE 323 and IEEE 344 test conditions. This information could then be submitted to the customer for approval. The test information acquired is contained herein.

TEST EQUIPMENT:

The MICRO SWITCH Evaluation Laboratory maintains records of test equipment, laboratory identification, and as applicable, equipment calibration. The equipment used, conducting the tests reported herein, was examined prior to each use and validity of calibration period verified. The test equipment used was as follows.

Equipment		Laboratory Serial No. LAB-	Frequency of Calibration
Characteristics Fixture-Micrometer		None	As used
Characteristics Fixture - Protractor		None	As used
Force Measurement - Scale		5-22	3 months
		5-2	3 months
Pilot Lamp Indicator (7.5 VAC, 0.170 ampere)		20-16	As used
Megohm Meter		4-55	3 months
Voltmeter	0-250 VAC	4-152C	6 months
	0-250 VDC	4-15D	6 months
Ammeter	0-10 amps, AC	4-9C	3 months
	0-50 amps, AC	4-121	6 months
	0-100 amps, AC	A-13	3 months
Ammeter	0-.5 amps. DC	1-161	6 months
	0-5 amps, DC	4-143C	6 months

Equipment (Cont.)

Equipment	Laboratory Serial No.	Frequency of Calibration
Industrial Analyzer	4-86	6 months
Inductor DC, MIL-I-81023	10-24E	NA
	10-24G	NA
Operation Recorder	18-7H	NA
	18-5C	NA
	18-1	NA
Oven 100°F to 500°F	1-12	NA
	1-12B	NA
	1-12D	NA
Pyr-O-Vane Controller 100 to 600°F	8-14C	3 months
	8-14B	3 months
	8-14D	3 months
Humidity Chamber	1-19B	NA
Recorder Controller - Dry Bulb	8-16B	3 months
Recorder Controller - Wet Bulb	8-16	3 months
Vibrator - 5-55 Hz. - Mechanical	2-2	6 months
Linear Actuator 1-250 per min.	0-81B	NA
	Table D	NA
	Table E	NA
	Table H	NA
	1	NA
Rotary Actuator - Motor	11-18D	NA
Chatter Detector	20-79	3 months

TEST PROCEDURE:

Unless otherwise specified, all tests were conducted at room temperature, pressure and humidity.

BASIC MEASUREMENTS:

A. CHARACTERISTICS:

Switch travel characteristics were measured (when applicable) using a micrometer fixture graduated in .001 inch increments or a protractor fixture graduated in 1 degree increments, whichever was appropriate. The switch actuator was moved at a slow uniform rate (approximately .002 inch/second or 2° per second) using a manual drive. Switch circuits were monitored for continuity throughout switch travel using a pilot light circuit (Lab 20-16) operating at 7.5 VAC and .170 ampere. Although switch characteristics measurements were not applicable to manually operate devices, switch function was verified using the pilot light circuit.

Operating forces (when applicable) were measured using a scale (Lab No. 5-2 or 5-22) moving the actuator at a slow uniform rate. The scale was graduated in 1/4 ounce increments. Circuit continuity was, as noted above, monitored throughout the switch plunger travel.

B. INSULATION RESISTANCE:

Insulation resistance was measured at 200 VDC. Equipment accuracy limited the range of readings from 1 megohm to 100,000 megohms. Points of measurement were as follows:

1. Mutually insulated terminals of the same pole for those poles scheduled for electrical tests.

2. Terminals to grounded case (when applicable).

ELECTRICAL LIFE (Aging):

The object of this test was to apply sufficient mechanical and electrical operations, on typical 125 VDC and 125 VAC loads, to approximate switch conditions following a 40 year mechanical and electrical service life. For each switch type we selected a service life that was compatible with projected switch use in the application. The operational life and loads selected do not necessarily reflect maximum switch capabilities. The life and load conditions selected were typical of those encountered in various customer specifications and applications at this time.

This test was divided into three sections. The first was the initial electrical aging of the samples, intended to represent a 40 year life. The second was an overtest following environemntal aging. This was intended to verify sustained electrical function following accelerated degradation of the switch dielectric materials. The third was verification of switch operation following a simulated earthquake condition (seismic vibration).

Operational details for the various switch listings are shown on the charts titled "Electrical Test Parameters." One sample of each catalog listing was subjected to the specified load conditions following initial "Basic Measurements", "Environmental Aging", and "Seismic Testing". Each switch operation was monitored on a suitable chart type recorder. These charts were reviewed to verify proper switch operation throughout the life tests.

ENVIRONMENTAL AGING:

The environmental aging portion of the tests consisted of three cycles. Each cycle included Thermal Aging, Humidity Exposure, and Sinusoidal Vibration conducted in that order.

A. THERMAL AGING:

Each switch construction and its related materials were examined carefully to determine the maximum temperature at which the switch could survive, without significant deterioration of materials or performance, for a period of at least 700 hours. The temperatures selected were intended to provide an accelerated thermal degradation which would approximate a 40 year period of switch use under normal operating conditions. Obviously we do not have 40 years of experience accumulated on the switch listings tested. As a consequence, Aging Temperatures were based on our engineering judgements and available information. We will not, and have not attempted to justify our judgements. At this time we could not justify

ELECTRICAL TEST PARAMETERS

Catalog Listing	Voltage	Current Amperes	Inductor or Power Factor	Actuation Type	Actuation Rate	Circuit Tested
LSA2B-1D	125 VDC	0.25 Ind.	MIL-I-81023	Linear	6/min.	1-2, N.C. 7-8, N.O.
LSD1A	125 VAC	M60-B6 Ind.	M22%-B28%	Linear	30/min.	3-4, N.O.
LSQ051	125 VDC	0.5 Ind.	MIL-I-81023	Linear	6/min.	1-2, N.C. 7-8, N.O.
PTP22BB	125 VDC	1.1 Ind.	MIL-I-81023	Linear	6/min.	3-4, N.O., Block #1 3-4, N.O., Block #2
PTH2214CCC	125 VAC	M60-B6 Ind.	M22%-B28%	Linear	30/min.	1-2, N.C., Block #1 5-6, N.C., Block #2
	125 VAC	M7.5-B1.2 Ind.	M14%-B33%	Linear	30/min.	3-4, N.O. Block #3 7-8, N.O., Block #3
2C203, 2D9	125 VAC	5 Res.		Linear	30/min.	1-2, N.O., Basic #1 4-6, N.O., Basic #2 7-8, N.C., Basic #3 10-11, N.C., Basic #4
2C206, 2D33	125 VDC	0.25 Ind.	MIL-I-81023	Linear	6/min.	1-3, N.O. Basic #1 4-6, N.O., Basic #2 7-8, N.C., Basic #3 10-11, N.C. Basic #4
911BGD011MC, 2 PTCC	125 VDC	1.1 Ind.	MIL-I-81023	Linear	6/min.	1-2, N.C., Block #1 5-6, N.C., Block #2
910CGF511, 4 PTCC	125 VAC	M60-B6 Ind.	M22%-B28%	Rotary	6/min.	1-2, N.C., Block #1 5-6, N.C., Block #2
		M7.5-B1.2	M14%-B33%			3-4, N.O., Block #3 7-8, N.O., Block #3
	250 VAC	M30-B3	M20%-B30%			5-6, N.C., Block #4
1HS1	125 VDC	.5 Res.		Linear	6/min.	C-N.O.

M - Make or inrush load parameters.
B - Break or current interruption load parameters.
N.O. - Normally open circuit
N.C. - Normally closed circuit

the cost of complex verification tests. We can only offer our tests for customer consideration and/or acceptance.

Each of the three test cycles consisted of a minimum of 235 hours exposure at the selected temperature. The total exposure time in all cases was in excess of 700 hours. The thermal aging was conducted in circulating air ovens with uncontrolled humidity. The individual test temperatures and exposure times are shown on the chart titled "Environmental Aging - Thermal Aging".

B. MOISTURE ABSORPTION:

This portion of the Environmental Aging test was included to evaluate the properties of materials as they are influenced by the absorption and diffusion of moisture. Absorption of moisture by many materials results in swelling, loss of physical strength and degradation in dielectric properties. These affects are further magnified by thermal aging. It was, therefore, logical to include such a test in our Environmental Aging.

Each switch was subjected to a minimum exposure of 48 hours duration at 104°F and 95 to 100 relative humidity following each cycle of thermal aging. A 48 hour time period was considered sufficient to allow material saturation for the material volumes used in the tested switch listings.

C. VIBRATION (SINUSOIDAL) AGING:

The purpose of vibration aging was to impose mechanical stresses on the switches, compensating for those introduced during shipping, installation and service life. These stress factors are variable in the customer applications. Having no clear definition of vibration aging parameters from IEEE 323, the author selected a sinusoidal vibration having a frequency range of 10 to 55 hertz. The harmonic motion had a displacement as specified in the chart titled "Environmental Aging - Vibration Aging". The entire frequency range from 10 to 55 and back to 10 hertz was traversed in 1 minute, the frequency being varied uniformly between these limits as per MIL-STD-202E, Method 201A. Each switch, mounted by its normal mounting means, was subjected to one half hour of vibration in each of its three major planes, following each of the three "Moisture Absorption" cycles. The total vibration time was four and one half hours. Since the purpose of this test was to provide mechanical stress, we did not attempt to monitor switch contacts for separation or transfer. Following each vibration exposure the switches were examined visually for breakage or deformation, and mechanical function was verified using a pilot lamp load (Lab No. 20-16).

SEISMIC VIBRATION TESTING:

The seismic vibration portion of this switch testing was conducted at Acton Environmental Testing Corporation by B. Esposito on 8 December 1976. The following section of this report concerning these tests was extracted from the Acton report number 12762.

At this time we have no well defined requirements concerning switch performance during vibration. This must be specified by the individual customers. Therefore, we decided to monitor contact separation or transfer as applicable, report the duration of any separation or transfer and let the customer determine if the switch performance would be satisfactory in his application.

A. TEST MOUNTING:

The ten switches were mounted to an aluminum test fixture which was securely attached to the small biaxial table of the Acton Enviornmental Testing Corporation (AETC) 45° biaxial seismic test facility such that the fixture had a transmissibility of 1.0. the switches were attached to the test fixture in a manner similar to actual field mounting. The mounting configuration of each switch was as follows:*

Switch	Mounting Configuration
1. LSA2B-1D	2 Allen screws through switch to auxilary mounting plate and 4 allen screws through this plate to the test fixture.
2. LSD1A	2 allen screws through switch to test fixture.
3. LSQ051	Same as LSA2B-1D.
4. 1HS1	2 allen screws through switch to the 3/8 inch angle fixture.
5. PTP22BB	Panel type mount, cross section of 3/8 inch angle fixture reduced to 1/4 inch for mounting.
6. PTH2214CCC	Same as PTP22BB.
7. 2C203 (2D9)	Panel type mount, cross section of 3/8 inch angle fixture reduced to 1/8 inch for mounting.
8. 2C206 (2D33)	Panel type mount, cross section of 1/4 inch angle fixture (furnished by MICRO SWITCH) reduced to 1/8 inch for switch mounting , angle fixture attached to test plate using 2 allen screws.
9. 910CGF511 (4-PTCC)	Panel type mount to the 3/8 inch angle fixture.
10. 911BGD011MC (2-PTCC)	Same as 910CGF511.

* Refer to included photographs.

B. TEST MONITORING:

The ten switches were visually monitored for any evidence of mechanical damage or deterioration.

The switches were monitored with accelerometers by AETC personnel to determine their mechanical response. Data from these accelerometers was recorded on visicorder chart paper. The five monitoring accelerometers and one control accelerometer were mounted in the following locations:*

Accelerometer Number	Axis	Location*
1	Vertical	On Switch 911BGD011MC
2	Vertical	On Switch 910CGF511
3	Vertical	On Switch LSQ051
4	Vertical	On Switch LSA2B-1D
5	Front-to-back	On fixture angle
6	Vertical	On fixture plate (control)

MICRO SWITCH personnel wired the closed contacts of switches LSA2B-1D, LSD1A, LSQ051, 1HS1, PTP22BB, PTH2214CCC, 2C203, 911BGD011MC, 910CGF511 and the open contacts of Switch 2C206 for monitoring of contact chatter or false closure by means of a 10 station detector provided by MICRO SWITCH. The MICRO SWITCH detector had four ranges of detection as follows:

* Refer to included photographs.

Range No.	Detection
1	In excess of 10 microseconds
2	In excess of 100 microseconds
3	In excess of 1 millisecond
4	In excess of 8 milliseconds

C. RESONANCE SURVEY:

A resonance survey using a sinusoidal input of 0.2 g's (vertical and horizontal peak acceleration) at frequencies of 1 through 35 Hz. was conducted at a sweep rate of 1 octave/minute. The input was applied to the small biaxial table of the AETC 45° biaxial seismic test facility in the following sequence:

Test No.	Biaxial Direction
1	Front-to-Back & Vertical
2	Left-to-Right & Vertical
3	Back-to-Front & Vertical
4	Right-to-Left & Vertical

D. SINE BEAT TEST:

The sine beat test consisted of amplitude modulated sinusoids with a vertical and horizontal peak acceleration as shown in the attached Generic Rim Specification, Figure 1, limited by 20" DA and 90"/sec. piston velocity. The sine beat test was to be performed at any resonant frequencies found in the "Resonance Survey" as well as at 33 Hz. The test for a given frequency was 5 beats, 10 cycles/beat, with a sufficient pause between beats to preclude any superposition of motion. The sine beat test performed in the following sequence:

Test No.	Biaxial Direction
5	Right-to-Left & Vertical
6	Back -to-Front & Vertical
7	Left-to-Right & Vertical
8	Front-to-Back & Vertical

E. MULTIPLE FREQUENCY TEST:

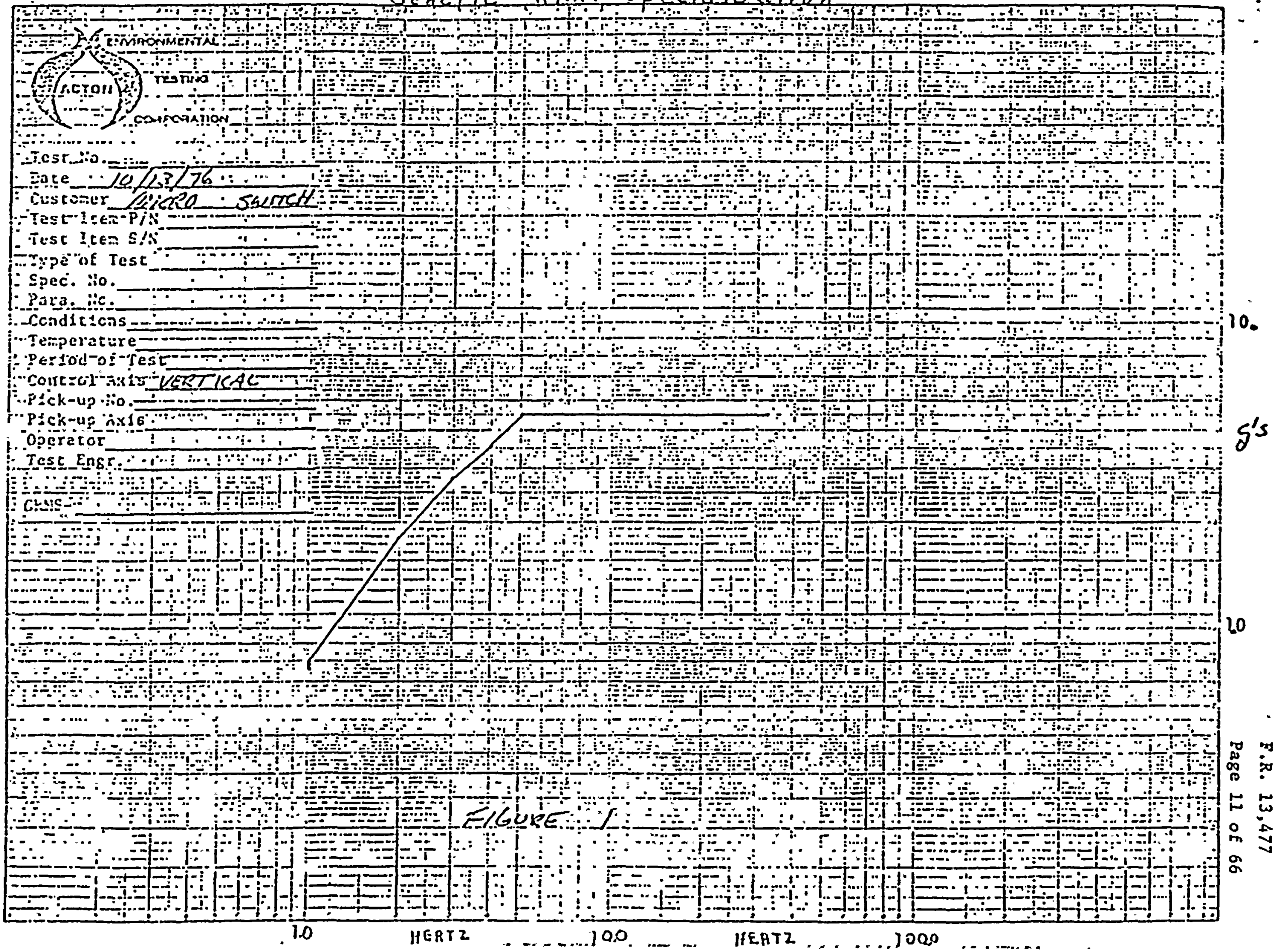
A biaxial multiple frequency excitation was applied to the switches for a period of 30 seconds per test. The horizontal and vertical input level of multiple frequency excitation was such that the Test Response Spectra (TRS) computed at Q=10 by a Spectral Dynamics SD321 Shock Spectrum Analyzer would envelop the Required Response Spectra (RRS), Figure 2, limited by 20" DA and 90"/second velocity. The input was applied 6 times in each axis, 5 OBE's followed by one SSE.

OBE - Operational basis earthquake
SSE - Safe shutdown earthquake

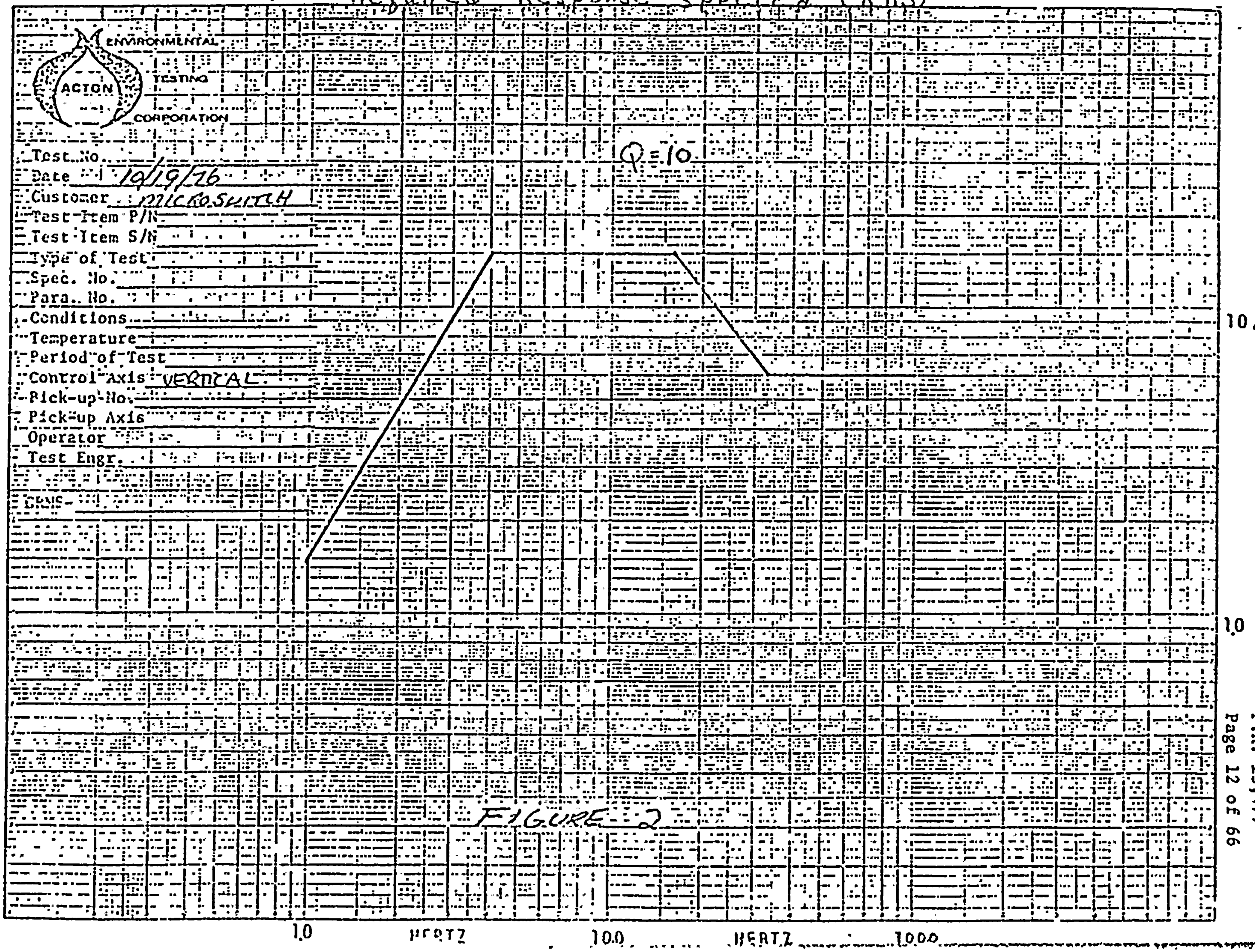
The multiple frequency test was performed in the following sequence:

Test No.	Biaxial Direction
9	Front-to-Back & Vertical
10	Left-to-Right & Vertical
11	Back-to-Front & Vertical
12	Right-to-Left & Vertical

Generic Rim Specification



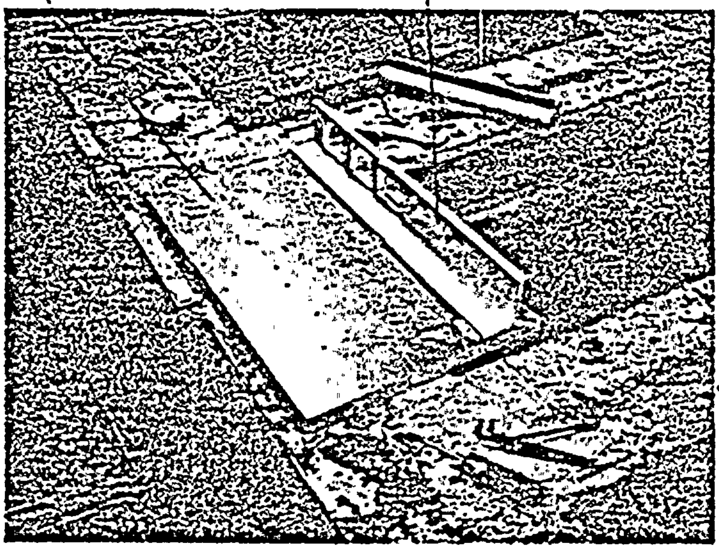
Required Response Spectra (RRS)



TEST EQUIPMENT LIST

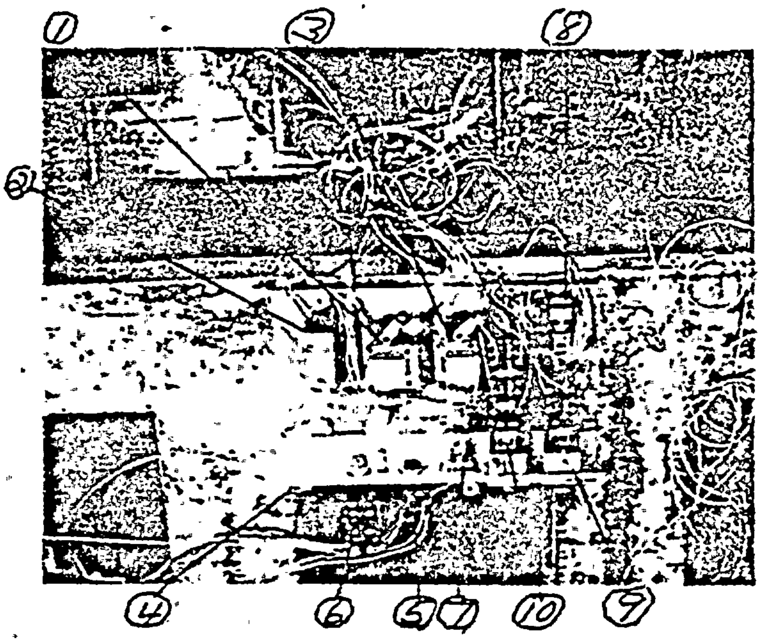
NAME	MFGR.	MODEL	SER.NO.	RANGE	ACCURACY	INV.#	CAL.FREQ.
General Purpose Oscilloscope	Tektronix	515A	2624	0.05 to 20v/cm 0.2usec to 2 sec	±3%	OS307	3 months
VTVM	HP	403A		10 Hz-1 MHz, 0-300 volts, 12 ranges	±3%	MV322	3 months
Power Supply	BUBR	506/16	322	±15 VDC, 1 ADC	0.5%	PD372	6 months
Hydraulic Actuator	MTS	204.63S		DC-300 Hz,25K force lbs. 25" DA max.	±2%F ±5%A		
Controller	MTS	443.115		DC to 2000 Hz	±1%	PE367	3 months
Shock Spectrum Analyzer	Spec.Dyna.	SD321	18	Input 0.1 Hz-10 KHz Sens 31.6 MV to 100V FS	±.5db	PE381	3 months
Recorder X-Y	MFE	715E	70154	Input: 1-10-100 MV Both channels	±0.5%	RE342	3 months
Visicorder	Honeywell	1508B	0304A	24 channel-Inches	±1 db	RE348	3 months
Sweep Oscillator	SDY	SD-104-5	21A	0.005 Hz - 50 KHz	±1%	SG315	6 months
Low Freq. Generator	HP	202B	397	0.01 Hz - 1 KHz	±5%	SG319	6 months
Tone Burst Gen.	GRC	1396	1052	DC - 2 MHz	N/A	SG326	6 months
Sine-Sq.Wave. Gen.	HEA	1GW47	1115	20 Hz - 1 MHz	±5%	SG329	6 months
Tape Deck	Honeywell	5600C - RENTAL					
Detector Microswitch	Lab 20-79	Property Tag No.9508		10 channel - Provided by Micro Switch			11/19/76

NAME	MFGR.	MODEL	SER.NO.	RANGE	ACCURACY	INV.#	CAL.FREQ.
Accelerometer	PCB	302A	1772	1 Hz - 5 KHz	±5%	AC415	3 months
"	"	"	1773	"	"	AC416	" "
"	"	"	1774	"	"	AC417	" "
"	"	"	1775	"	"	AC418	" "
"	"	"	1776	"	"	AC419	" "
"	"	"	1777	"	"	AC420	" "



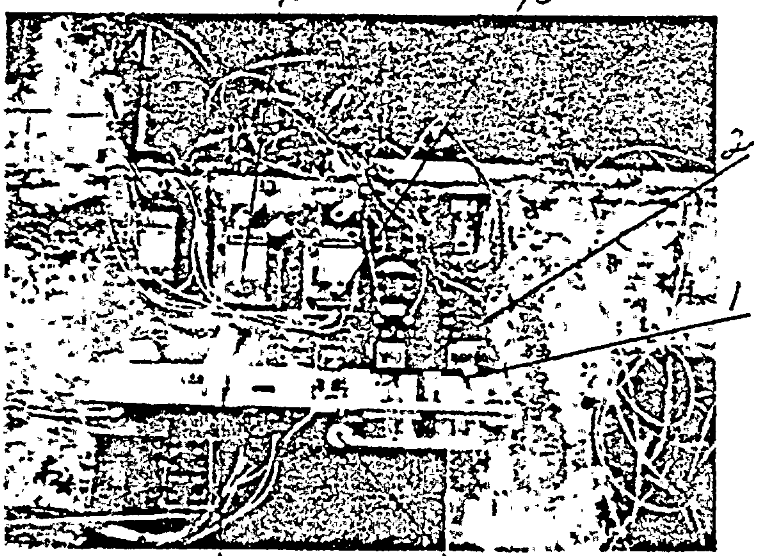
TEST FIXTURE

Report No. 12762



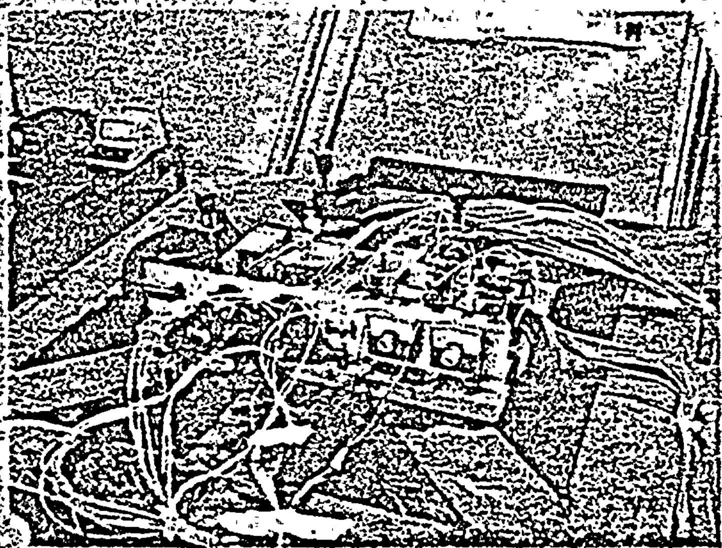
SWITCH LOCATIONS

Report No. 12762



ACCELEROMETER LOCATIONS

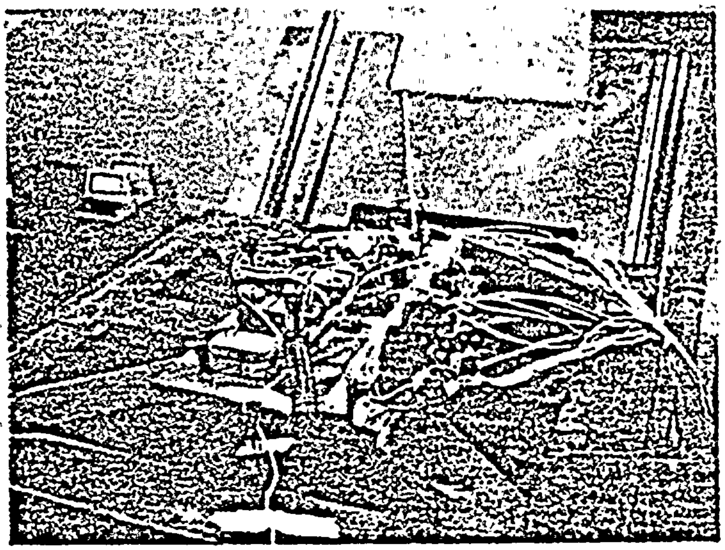
Report No. 12762



FRONT-TO-BACK & VERTICAL
TESTS #1, 8 & 9

Report No. 12762

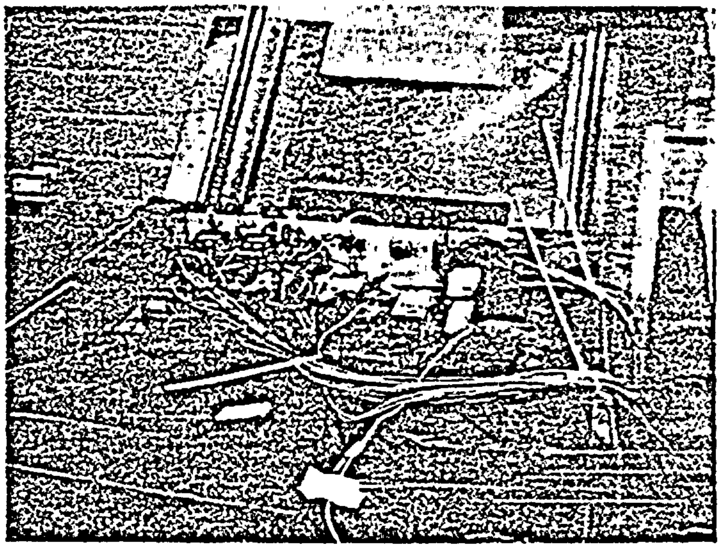
ACTON ENVIRONMENTAL TESTING CORPORATION



LEFT-TO-RIGHT & VERTICAL
TESTS #2, 7 & 10

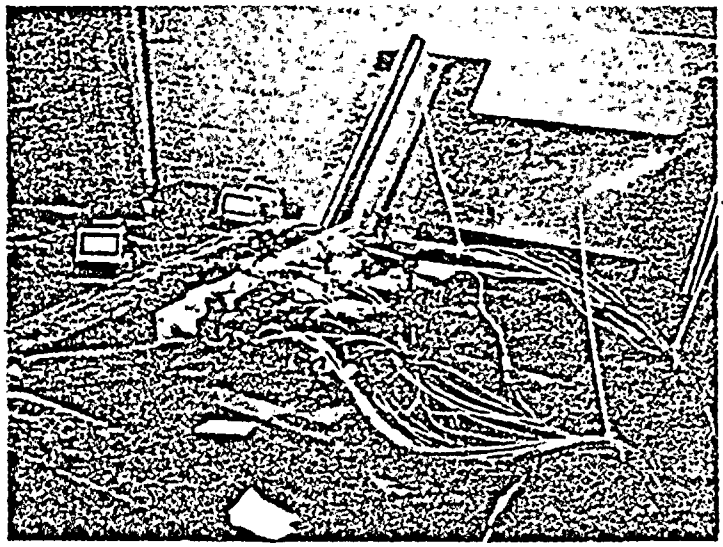
Report No. 12762

ENVIRONMENTAL TESTING CORPORATION
ACTON



BACK-TO-FRONT & VERTICAL
TESTS #3, 6 & 11

Report No. 12762



RIGHT-TO-LEFT & VERTICAL

TESTS #4, 5 & 12

Report No. 12762

TEST REQUIREMENTS

BASIC MEASUREMENTS:

A. CHARACTERISTICS AND FORCES:

All switches are required to function mechanically and electrically both before and after completion of the test program.

Characteristics and force measurements were applicable only to the switches shown below. The requirement limits were as follows:

	LSA2B-1D	LSD1A	LSQ051	1HS1
Pretravel	15° Max.	.070" Max.	15° Max.	.065" Max.
Differential Travel	7° Max.	.015" Max.	8° Max.	.020" Max.
Operating Force	4 in. lbs. Max.	4 lb. Max.	4 in. lb. Max.	10 to 22 oz.
Release Force	N.A.	N.A.	N.A.	4 oz. Min.

N.A. - Not Applicable

B. INSULATION RESISTANCE:

There were no requirements established in IEEE 323 concerning the dielectric properties of insulating materials. Therefore, we selected the requirements of MIL-S-8805C, paragraph 3.9 which specifies 1000 megohms minimum.

ELECTRICAL LIFE (Aging)

The electrical life requirements for switches would be a function of the application and must be specified by the individual customers. After reviewing customer specifications and discussing this problem with several customers we selected the following:

All switches must complete all phases of the electrical testing without any failure to make or break the electrical load in proper sequence. The life requirements for the various portions of this test were as follows:

Initial Life Test: 40,000 operations minimum
Extended Life Test: 10,000 operations minimum
(Following environmental Aging)
Final Operation Verification: 10 operations minimum
(Following seismic vibration)

ENVIRONMENTAL AGING:

The switches shall be mechanically and electrically functional following environmental aging and there shall be no visual evidence of product deformation or damage.

SEISMIC VIBRATION:

Following the seismic vibration test the switches must be mechanically and electrically functional and have no visual evidence of damage.

There is, at this time, no requirement concerning contact stability during vibration. As a result we monitored the switch contacts for separation or transfer as applicable to the test circuit and recorded the results. The customer must determine the product suitability for his application.

We must point out the fact that most switches of the types tested would be controlling relay, solenoid, indicator lamp and resistive loads which are not normally sensitive to contact disturbances in the 1 millisecond or less range.

TEST RESULTS AND TEST RECORDS:

BASIC MEASUREMENTS:

The test records are found on pages 25 thru 35 .

All switches except the 2C203 met all of the basic measurements requirements throughout the test. As noted on page 32, basic switch number 4 of the 2D9 module attached to the 2C203 actuator failed during electrical life testing following environmental aging. The switch life was exceeded rendering that basic switch inoperable. Therefore, no further basic measurements were recorded on that basic switch.

ELECTRICAL LIFE (Aging);

The test records are found on pages 25 thru 35.

As above, all switches except the 2C203 met all of the electrical life requirements. Basic switch number 4 of the 2D9 module attached to the 2C203 actuator failed to function after 46,178 operations on a 125 VAC, 5 ampere resistive load. An X-ray photograph (radiograph) of the basic switch showed severe electrical erosion of the switch contact areas which upset the balance of the snap acting mechanism resulting in failure to operate. In other words the basic switch had exceeded its electrical life capabilities. No further electrical tests were conducted on this basic switch, although it was not physically removed from the 2D9 switch module.

ENVIRONMENTAL AGING:

The test records are found on pages 37 thru 39.

All of the swtiches met the test requirements since all were electrically and mechanically functional following the test and there were no evidences of switch deformation or damage.

SEISMIC VIBRATION:

The test records are found on pages 40 thru 66.

All switches met the test requirements since all were electrically and mechanically functional following test and there was no evidence of switch damage.

Contact distrubances in excess of 10 microseconds were noted on the following switch listings.

LSQ051
910CGF511 with 4-PTCC blocks

This is reported on pages 41 and 42 . The significance of such contact disturbances in customer applications must be resolved by the customer.

VH/mk

File Reference: 5177 Report Number [illegible]

TITLE: Basic Measurements

TEST: Function; Characteristics; Forces, Insulation Resistance

DATE: 2-16-77

BY: Virgil Hoerzfler

	LSA2B-1D	LSD1A	LSQ051	1HS1	PTP22BB (2-PTCC)	PTH2214CCC (3-PTCC)	2C203 (2D9)	2C206 (2D33)	911BGD011MC (2-PTCC)	910CGF511 (4-PTCC)
Initial Measurements										
Function	9-9-75	9-9-75	9-9-75	9-9-75	9-24-75	9-19-75	9-18-75	9-14-75	9-21-75	9-21-75
Characteristics, Forces	9-9-75	9-9-75	9-9-75	9-9-75	9-24-75	9-19-75	9-18-75	9-14-75	9-21-75	9-21-75
Insulation Resistance	9-9-75	9-9-75	9-9-75	9-9-75	9-24-75	9-19-75	9-18-75	9-14-75	9-21-75	9-21-75
After Enviornmental Aging										
Function	11-5-75	11-18-75	11-6-75	11-5-75	11-18-75	11-4-75	11-4-75	11-4-75	1-5-76	10-1-75
Characteristics, Forces	11-5-75	11-18-75	11-6-75	11-5-75	11-18-75	11-4-75	11-4-75	11-4-75	1-5-76	10-1-75
Insulation Resistance	11-5-75	11-18-75	11-6-75	11-5-75	11-18-75	11-4-75	11-4-75	11-4-75	1-5-76	10-1-75
After Electrical Aging										
Function	11-1875	11-20-75	11-18-75	11-18-75	11-20-75	11-17-75	1-7-76	11-8-76	1-9-76	1-9-76
Characteristics, Forces	11-18-75	11-20-75	11-18-75	11-18-75	11-20-75	11-17-75	1-7-76	11-8-76	1-9-76	1-9-76
Insulation Resistance	11-18-75	11-20-75	11-18-75	11-18-75	11-20-75	11-17-75	1-7-76	11-8-76	1-9-76	1-9-76
After Seismic Vibration										
Function	2-11-77	2-11-77	2-11-77	2-9-77	2-11-77	2-11-77	2-9-77	2-9-77	2-11-77	2-11-77
Characteristics, Forces	2-11-77	2-11-77	2-11-77	2-9-77	2-11-77	2-11-77	2-9-77	2-9-77	2-11-77	2-11-77
Insulation Resistance	2-11-77	2-11-77	2-11-77	2-9-77	2-11-77	2-11-77	2-9-77	2-9-77	2-11-77	2-11-77

Catalog Listing LSA2B-1D

Date Code: 7524

Basic Measurements	Initial	After Thermal Cycle	After Electrical Aging	After Seismic
Characteristics	Travel in Degrees, Forces in Inch Pounds			
Function	OK	OK	OK	OK
Pretravel	cw 10, ccw 13	cw 12, ccw 13	cw 9, ccw 13	cw 11, ccw 13
Differential Travel	cw 4, ccw 5	cw 5, ccw 6	cw 4, ccw 4	cw 4, ccw 4
Operating Force	cw 2.2, ccw 2.2	cw 2.3, ccw 2.3	cw 2.0, ccw 2.0	cw 2.0, ccw 1.8
Insulation Resistance	Recorded in Megohms			
7-8	14,000	100,000	100,000	100,000
1-2	14,000	100,000	100,000	100,000
All leads to Case	3,300	38,000	100,000	100,000

Electrical Life	125 VDC, 0.25 Amp. Inductive
Ops. Initial Aging	47 614
Ops. After Thermal Aging	10 000
Ops. After Seismic Test	10

Thermal Aging	Temperature 125°C	40°C, 95% RH	Vibration 10 to 50 Hz.
Cycle No. 1	240 hrs.	72 hrs	1.5 hrs.
Cycle No. 2	240 hrs.	66 hrs	1.5 hrs.
Cycle No. 3	261 hrs.	53 hrs	1.5 hrs.

Seismic Vibration	Resonance Search 5 to 33 Hz.	Sine Beat at 33 Hz.	Multiple Frequency 5 to 33 Hz., Random Input
Fixture Position #1	None	OK	OK
#2	"	OK	OK
#3	"	OK	OK
#4	"	OK	OK

Engineering Comments:

CW - Clockwise ; CCW - Counterclockwise

Catalog Listing LSC1A Date Code: 4534

Basic Measurements	Initial	After Thermal Cycle	After Electrical Aging	After Seismic
Characteristics	Travel in Inches, Forces in Pounds			
Function	OK	OK	OK	OK
Pretravel	.037	.039	.041	.036
Differential Travel	.010	.017	.015	.012
Operating Force	3	3.3	3.3	3
Insulation Resistance	Recorded in Megohms			
3-4	100,000	100,000	100,000	100,000
3+4 To Case	32,000	100,000	100,000	100,000

Electrical Life	125 VAC, Make 60 Amp. - Break 6 Amp., Inductive
Ops. Initial Aging	40,000
Ops. After Thermal Aging	12,000
Ops. After Seismic Test	10

Thermal Aging	Temperature 93°C	40°C, 95% RH	Vibration 10 to 50 Hz.
Cycle No. 1	240 hrs.	72 hrs.	1.5 hrs.
Cycle No. 2	240 hrs.	66 hrs.	1.5 hrs.
Cycle No. 3	261 hrs.	53 hrs.	1.5 hrs.

Seismic Vibration	Resonance Search 5 to 33 Hz.	Sine Beat at 33 Hz.	Multiple Frequency 5 to 33 Hz., Random Input
Fixture Position #1	None	OK	OK
#2	"	OK	OK
#3	"	OK	OK
#4	"	OK	OK

Engineering Comments:

F.R. 13477 LTR- 24407

Catalog Listing LSQC51 Date Code: 7533 Page 28 of 66

Basic Measurements	Initial	After Thermal Cycle	After Electrical Aging	After Seismic
Characteristics	Travel in Degrees, Forces in Inch Pounds			
Function	OK	OK	OK	OK
Pretravel	CW 11, CCW 12	CW 12, CCW 14	CW 11, CCW 13	CW 11, CCW 12
Differential Travel	CW 5, CCW 5	CW 5, CCW 5	CW 5, CCW 5	CW 4, CCW 4
Operating Force	CW 2.2, CCW 2.2	CW 2.8, CCW 2.7	CW 2.2, CCW 1.9	CW 2.0, CCW 1.9
Insulation Resistance	Recorded in Megohms			
7-8	30,000	100,000	100,000	100,000
1-2	100,000	100,000	100,000	100,000
All Leads to Case	50,000	100,000	100,000	100,000

Electrical Life	125 VDC, 0.5 Amp. Inductive
Ops. Initial Aging	47,614
Ops. After Thermal Aging	10,000
Ops. After Seismic Test	10

Thermal Aging	Temperature 125°C	40°C, 95% RH	Vibration 10 to 50 Hz.
Cycle No. 1	240 hrs.	72 hrs	1.5 hrs.
Cycle No. 2.	240 hrs.	66 hrs	1.5 hrs.
Cycle No. 3	261 hrs.	53 hrs	1.5 hrs.

Seismic Vibration	Resonance Search 5 to 33 Hz.	Sine Beat at 33 Hz.	Multiple Frequency 5 to 33 Hz., Random Input
Fixture Position #1	None	100 u sec.	None
#2	"	None	10 u sec (SSE)
#3	"	100 u sec.	None
#4	"	100 u sec.	10 u sec (SSE)

Engineering Comments:

CW - Clockwise; CCW - Counterclockwise.

100 u sec (SSE) - Contact separation greater than 100 u sec, but less than 1 millisecond during simulated Safe Shutdown Earthquake

Catalog Listing 1HS1 Date Code: 7531

Basic Measurements	Initial	After Thermal Cycle	After Electrical Aging	After Seismic
Characteristics	Travel in Inches, Forces in Ounces.			
Function	O.K.	O.K.	O.K.	O.K.
Operating Point	.544	.542	.544	.540
Pretravel	.043	.042	.042	.040
Differential Travel	.012	.012	.010	.010
Operating Force	15	14	15	14
Release Force	8	7	9	8
Insulation Resistance	Recorded in Megohms.			
NC to NO	100,000 megohms	100,000	100,000	100,000
Leads to Case	100,000 "	46,000	100,000	100,000

Electrical Life	125 VDC, 0.5 Amp. Res.
Ops. Initial Aging	24462
Ops. After Thermal Aging	10,000
Ops. After Seismic Test	10

Thermal Aging	Temperature 85°C	40°C, 95% RH	Vibration 10 to 50 Hz.
Cycle No. 1	240 hrs.	72 hrs.	1.5 hrs.
Cycle No. 2	240 "	66 "	1.5 "
Cycle No. 3	261 "	53 "	1.5 "

Seismic Vibration	Resonance Search	Sine Beat at	Multiple Frequency
	5 to 33 Hz.	33 Hz.	5 to 33 Hz., Random Input
Fixture Position #1	None	OK	OK
#2	"	OK	OK
#3	"	OK	OK
#4	"	OK	OK

Engineering Comments:

Catalog Listing PTP22B3 Date Code: 7519

Basic Measurements Characteristics	Initial	After Thermal Cycle	After Electrical Aging	After Seismic
Function	OK	OK	OK	OK
Insulation Resistance	Recorded in Megohms			
Block #1 3-4	100,000	100,000	100,000	100,000
" #2 3-4	100,000	100,000	100,000	100,000

Electrical Life	125 VDC, 1.1 Amp., Inductive
Ops. Initial Aging	40,013
Ops. After Thermal Aging	10,000
Ops. After Seismic Test	10

Thermal Aging	Temperature 85 °C	40°C, 95% RH	Vibration 10 to 50 Hz.
Cycle No. 1	242 hrs.	70 hrs.	1.5 hrs.
Cycle No. 2	236 hrs.	71 hrs.	1.5 hrs.
Cycle No. 3	266 hrs.	67 hrs.	1.5 hrs.

Seismic Vibration	Resonance Search 5 to 33 Hz.	Sine Beat at 33 Hz.	Multiple Frequency 5 to 33 Hz., Random Input
Fixture Position #1	None	OK	OK
#2	"	OK	OK
#3	"	OK	OK
#4	"	OK	OK

Engineering Comments:

F.R. 13477 LTR-24437

Catalog Listing PTH2214CCC | Date Code: 7519 | Page 31 of 66

Basic Measurements Characteristics	Initial	After Thermal Cycle	After Electrical Aging	After Seismic
Function	OK	OK	OK	OK

Insulation Resistance	Recorded in Megohms			
Block #1 1-2	100,000	100,000	100,000	100,000
Block #2 5-6	100,000	100,000	100,000	100,000
Block #3 3-4	100,000	100,000	100,000	100,000
7-8	100,000	100,000	100,000	100,000
Block #4 5-6	100,000	100,000	100,000	100,000

Electrical Life	Various - See Chart "Electrical Test Parameters"
Ops. Initial Aging	55,000
Ops. After Thermal Aging	10,000
Ops. After Seismic Test	10

Thermal Aging	Temperature 85 °C	40°C, 95% RH	Vibration 10 to 50 Hz.
Cycle No. 1	241 hrs.	73 hrs.	1.5 hrs.
Cycle No. 2	265 hrs	66 hrs.	1.5 hrs.
Cycle No. 3	261 hrs	71 hrs.	1.5 hrs.

Seismic Vibration	Resonance Search 5 to 33 Hz.	Sine Beat at 33 Hz.	Multiple Frequency 5 to 33 Hz., Random Input
Fixture Position #1	None	OK	OK
#2	"	OK	OK
#3	"	OK	OK
#4	"	OK	OK

Engineering Comments:

Catalog Listing 2C203 with 2D9 Date Code: 7527

Basic Measurements	Initial	After Thermal Cycle	After Electrical Aging	After Seismic
Characteristics	Travel in Inches, Forces in Pounds			
Function	O.K.	O.K.	O.K.	O.K.
Pretravel	.129	.149	.152	.149
Operating Force	4.2	6	5.8	6
Release Force	1.9	1.8	2	2
Insulation Resistance	Recorded in Megohms			
Basic No 1 C-NO	100,000	100,800	100,000	100,000
" " 2 C-NO	100,000	100,000	100,000	100,000
" " 3 C-NC	40,000	73,000	100,000	100,000
" " 4 C-NC	38,000	70,000		
All Terminals-Housing	26,000	36,000	100,000	100,000
Electrical Life	125 VAC, 5 Amp. Resistive			
Ops. Initial Aging	42,330			
Ops. After Thermal Aging	12,000	Basic No 4 Failed after 46,178 ops.		
Ops. After Seismic Test	10			
Thermal Aging	Temperature 65°C	40°C, 95% RH	Vibration 10 to 50 Hz.	
Cycle No. 1	241 hrs.	73 hrs.	1.5 hrs.	
Cycle No. 2	265 hrs.	66 hrs.	1.5 hrs.	
Cycle No. 3	261 hrs.	71 hrs.	1.5 hrs.	
Seismic Vibration	Resonance Search 5 to 33 Hz.	Sine Beat at 33 Hz.	Multiple Frequency 5 to 33 Hz., Random Input	
Fixture Position #1	None	OK	OK	
#2	"	OK	OK	
#3	"	OK	OK	
#4	"	OK	OK	

Engineering Comments:

Basic Switch No 4 exceeded its electrical life at 46,177 operations. The switch was disconnected from the electrical load at that time and no further electrical or enviornmental test information applies to this basic switch.

Catalog Listing 2C206 with 2D33 Date Code: 7532

Basic Measurements	Initial	After Thermal Cycle	After Electrical Aging	After Seismic
Characteristics				
Function	OK	OK	OK	OK
Insulation Resistance	Recorded in Megohms			
Basic No. 1 C-NO	100,000	84,000	67,000	100,000
" " 2 C-NO	100,000	100,000	100,000	100,000
" " 3 C-NC	100,000	100,000	100,000	100,000
" " 4 C-NC	100,000	100,000	100,000	100,000
All Terminals to Housing	85,000	26,000	80,000	90,000

Electrical Life	125 V.D.C., 0.25 Amp. Inductive
Ops. Initial Aging	42330
Ops. After Thermal Aging	10,000
Ops. After Seismic Test	10

Thermal Aging	Temperature 65°C	40°C, 95% RH	Vibration 10 to 50 Hz.
Cycle No. 1	241 hrs.	73 hrs.	1.5 hrs.
Cycle No. 2	265 hrs.	66 hrs.	1.5 hrs.
Cycle No. 3	261 hrs.	71 hrs.	1.5 hrs.

Seismic Vibration	Resonance Search 5 to 33 Hz.	Sine Beat at 33 Hz.	Multiple Frequency 5 to 33 Hz., Random Input
Fixture Position #1	None	OK	OK
#2	"	OK	OK
#3	"	OK	OK
#4	"	OK	OK

Engineering Comments:

Catalog Listing 911BGDOHMC with 2 PTCC   Date Code: 7440

Basic Measurements	Initial	After Thermal Cycle	After Electrical Aging	After Seismic
Characteristics				
Function	OK	OK	OK	OK

Insulation Resistance	Recorded in Megohms			
Block No. 1 1-2	100,000	100,000	100,000	100,000
" " 2 5-6	100,000	100,000	100,000	100,000

Electrical Life	125 VDC, 1.1 Amp. Inductive
Ops. Initial Aging	48,964
Ops. After Thermal Aging	20,000
Ops. After Seismic Test	10

Thermal Aging	Temperature 65 °C	40°C, 95% RH	Vibration 10 to 50 Hz.
Cycle No. 1	223 hrs.	117 hrs.	1.5 hrs.
Cycle No. 2	240 hrs.	64 hrs	1.5 hrs.
Cycle No. 3	259 hrs.	72 hrs	1.5 hrs.

Seismic Vibration	Resonance Search 5 to 33 Hz.	Sine Beat at 33 Hz.	Multiple Frequency 5 to 33 Hz., Random Input
Fixture Position #1	None	OK	OK
#2	"	OK	OK
#3	"	OK	OK
#4	"	OK	OK

Engineering Comments:

Catalog Listing 910CGF511 with 4 PTCC   Date Code: 7542

Basic Measurements Characteristics	Initial	After Thermal Cycle	After Electrical Aging	After Seismic
Function	OK	OK	OK	OK

Insulation Resistance — Recorded in Megohms

		Initial	After Thermal Cycle	After Electrical Aging	After Seismic
Block No. 1	1-2	100,000	100,000	100,000	100,000
" " 2	5-6	100,000	100,000	100,000	100,000
" " 3	3-4	100,000	100,000	100,000	100,000
" " 3	7-8	100,000	100,000	100,000	100,000
" " 4	56	100,000	100,000	100,000	100,000

Electrical Life — Varous - See Chart "Electrical Test Parameters"

Ops. Initial Aging	40,000
Ops. After Thermal Aging	10,000
Ops. After Seismic Test	10

Thermal Aging	Temperature 65 °C	40°C, 95% RH	Vibration 10 to 50 Hz.
Cycle No. 1	223 hrs.	117 hrs.	1.5 hrs.
Cycle No. 2	240 hrs.	64 hrs.	1.5 hrs.
Cycle No. 3	259 hrs.	72 hrs.	1.5 hrs.

Seismic Vibration	Resonance Search 5 to 33 Hz.	Sine Beat at 33 Hz.	Multiple Frequency 5 to 33 Hz., Random Input
Fixture Position #1	None	10 u sec.	OK
#2	"	10 u sec.	OK
#3	"	OK	OK
#4	"	10 u sec.	OK

Engineering Comments:

10 u sec - Contact separation greater than 10 u sec. but less than 100 u sec.

File Reference: 13477. Report Number 24407.

TITLE: Electrical Life (Aging)

TEST: See "Electrical Test Parameters" for test details

DATE: 2-14-77

BY: Virgil Hocroffer

	LSA2B-1D	LSD1A	LSQ051	1HS1	PTP22BB (2-PTCC)	PTH2214CCC (3-PTCC)	2C203 (2D9)	2C206 (2D33)	911BGD011MC (2-PTCC)	910CGF511 (4-PTCC)
Initial Electrical Aging										
Date Start	9-9-75	9-9-75	9-9-75	9-9-75	9-28-75	9-21-75	11-4-75	9-15-75	9-22-75	9-22-75
Date Stop	9-15-75	9-11-75	9-15-75	9-9-75	9-30-75	9-23-75	11-6-75	9-23-75	9-30-75	9-30-75
Operations	47,614	40,000	47614	24,462	40,013	55,000	42,330	42,330	48,964	40,000
After Environmental Aging										
Date Start	11-12-75	11-19-75	11-12-75	11-12-75	11-19-75	11-4-76	1-6-76	11-4-76	1-5-76	1-5-76
Date Stop	11-13-75	11-19-75	11-12-75	11-13-75	11-19-75	11-4-76	1-6-76	11-4-76	1-8-76	1-8-76
Operations	10,000	12,000	10,000	10,000	10,000	10,000	12,000	10,000	20,000	10,000
After Seismic Vibration										
Date Start	2-8-77	2-7-77	2-8-77	2-8-77	2-8-77	2-7-77	2-8-77	2-8-77	2-8-77	2-7-77
Date Stop	2-8-77	2-7-77	2-8-77	2-8-77	2-8-77	2-7-77	2-8-77	2-8-77	2-8-77	2-7-77
Operations	10	10	10	10	10	10	10	10	10	10
Total Switch Operations	57,624	52,010	57,624	34,472	50,023	65,010	54,340	52,340	68,974	50,010

File Reference: 13477 Report Number [illegible]

TITLE: Environmental Aging - Thermal Aging

TEST: Test Temperatures and Exposure Times As Defined Below.

DATE: 2-10-77

BY: Virgil Hocraffer

		LSA2B-1D	LSD1A	LSQ051	1HS1	PTP22BB (2-PTCC)	PTH2214CCC (3-PTCC)	2C203 (2D9)	2C206 (2D33)	911BGD011MC (2-PTCC)	910CGF511 (4-PTCC)
Test Temperature		125°C	93°C	125°C	85°C	85°C	85°C	65°C	65°C	65°C	65°C
Cycle #1	start	9-15-75	9-15-75	9-15-75	9-15-75	9-30-75	9-23-75	9-23-75	9-23-75	11-17-75	11-17-75
	stop	9-25-75	9-25-75	9-25-75	9-25-75	10-10-75	10-3-75	10-3-75	10-3-75	11-26-75	11-26-75
	Hours	240	240	240	240	242	241	241	241	223	223
Cycle #2	start	9-30-75	9-30-75	9-30-75	9-30-75	10-14-75	10-6-75	10-6-75	10-6-75	12-2-75	12-2-75
	Stop	10-10-75	10-10-75	10-10-75	10-10-75	10-24-75	10-17-75	10-17-75	10-17-75	12-12-75	12-12-75
	Hours	240	240	240	240	236	265	265	265	240	240
Cycle #3	start	10-13-75	10-13-75	10-13-75	10-13-75	10-27-75	10-20-75	10-20-75	10-20-75	12-15-75	12-15-75
	Stop	10-24-75	10-24-75	10-24-75	10-24-75	11-7-75	10-31-75	10-31-75	10-31-75	12-26-75	12-26-75
	Hours	261	261	261	261	266	261	261	261	259	259
Total Exposure	Hours	741	741	741	741	744	767	767	767	722	722

File Reference: 13772 Report Number 34767

TITLE: Environmental Aging – Moisture Absorption

TEST: 40°C (104°F), 95 to 100 percent Relative Humidity

DATE: 2-10-77

BY: Virgil Hoerauf

		LSA2B-1D	LSD1A	LSQ051	1HS1	PTP22BB (2-PTCC)	PTH2214CCC (3-PTCC)	2C203 (2D9)	2C206 (2D33)	911BGD011MC (2-PTCC)	910CGF511 (4-PTCC)
Cycle #1	Start	9-26-75	9-26-75	9-26-75	9-26-75	10-10-75	10-3-75	10-3-75	10-3-75	11-26-75	11-26-75
	Stop	9-29-75	9-29-75	9-29-75	9-29-25	10-13-75	10-6-75	10-6-75	10-6-75	12-1-75	12-1-75
	Hours	72	72	72	72	70	73	73	73	117	117
Cycle #2	Start	10-10-75	10-10-75	10-10-75	10-10-75	10-24-75	10-17-75	10-17-75	10-17-75	12-12-75	12-12-75
	Stop	10-13-75	10-13-75	10-13-75	10-13-75	10-27-75	10-20-75	10-20-75	10-20-75	12-15-75	12-15-75
	Hours	66	66	66	66	71	66	66	66	64	64
Cycle #3	Start	10-24-75	10-24-75	10-24-75	10-24-75	11-7-75	10-31-75	10-31-75	10-31-75	12-26-75	12-26-75
	Stop	10-27-75	10-27-75	10-27-75	10-27-75	11-10-75	11-3-75	11-3-75	11-3-75	12-29-75	12-29-75
	Hours	53	53	53	53	67	71	71	71	72	72
Total Exposure	Hours	191	191	191	191	208	210	210	210	253	253

File Reference: 13477 Report Number 24757

TITLE: Enviornmental Aging – Vibration Aging

TEST: Frequency – 10 to 55 Hertz, Sweep Time – 1 minute, Duration – ½ Hour per Plane

DATE: 2-14-77

BY: Virgil Hoereffer

		LSA2B-1D	LSD1A	LSQ051	1HS1	PTP22BB (2-PTCC)	PTH2214CCC (3-PTCC)	2C203 (2D9)	2C206 (2D33)	911BGD011MC (2-PTCC)	910CGF511 (4-PTCC)
Displacement (Inches)		.060	.060	.060	.060	.060	.014	.060	.060	.014	.014
Cycle #1	Date	9-29-75	9-29-75	9-29-75	9-29-75	10-13-75	10-6-75	10-6-75	10-6-75	12-1-75	12-1-75
	Hours	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Cycle #2	Date	10-13-75	10-13-75	10-13-75	10-13-75	10-27-75	10-20-75	10-20-75	10-20-75	12-15-75	12-15-75
	Hours	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Cycle #3	Date	10-28-75	10-28-75	10-28-75	10-28-75	11-10-75	11-3-75	11-3-75	11-3-75	12-29-75	12-29-75
	Hours	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Total Vibration Time Hours		4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5

File Reference: 13477 Report Number 24467.

TITLE : Seismic Vibration - Resonance Survey

TEST: 1 to 35 Hz, 0.2 g vertical and horizontal, 1 octave per minute

DATE: 12-8-76

BY: Virgil Hoerauffer

	LSA2B-1D	LSD1A	LSQ051	1HS1	PTP22BB (2-PTCC)	PTH2214CCC (3-PTCC)	2C203 (2D9)	2C206 (2D33)	911BGD011MC (2-PTCC)	910CGF511 (4-PTCC)
Switch No.	1	2	3	4	5	6	7	8	9	10
Detector Circuit	NC	NC	NC	NC	NC	NC	NC	NO	NC	NC
Test #1	NS	NS	NS	NS	NS	NS	NS	NT	NS	NS
Test #2	NS	NS	NS	NS	NS	NS	NS	NT	NS	NS
Test #3	NS	NS	NS	NS	NS	NS	NS	NT	NS	NS
Test #4	NS	NS	NS	NS	NS	NS	NS	NT	NS	NS

NC - Normally closed circuit(s) monitored.

NO - Normally open circuit(s) monitored

NS - No contact separation noted during this test.

NT - No contact transfer noted during this test

Test Date 12-8-76

File Reference: 13477 Report Number 27457

TITLE: Seismic Vibration - Sine Beat Test

TEST: 33 Hz, 4.5 g Vertical and horizontal, 5 Beats - 10 cycles per beat

DATE: 12-7-76

BY: Virgil Houraffer

	LSA2B-1D	LSD1A	LSQ051	1HS1	PTP22BB (2-PTCC)	PTH2214CCC (3-PTCC)	2C203 (2D9)	2C206 (2D33)	911BGD011MC (2-PTCC)	910CGF511 (4-PTCC)
Switch No.	1	2	3	4	5	6	7	8	9	10
Detector Circuit	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Test #5	NS	NS	100 usec.	NS	NS	NS	NS	NT	NS	10 usec.
Test #6	NS	NS	NS	NS	NS	NS	NS	NT	NS	10 usec.
Test #7	NS	NS	100 usec	NS	NS	NS	NS	NT	NS	NS
Test #8	NS	NS	100 usec.	NS	NS	NS	NS	NT	NS	10 usec.

NC - Normally closed circuit(s) monitored

NO - Normally open circuit(s) monitored

NS - No contact separation noted during test.

NT - No contact transfer noted during test.

10 usec. - Contact separation > 10 usec. but < 100 usec.

100 usec - Contact separation > 100 usec. but < 1000 usec.

Test Date 12-8-76

File Reference: 13477 Report Number 4467

TITLE: Seismic Vibration - Multiple Frequency Test

TEST: RRS per Fig. 2, Q=10, 30 sec per run.

DATE: 12-8-76

BY: Virgil [illegible]

	LSA2B-1D	LSD1A	LSQ051	1HS1	PTP22BB (2-PTCC)	PTH2214CCC (3-PTCC)	2C203 (2D9)	2C206 (2D33)	911BGD011MC (2-PTCC)	910CGF511 (4-PTCC)
Switch No.	1	2	3	4	5	6	7	8	9	10
Detector Circuit	NC	NC	NC	NC	NC	NC	NC	NO	NC	NC
Test #9 5 OBE	NS	NS	NS	NS	NS	NS	NS	NT	NS	NS
1 SSE	NS	NS	NS	NS	NS	NS	NS	NT	NS	NS
Test #10 5 OBE	NS	NS	NS	NS	NS	NS	NS	NT	NS	NS
1 SSE	NS	NS	*10 μsec.	NS	NS	NS	NS	NT	NS	NS
Test #11 5 OBE	NS	NS	NS	NS	NS	NS	NS	NT	NS	NS
1 SSE	NS	NS	NS	NS	NS	NS	NS	NT	NS	NS
Test #12 5 OBE	NS	NS	NS	NS	NS	NS	NS	NT	NS	NS
1 SSE	NS	NS	*10 μsec.	NS	NS	NS	NS	NT	NS	NS

NC - Normally closed circuit(s) monitored

NO - Normally open circuit(s) monitored

NS - No contact separation noted during test

NT - No contact transfer noted during test

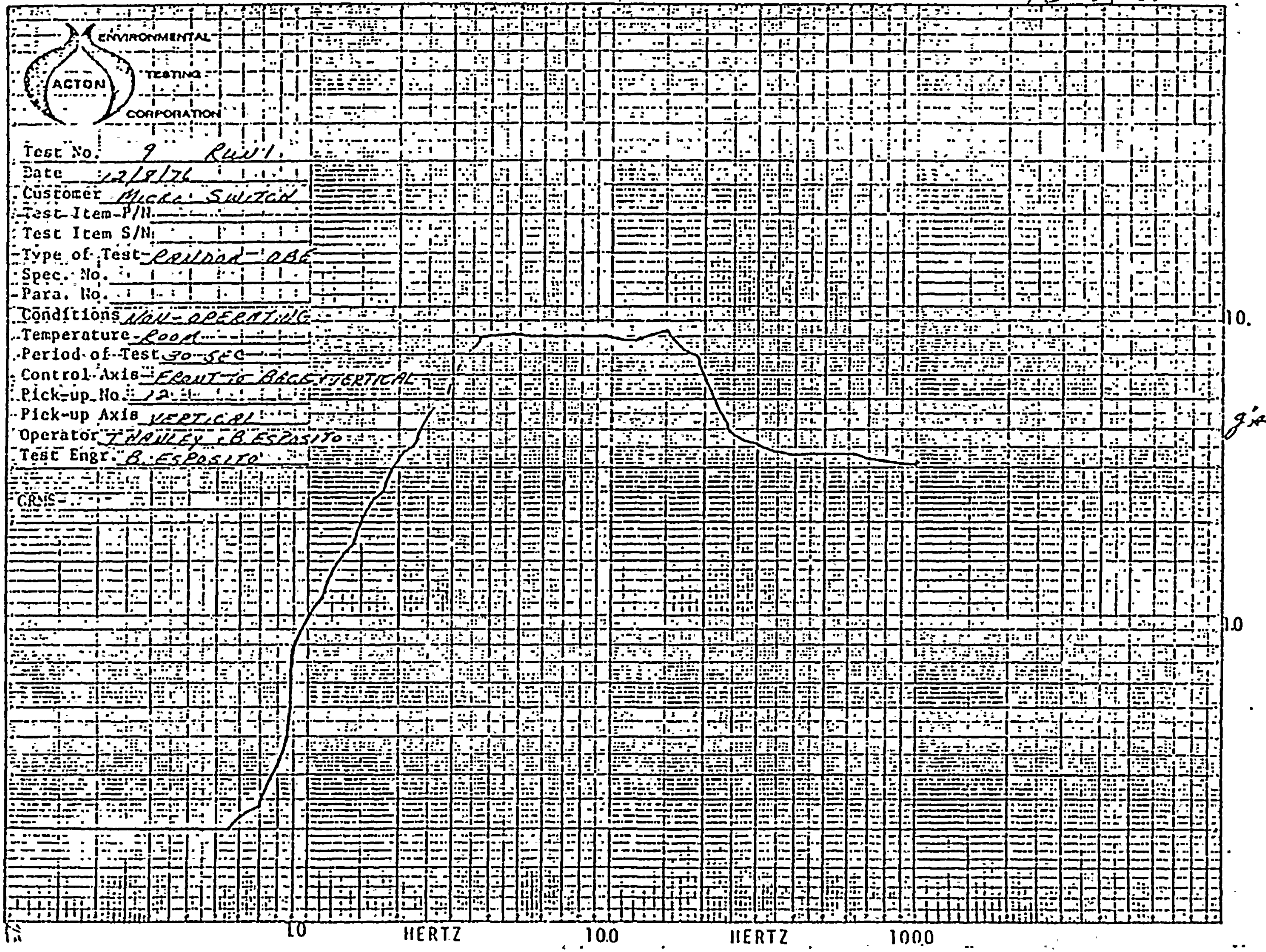
* - Contact separation exceeded 10 μsec but less than 100 μsec.

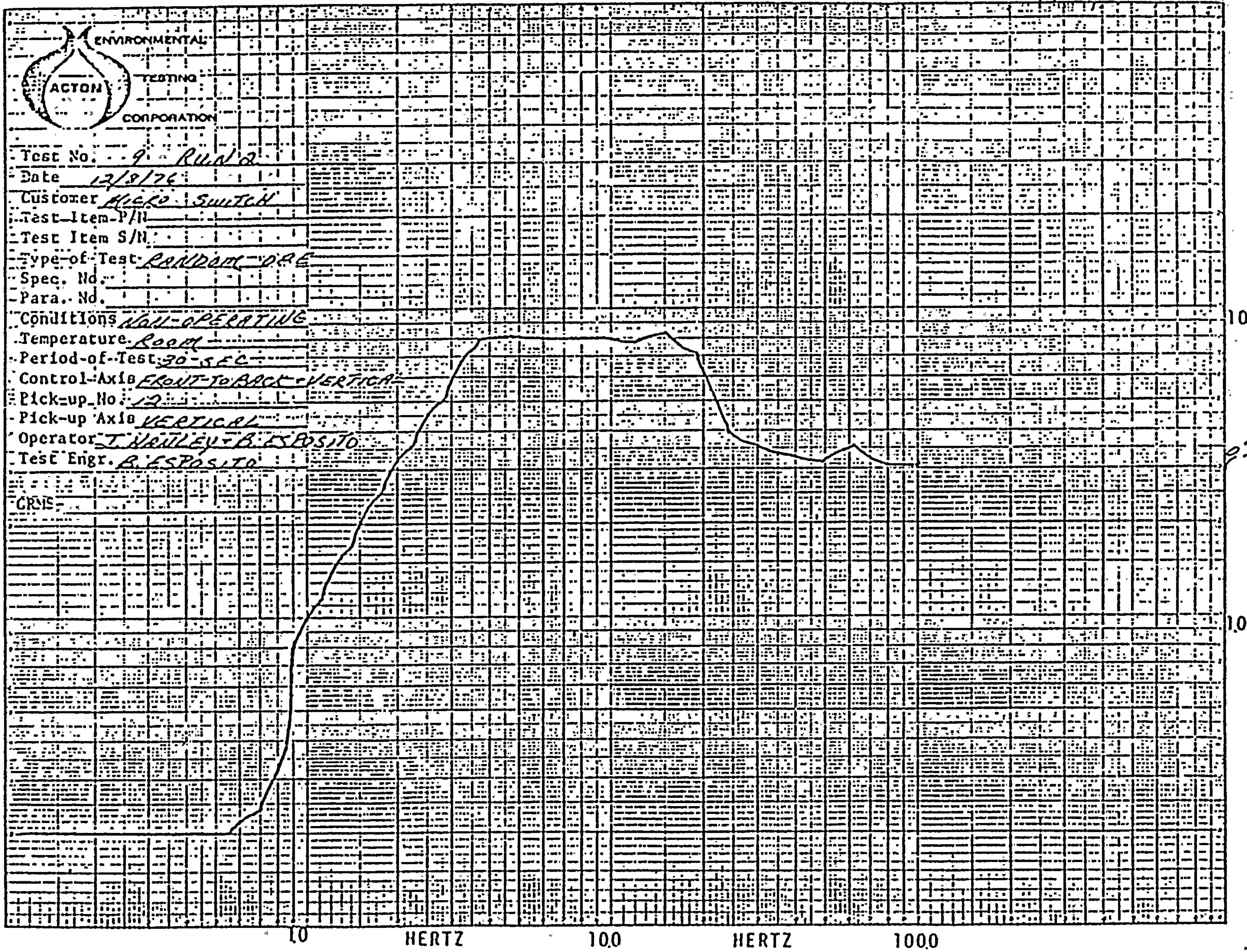
Test Date 12-8-76

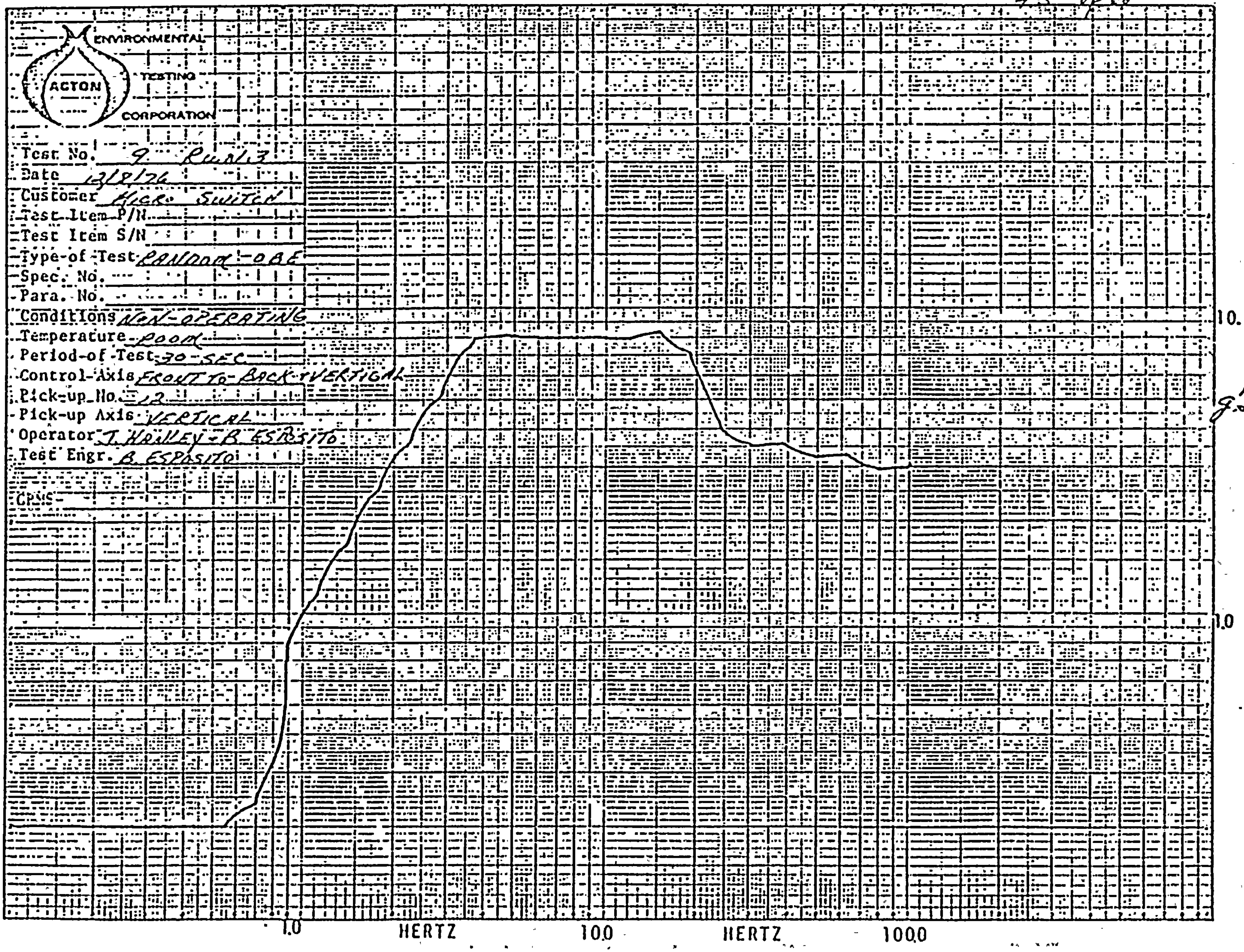
ENVIRONMENTAL TESTING ACTON CORPORATION

Test No. 9 Run 1
Date 12/8/76
Customer Micro Switch
Test Item P/N
Test Item S/N
Type of Test Railroad OBE
Spec. No.
Para. No.
Conditions Non-Operating
Temperature Room
Period of Test 30 SEC
Control Axis Front to Back/Vertical
Pick-up No. 12
Pick-up Axis Vertical
Operator T. Hawley & B. Esposito
Test Engr. B. Esposito

GRMS

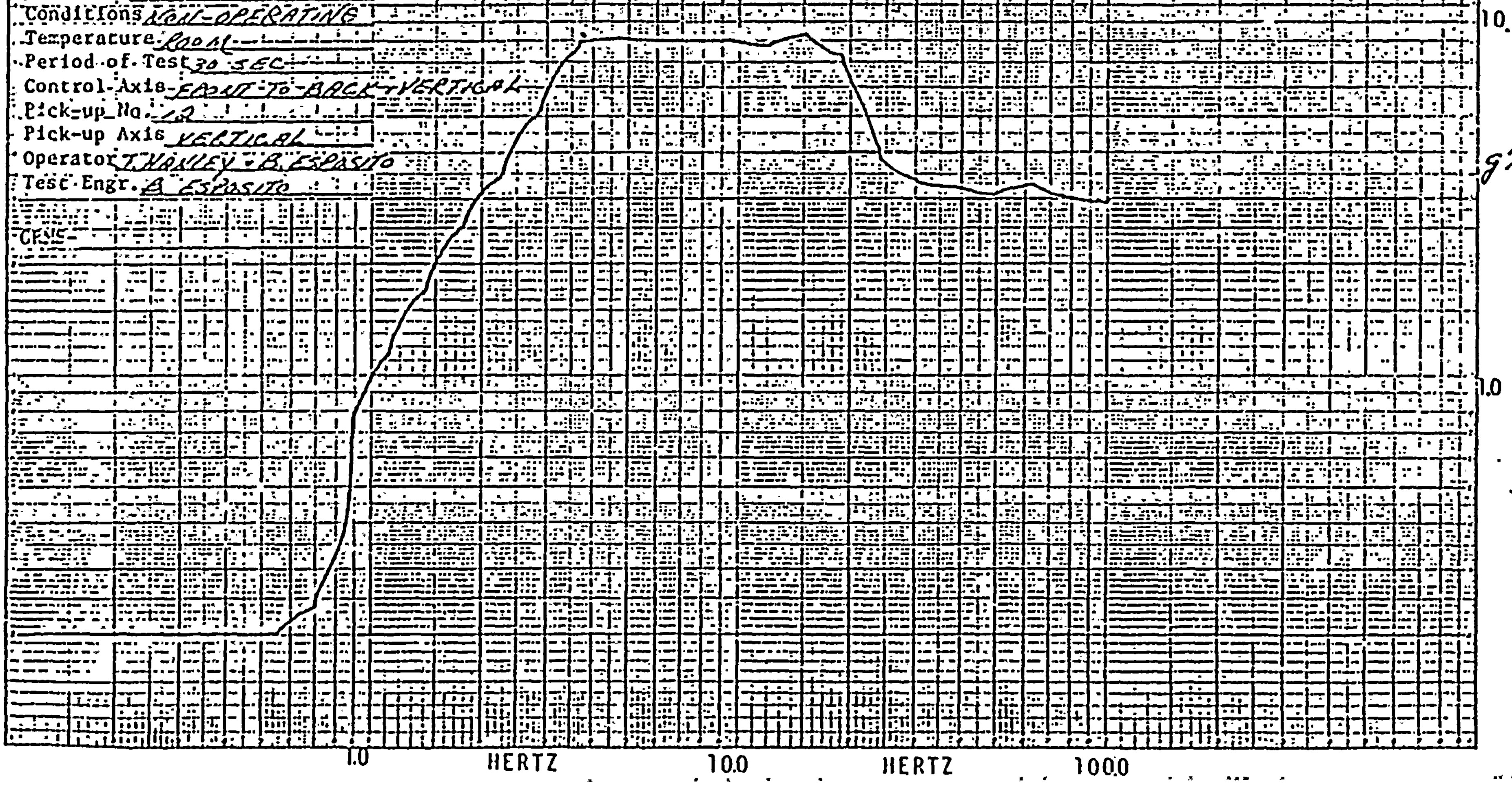



ENVIRONMENTAL
ACTON
TESTING
CORPORATION
Test No. 9 RUN 2
Date 12/8/76
Customer MICRO SWITCH
Test Item P/N
Test Item S/N
Type of Test RANDOM ORE
Spec. No.
Para. No.
Conditions NON-OPERATING
Temperature Room
Period of Test 30 SEC
Control Axis FRONT TO BACK - VERTICAL
Pick-up No. 12
Pick-up Axis VERTICAL
Operator T. HENLEY - B. ESPOSITO
Test Engr. B. ESPOSITO
GRMS
10
1.0
10
HERTZ
100
HERTZ
1000


ENVIRONMENTAL
ACTON
TESTING
CORPORATION
Test No. 9 Run 3
Date 12/8/76
Customer Micro Switch
Test Item P/N
Test Item S/N
Type of Test RANDOM - OBE
Spec. No.
Para. No.
Conditions NON-OPERATING
Temperature ROOM
Period of Test 30 SEC
Control Axis FRONT TO BACK + VERTICAL
Pick-up No. 12
Pick-up Axis VERTICAL
Operator J. HAWLEY - B. ESPOSITO
Test Engr. B. ESPOSITO
CPMS
10.
g's
1.0
1.0
HERTZ
10.0
HERTZ
100.0

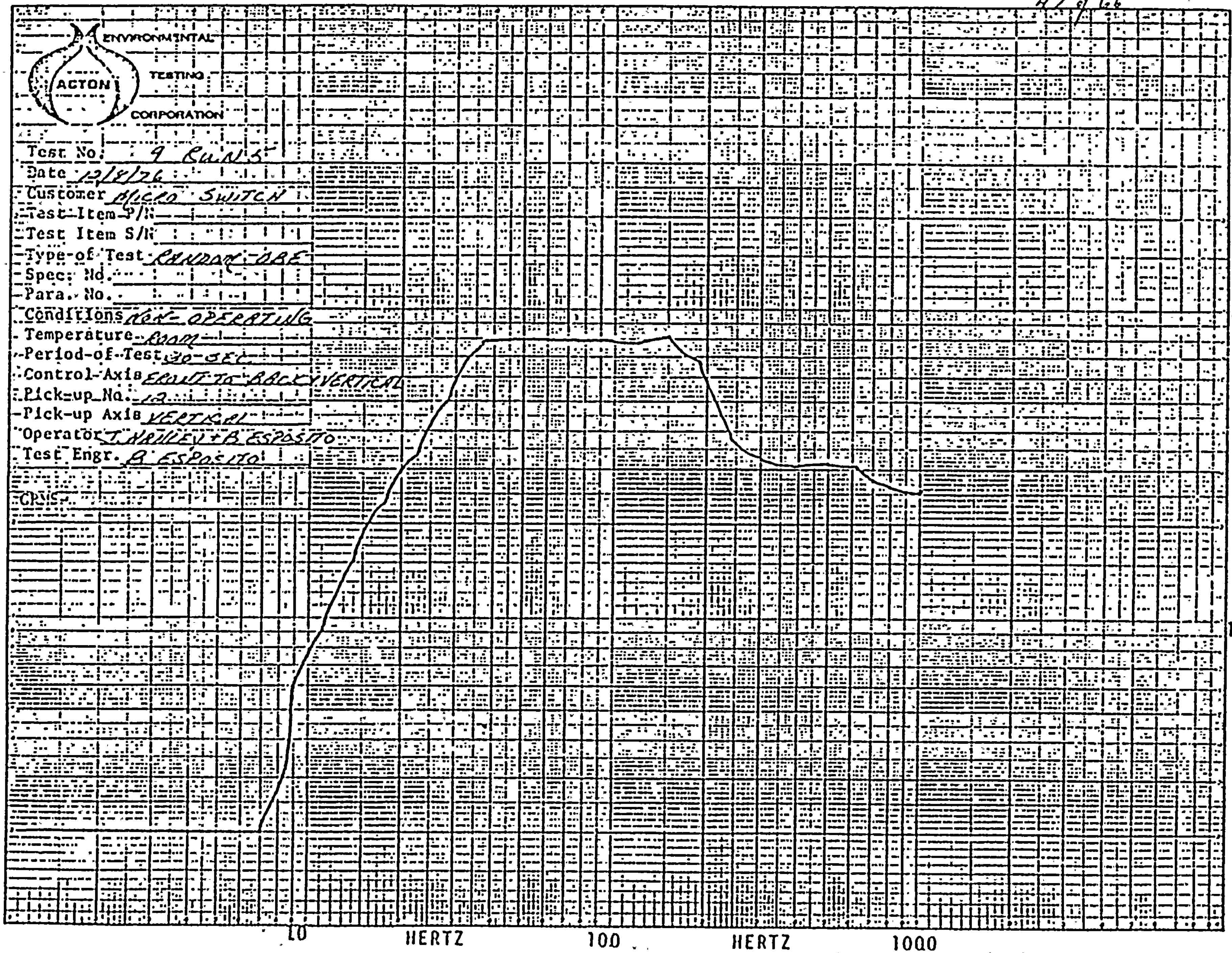
ENVIRONMENTAL ACTON TESTING CORPORATION

Test No. 9 RUN 4
Date 12/4/76
Customer MICRO SWITCH
Test Item P/N
Test Item S/N
Type of Test RANDOM - OBE
Spec. No.
Para. No.
Conditions NON-OPERATING
Temperature ROOM
Period of Test 30 SEC
Control Axis FRONT-TO-BACK + VERTICAL
Pick-up No. 12
Pick-up Axis VERTICAL
Operator T. HANLEY - B. ESPOSITO
Test Engr. B. ESPOSITO
CFNS-



F.R. 13477 LTR 24407:

42 of 66



27

FR 13477 RTR 24407

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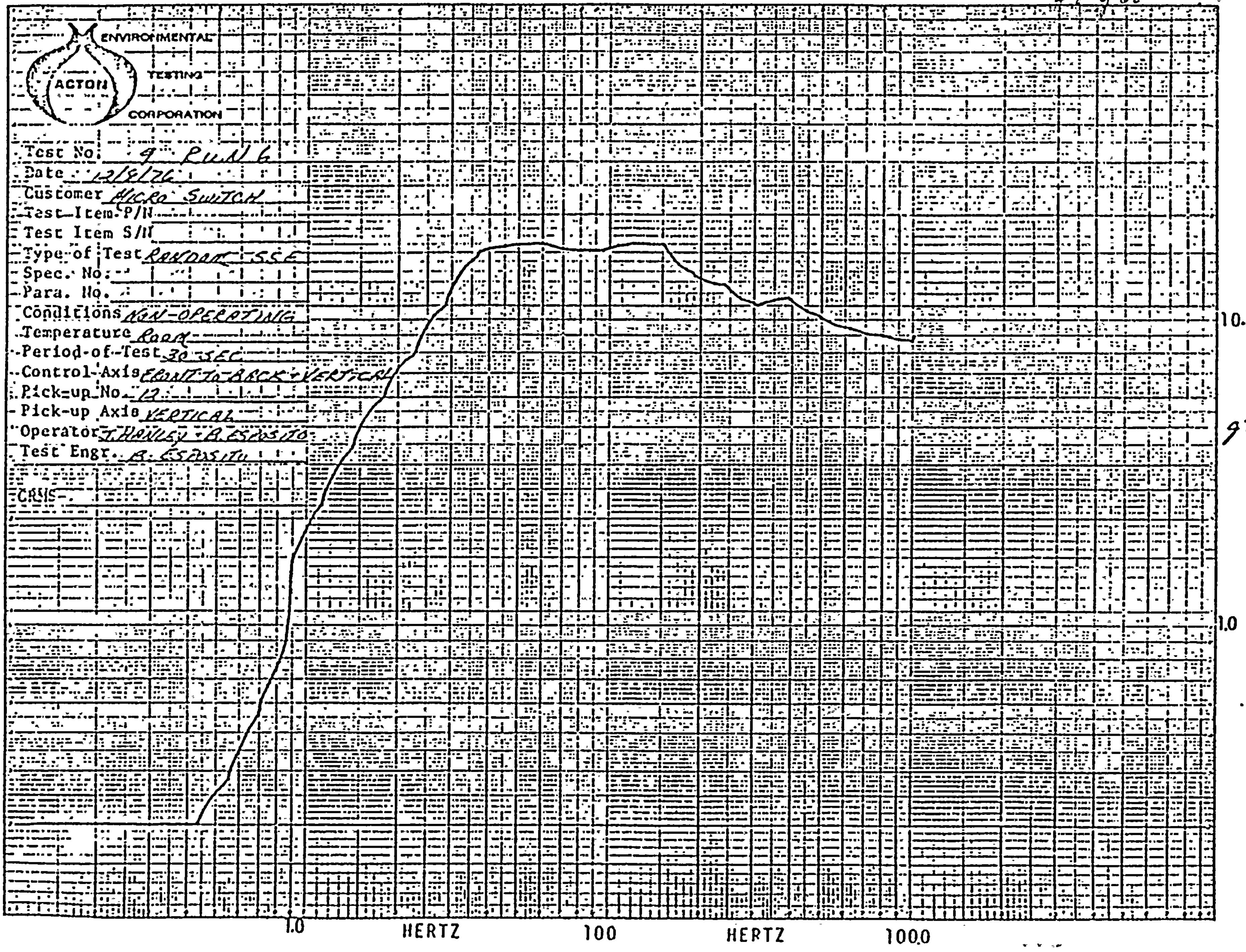
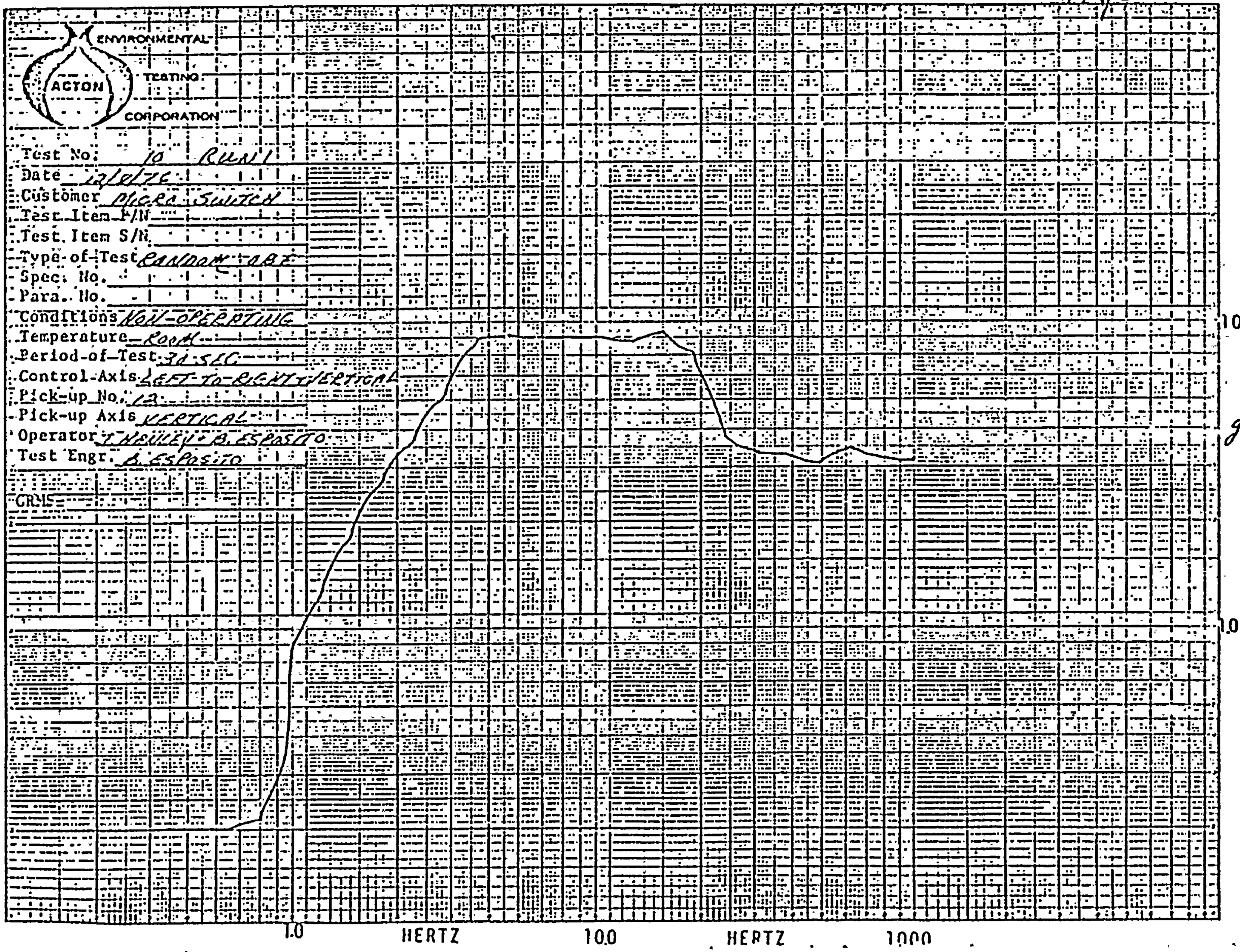


28

FR 13477 RTR 24407:
42 / 46



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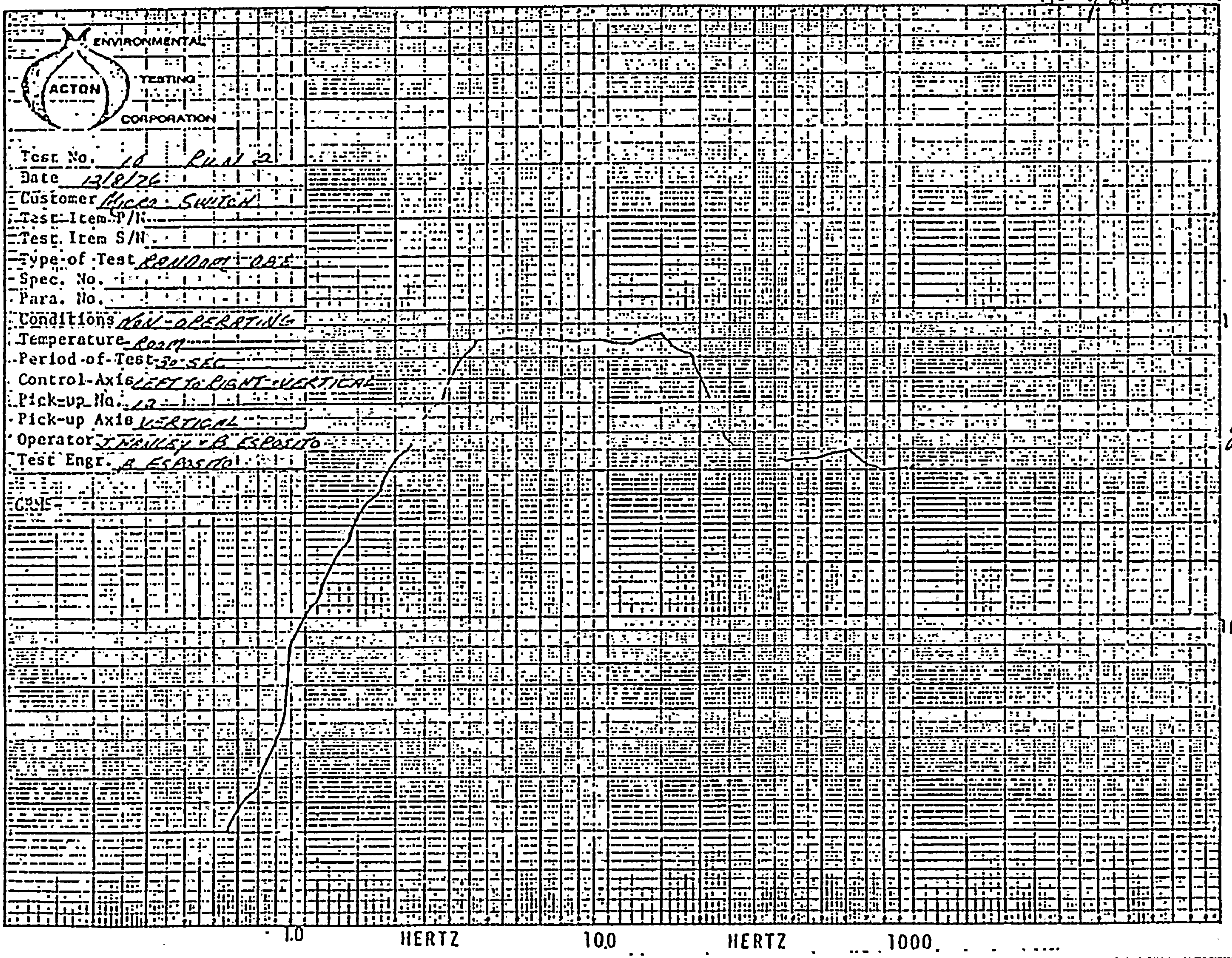

ENVIRONMENTAL
ACTON
TESTING
CORPORATION
Test No. 10 Run 2
Date 12/8/76
Customer Micro Switch
Test Item P/N
Test Item S/N
Type of Test Random
Spec. No.
Para. No.
Conditions Non-Operating
Temperature Room
Period of Test 30 SEC
Control-Axis Left to Right - Vertical
Pick-up No. 12
Pick-up Axis Vertical
Operator J. Haley - B. Esposito
Test Engr. B. Esposito
CRMS
10.
g's
10
1.0
HERTZ
10.0
HERTZ
1000.

ENVIRONMENTAL TESTING CORPORATION (ACTON)

Test No. 10 RUN 3

Date 12/8/76

Customer MICRO SWITCH

Test Item P/N

Test Item S/N

Type of Test RANDOM OBE

Spec. No.

Para. No.

Conditions NON-OPERATING

Temperature ROOM

Period of Test 30 SEC

Control Axis LEFT-TO-RIGHT-VERTICAL

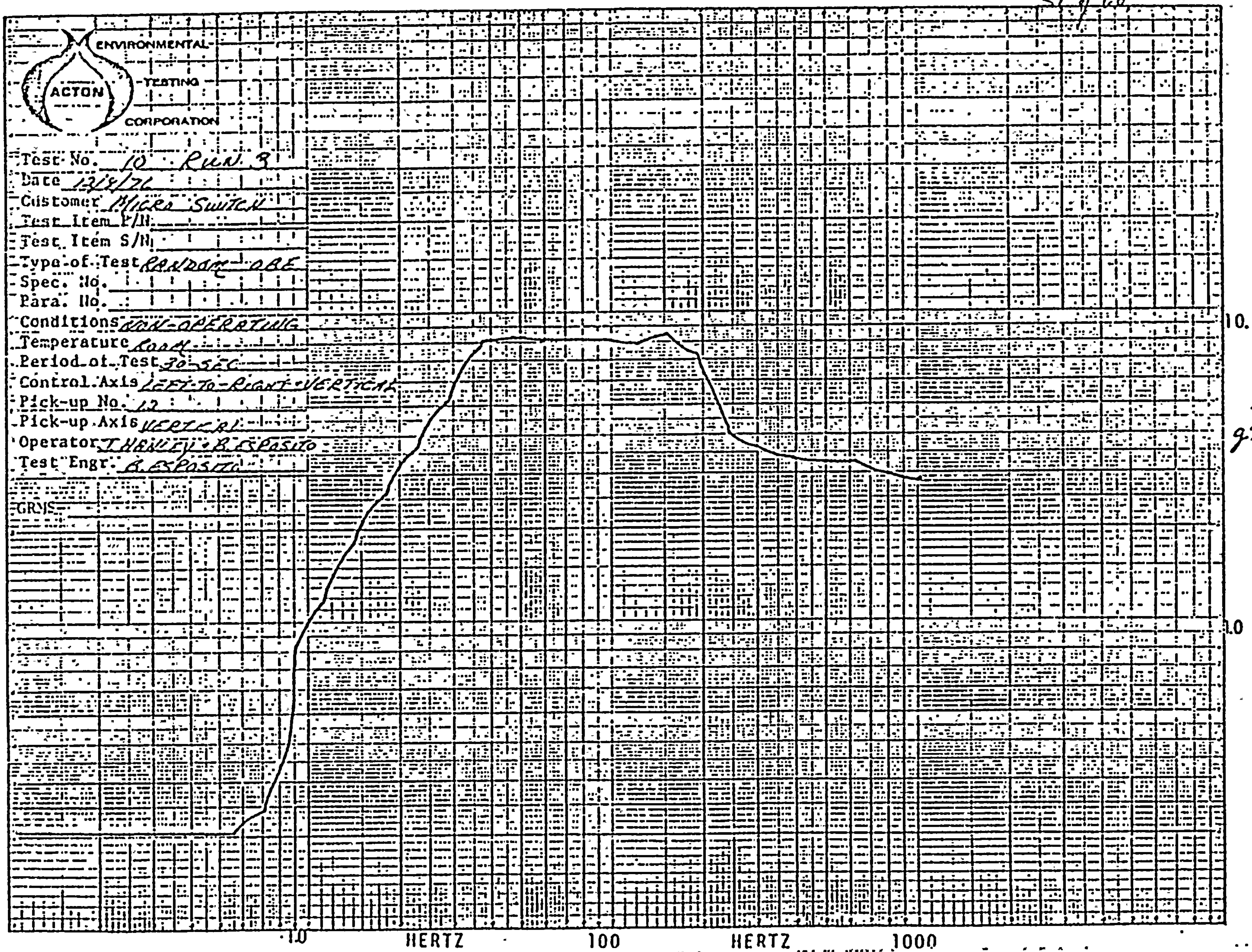
Pick-up No. 12

Pick-up Axis VERTICAL

Operator J. HENLEY - B. ESPOSITO

Test Engr. B. ESPOSITO

GRMS



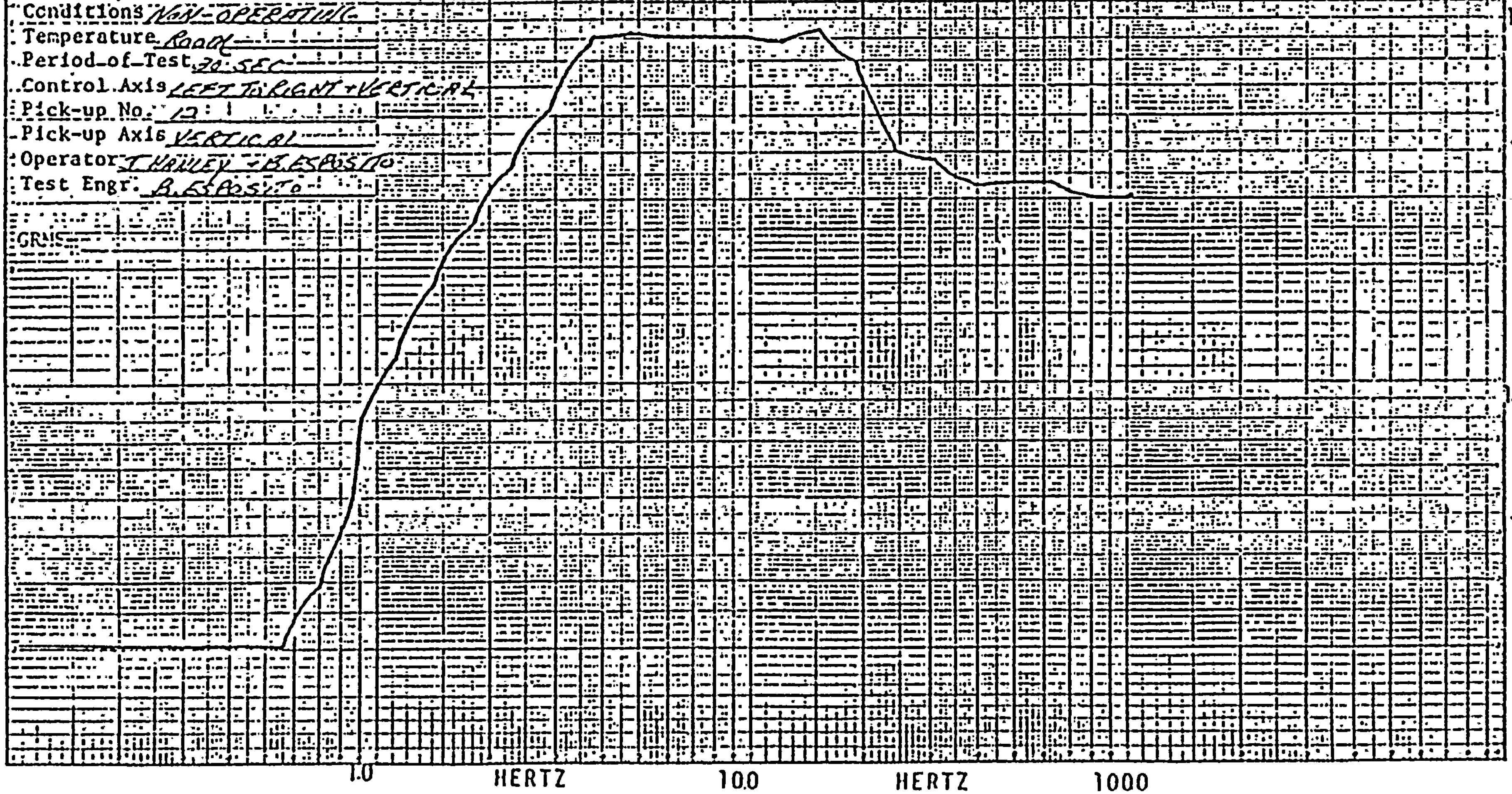
FR 13477 LTR 24407

52 g 66

ENVIRONMENTAL ACTON TESTING CORPORATION

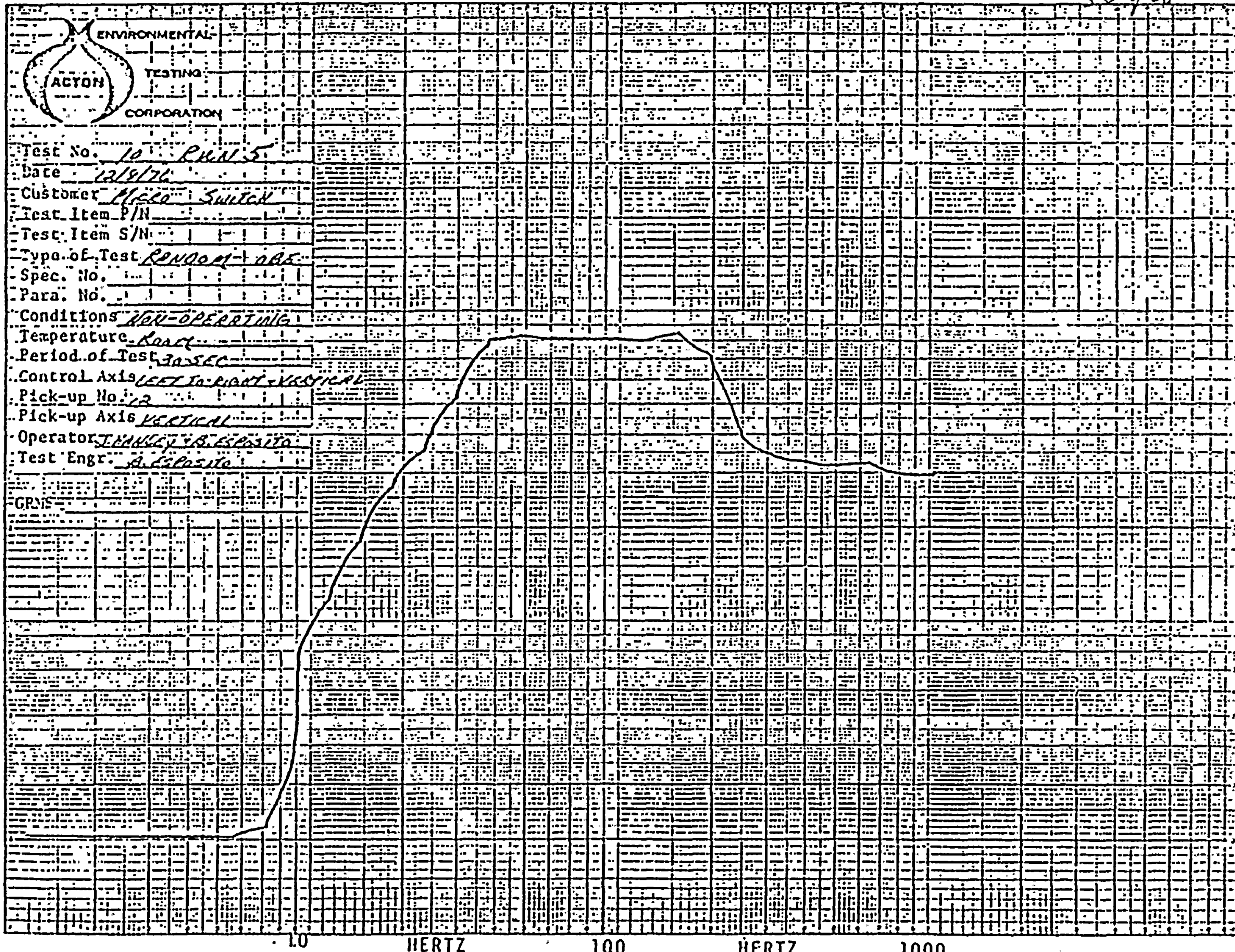
Test No. 10 RUN 4
Date 12/8/76
Customer MICRO SWITCH
Test Item P/N
Test Item S/N
Type of Test RANDOM DBE
Spec. No.
Para. No.
Conditions NON-OPERATING
Temperature ROOM
Period of Test 30 SEC
Control Axis LEFT TO RIGHT + VERTICAL
Pick-up No. 12
Pick-up Axis VERTICAL
Operator T. HALLEY - B. ESPOSITO
Test Engr. B. ESPOSITO

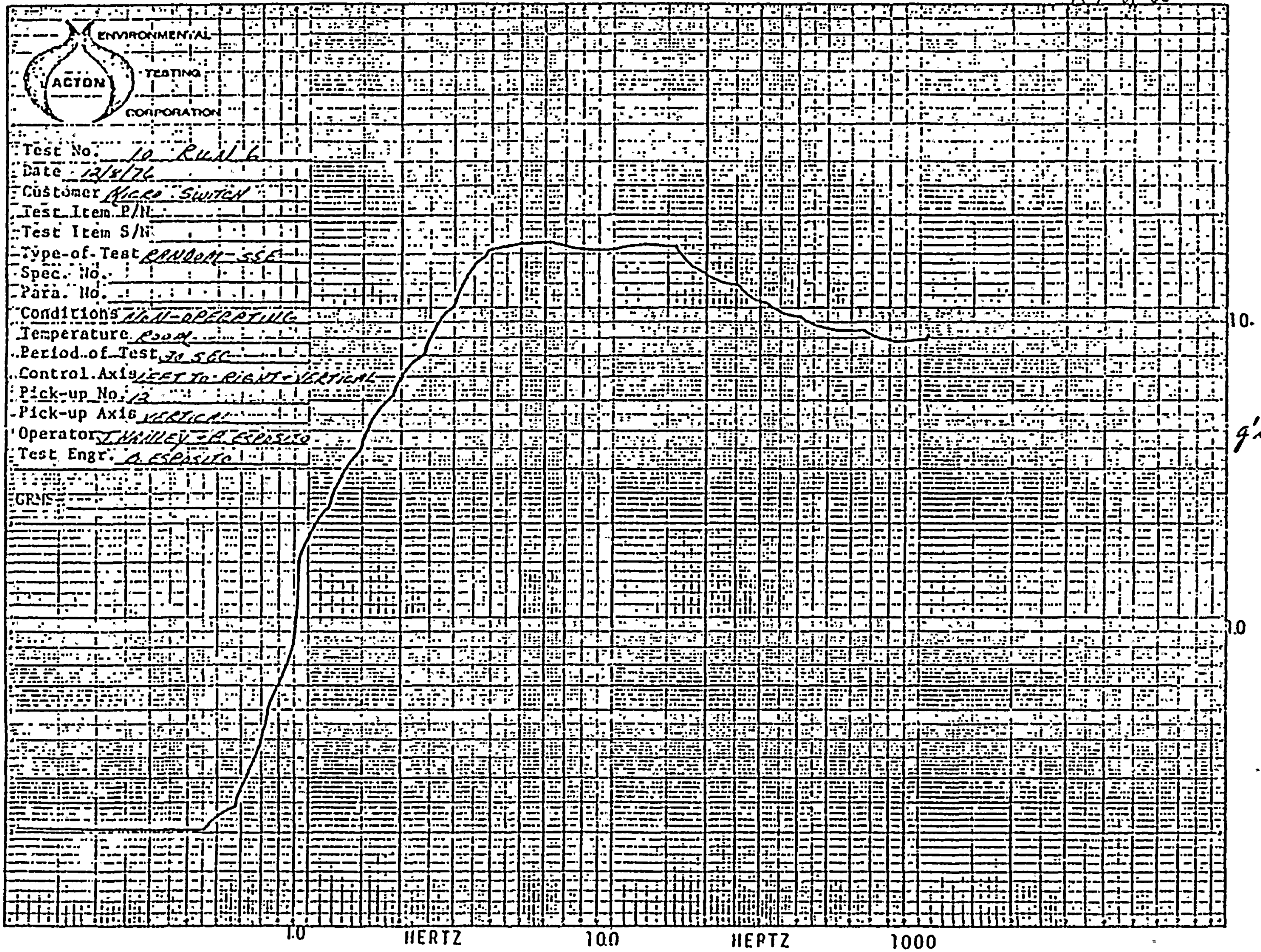
GRMS



ACTON ENVIRONMENTAL TESTING CORPORATION

Test No. 10 RUN 5
Date 12/8/76
Customer Micro Switch
Test Item P/N
Test Item S/N
Type of Test RANDOM - OBE
Spec. No.
Para. No.
Conditions NON-OPERATING
Temperature Room
Period of Test 30 SEC
Control Axis LEFT TO RIGHT - VERTICAL
Pick-up No. 12
Pick-up Axis VERTICAL
Operator J. HANLEY + B. ESPOSITO
Test Engr. A. ESPOSITO
GRMS

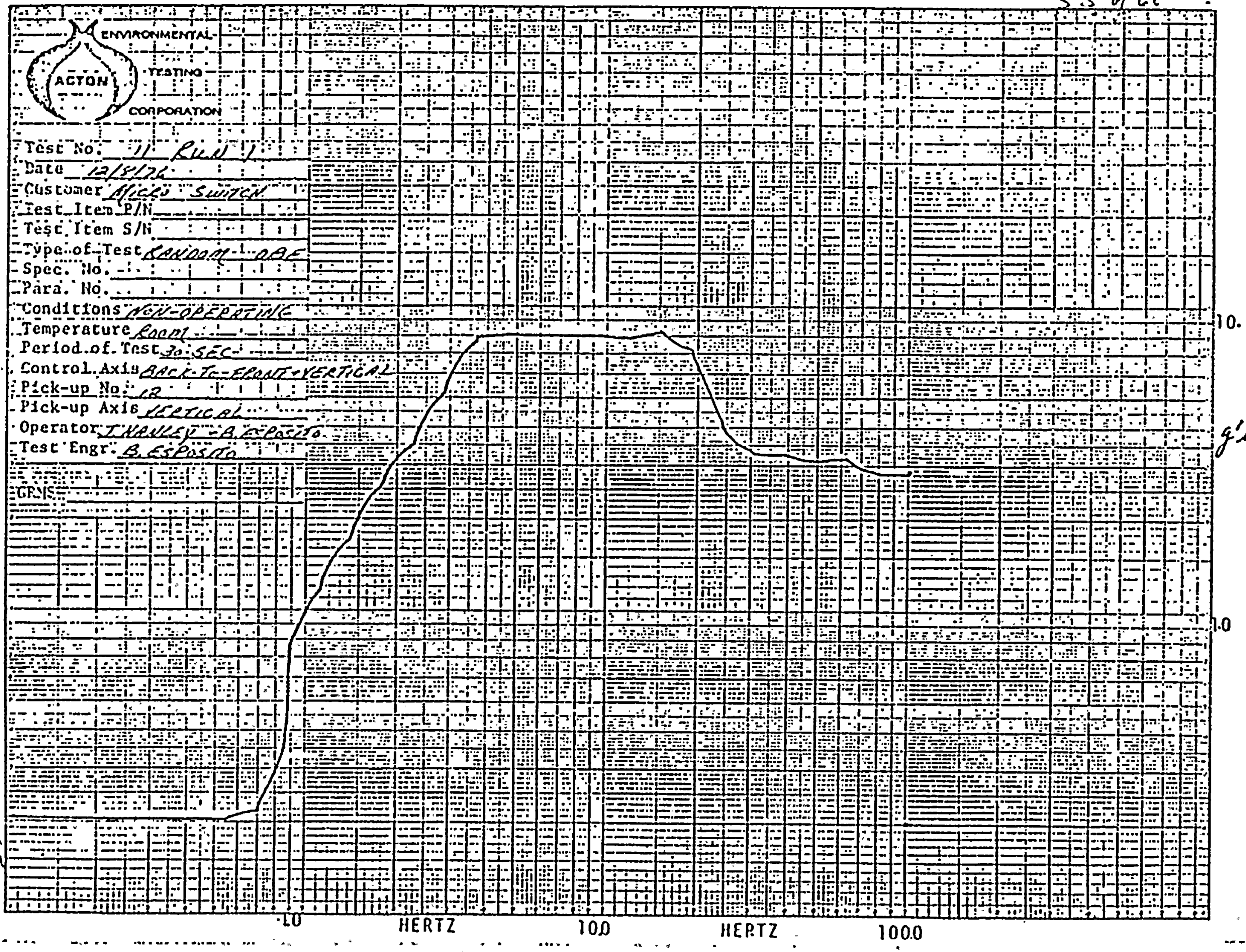



ENVIRONMENTAL
ACTON
TESTING
CORPORATION
Test No. 10 Run 6
Date 12/8/76
Customer Micro Switch
Test Item P/N
Test Item S/N
Type of Test Random-SSE
Spec. No.
Para. No.
Conditions Non-Operating
Temperature Room
Period of Test 30 sec
Control Axis Left to Right-Vertical
Pick-up No. 13
Pick-up Axis Vertical
Operator J. Hailey + R. Esposito
Test Engr. R. Esposito
GRMS
10.
1.0
g's
1.0
HERTZ
10.0
HERTZ
1000

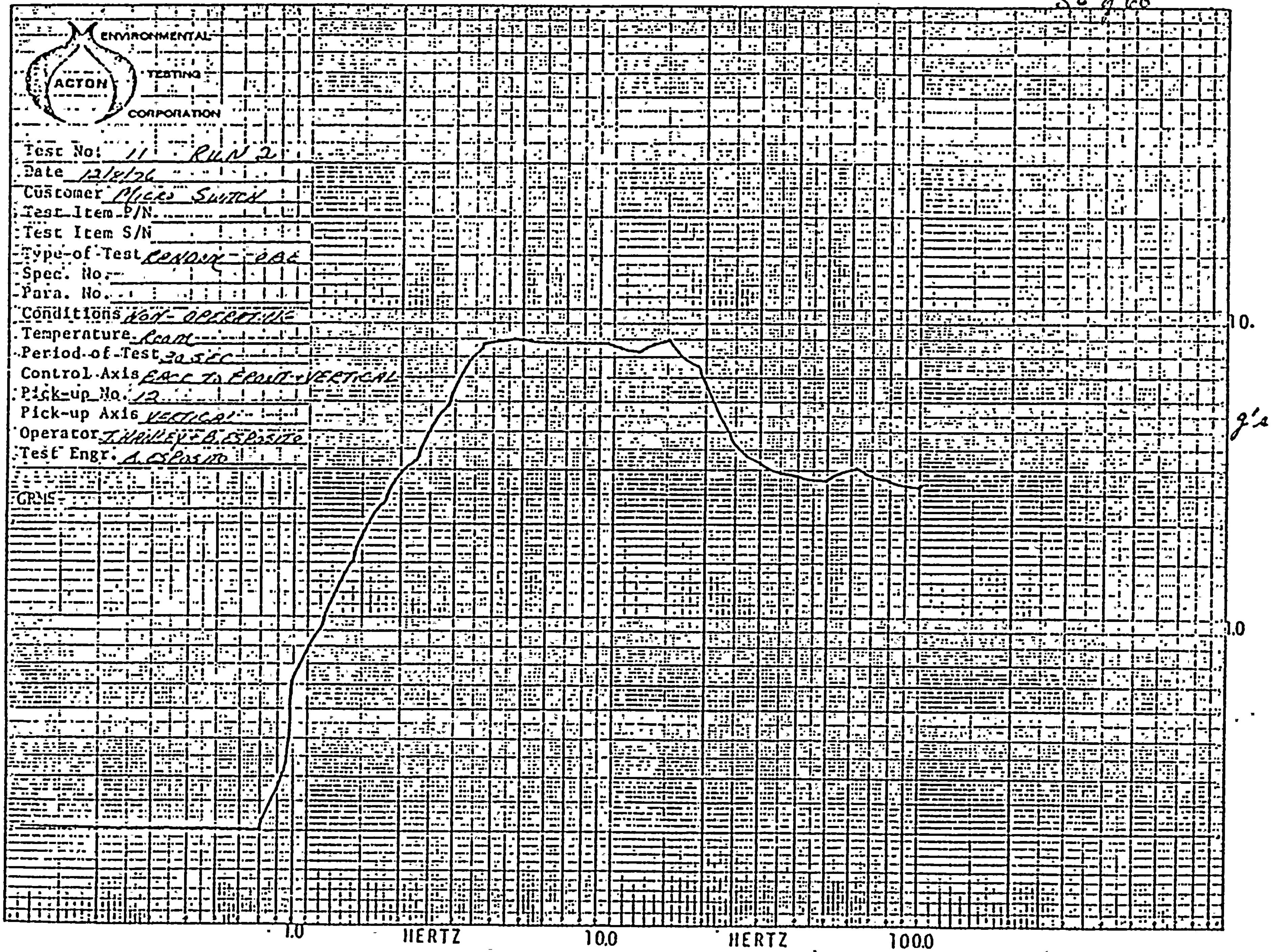
2.1

FR 13477   LTR 24407

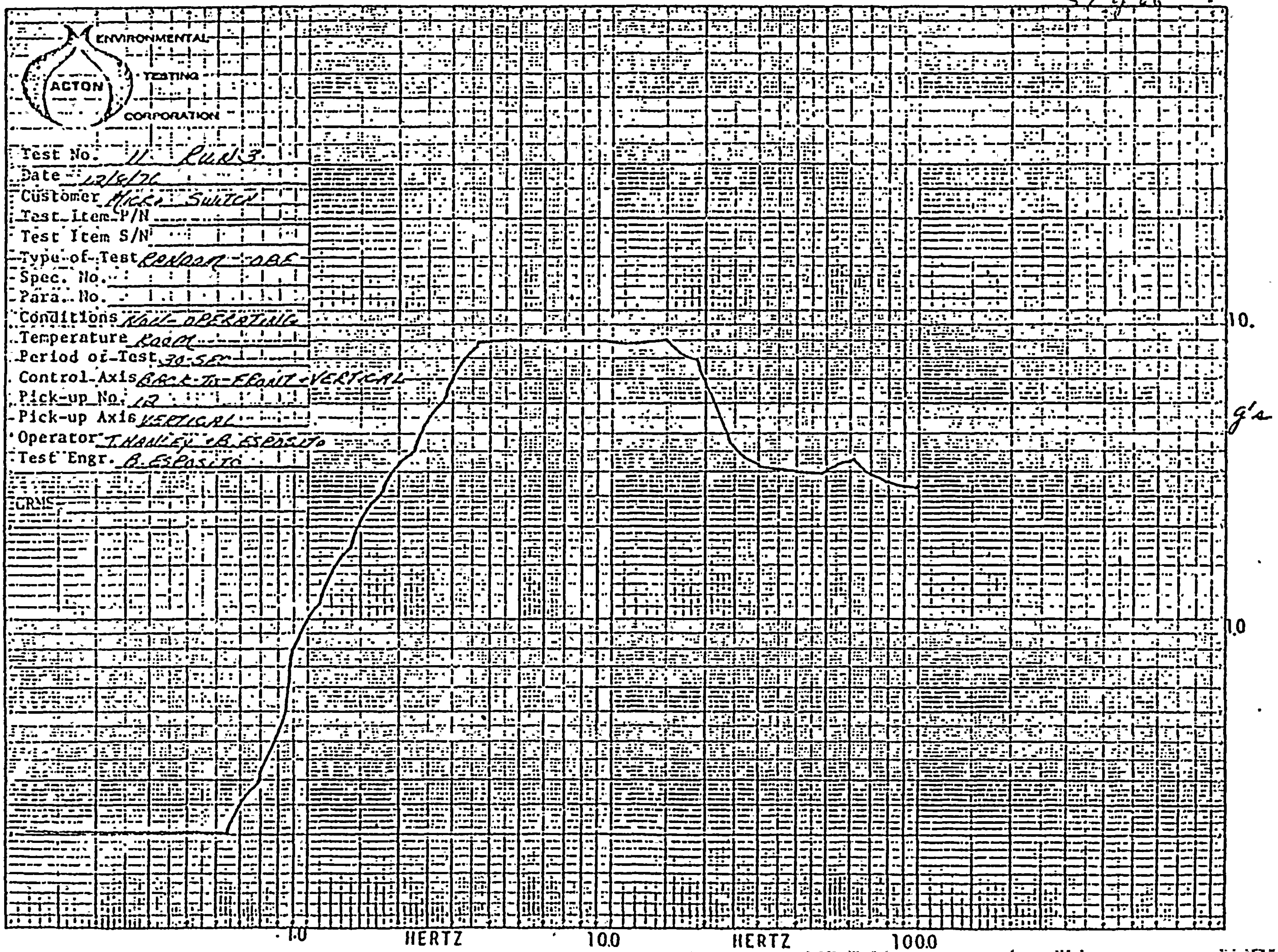
55 of 66



.35


ENVIRONMENTAL
ACTON
TESTING
CORPORATION
Test No: 11 RUN 2
Date 12/8/76
Customer Micro Switch
Test Item P/N
Test Item S/N
Type of Test RANDOM
Spec. No. —
Para. No.
Conditions NON-OPERATING
Temperature Room
Period of Test 20 SEC
Control Axis BACK TO FRONT + VERTICAL
Pick-up No. 12
Pick-up Axis VERTICAL
Operator T. HAILEY + B. ESPOSITO
Test Engr. A. ESPOSITO
GRMS
10.
g's
1.0
1.0
HERTZ
10.0
HERTZ
100.0

34

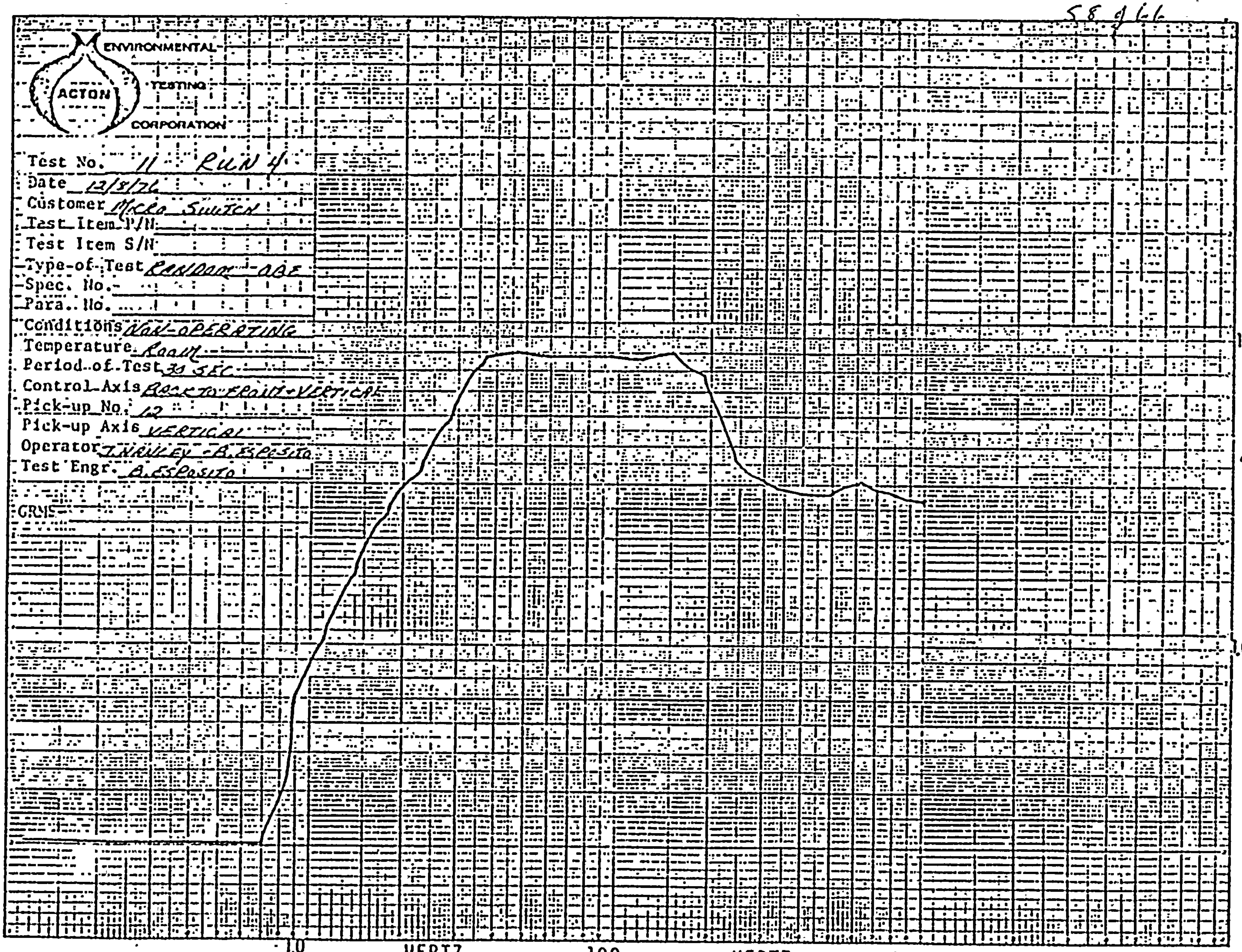

ENVIRONMENTAL
ACTON
TESTING
CORPORATION
Test No. 11 Run 3
Date 12/8/76
Customer Micro Switch
Test Item P/N
Test Item S/N
Type of Test Random - OBE
Spec. No.
Para. No.
Conditions Non-Operating
Temperature Room
Period of Test 30 SEC
Control Axis Back-To-Front - Vertical
Pick-up No. 12
Pick-up Axis Vertical
Operator T. Hanley - B. Esposito
Test Engr. B. Esposito
GRMS
10.
g's
1.0
1.0
HERTZ
10.0
HERTZ
100.0

FR 13477 LTR 24407
58 9 66

ENVIRONMENTAL
ACTON
TESTING
CORPORATION

Test No. 11 RUN 4
Date 12/8/76
Customer MICRO SWITCH
Test Item P/N
Test Item S/N
Type of Test RANDOM - ABE
Spec. No.
Para. No.
Conditions NON-OPERATING
Temperature ROOM
Period of Test 30 SEC
Control Axis BACK TO FRAME - VERTICAL
Pick-up No. 12
Pick-up Axis VERTICAL
Operator J. NULLEY - B. ESPOSITO
Test Engr. B. ESPOSITO

GRMS



38

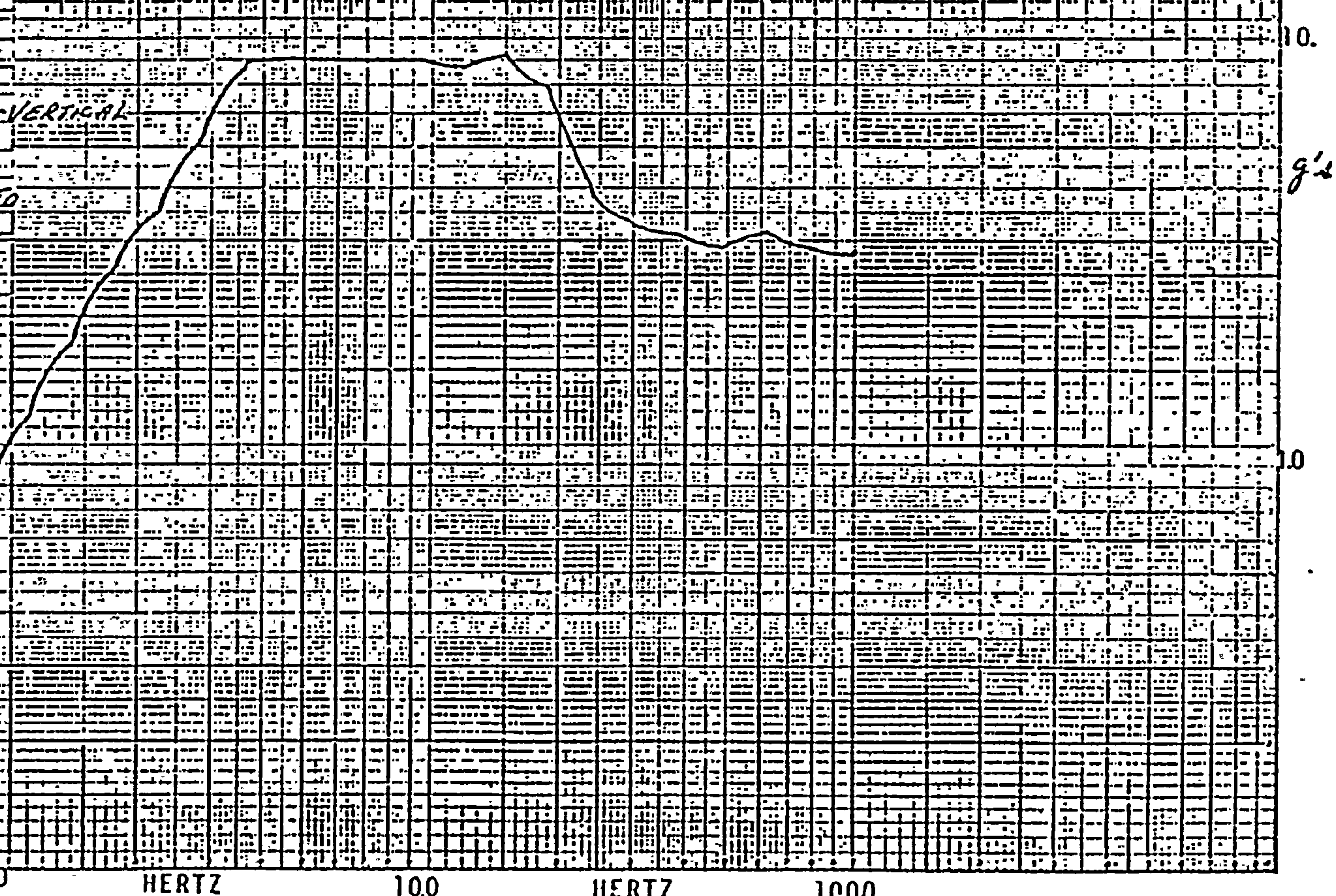
F.R. 13477 LTR 24407

59-1-66

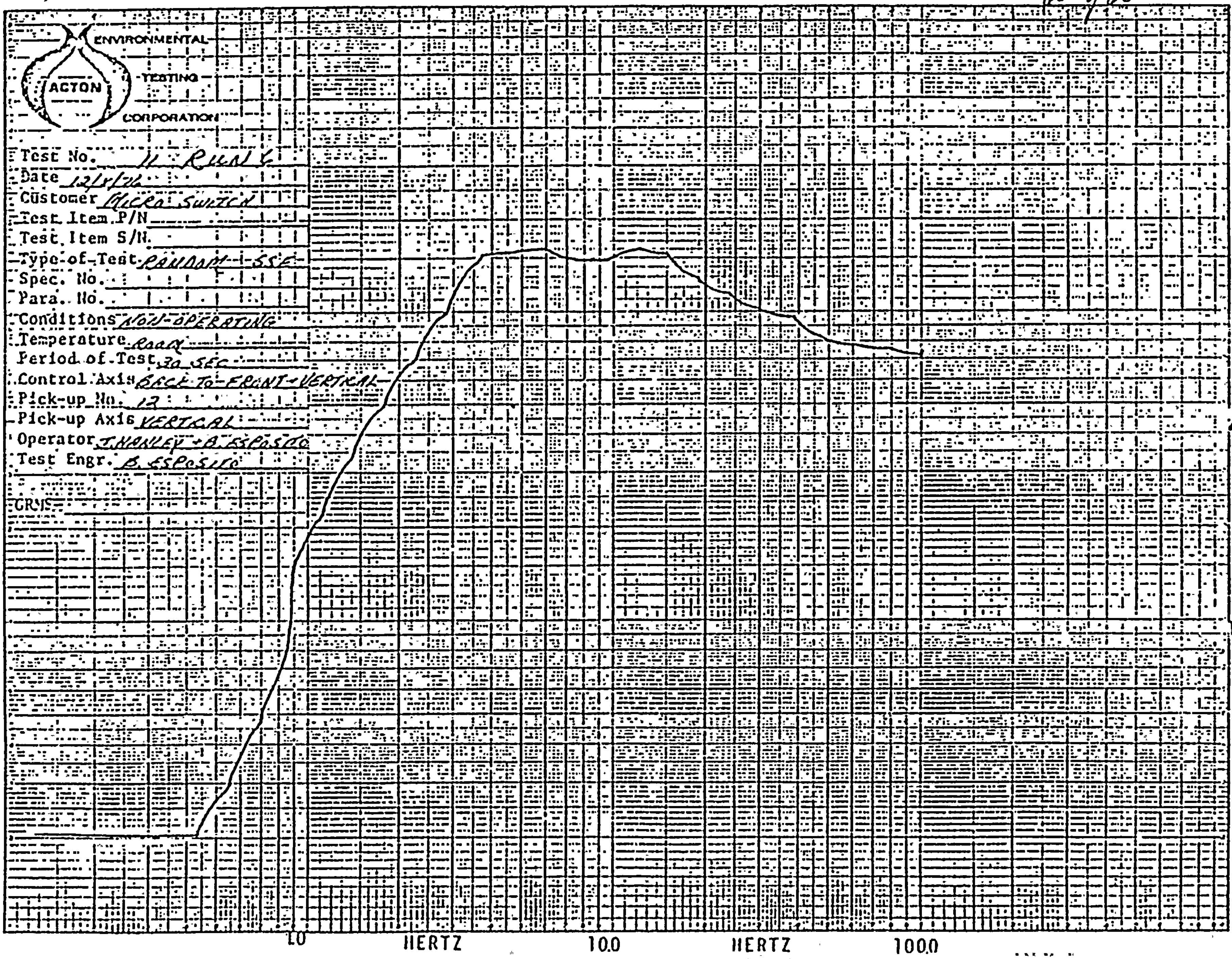
ACTON ENVIRONMENTAL TESTING CORPORATION

Test No. 11 RUN 5
Date 12/8/72
Customer MICRO SWITCH
Test Item P/N
Test Item S/N
Type of Test RANDOM - ABE
Spec. No.
Para. No.
Conditions NON-OPERATING
Temperature Room
Period of Test 30 SEC
Control Axis BACK-TO-FRONT-VERTICAL
Pick-up No. 12
Pick-up Axis VERTICAL
Operator T. HANLEY + B. ESPOSITO
Test Engr. B. ESPOSITO

GRMS



FR 13477 LTR 24407
60 966



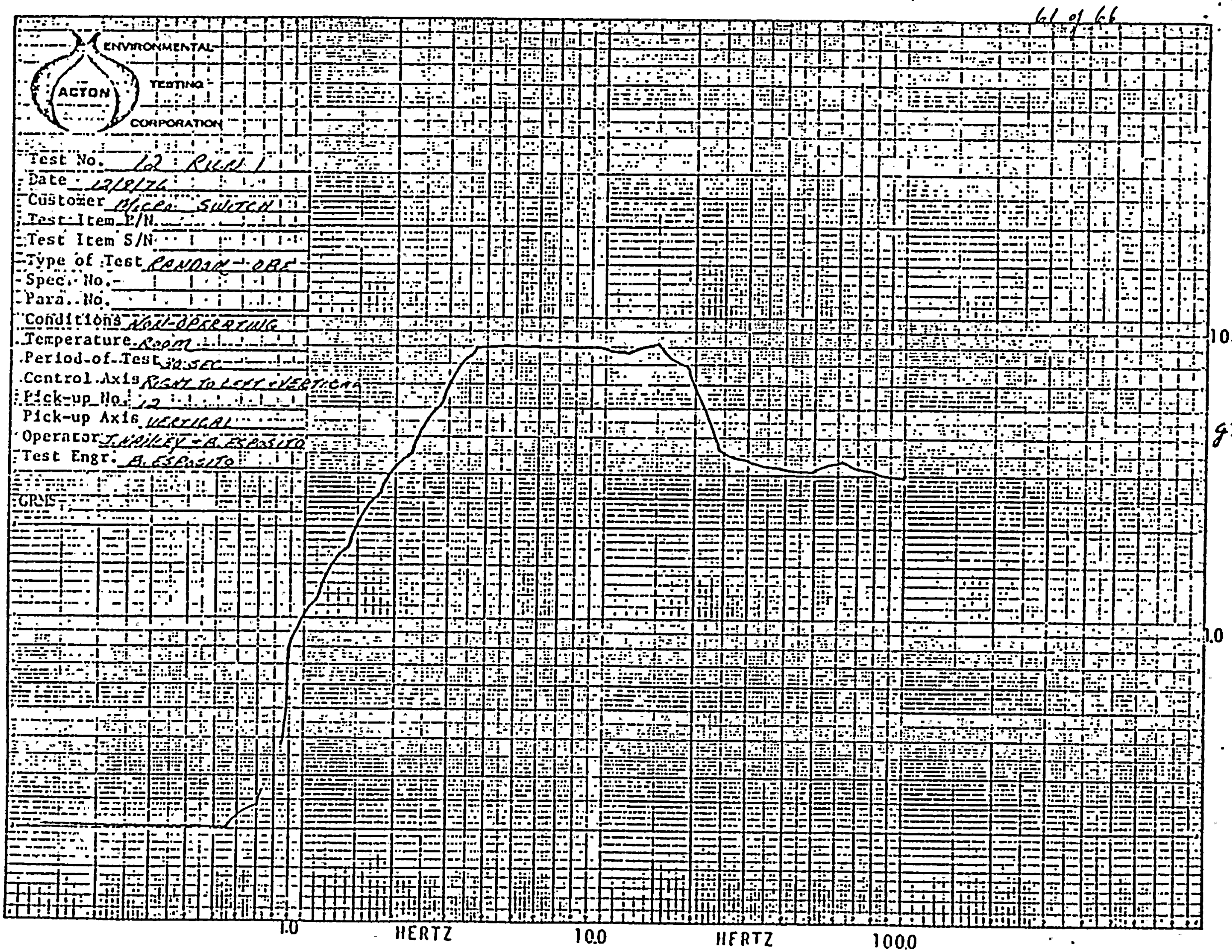
40

FR 13477 LTR 24407

ACTON ENVIRONMENTAL TESTING CORPORATION

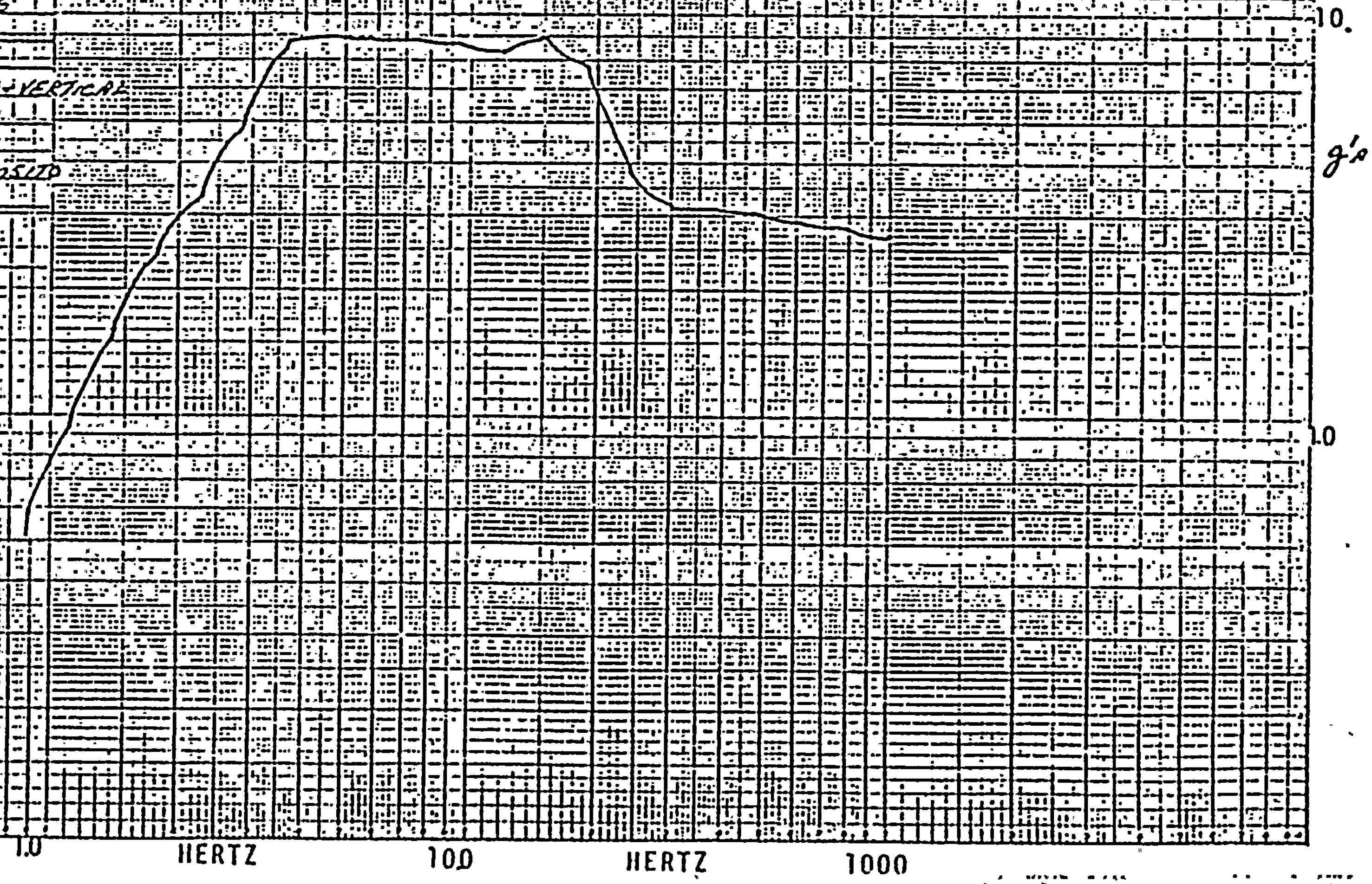
Test No. 12 Run 1
Date 12/8/76
Customer Micro Switch
Test Item P/N.
Test Item S/N
Type of Test Random - OBE
Spec. No.
Para. No.
Conditions Non-Operating
Temperature Room
Period of Test 30 SEC
Control Axis Right to Left + Vertical
Pick-up No. 12
Pick-up Axis Vertical
Operator J. Bailey + B. Esposito
Test Engr. B. Esposito

GRMS

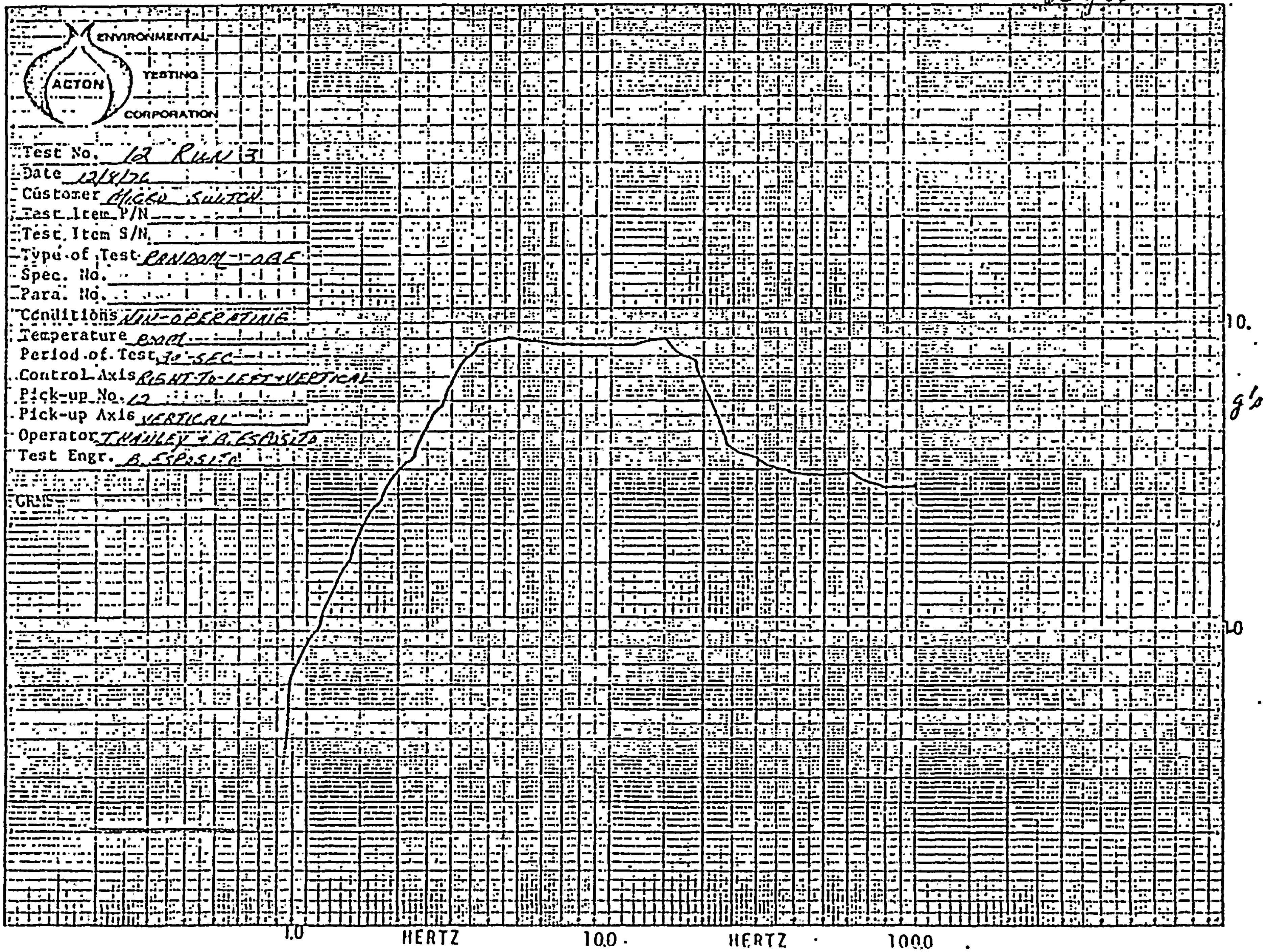


ACTON ENVIRONMENTAL TESTING CORPORATION

Test No. 12 RUN 2
Date 12/8/76
Customer MICRO SWITCH
Test Item P/N
Test Item S/N
Type of Test RANDOM - OBE
Spec. No.
Para. No.
Conditions NON-OPERATING
Temperature ROOM
Period of Test 30 SEC
Control Axis RIGHT-TO-LEFT + VERTICAL
Pick-up No. 12
Pick-up Axis VERTICAL
Operator T. HANLEY + B. ESPOSITO
Test Engr. B. ESPOSITO
GRMS



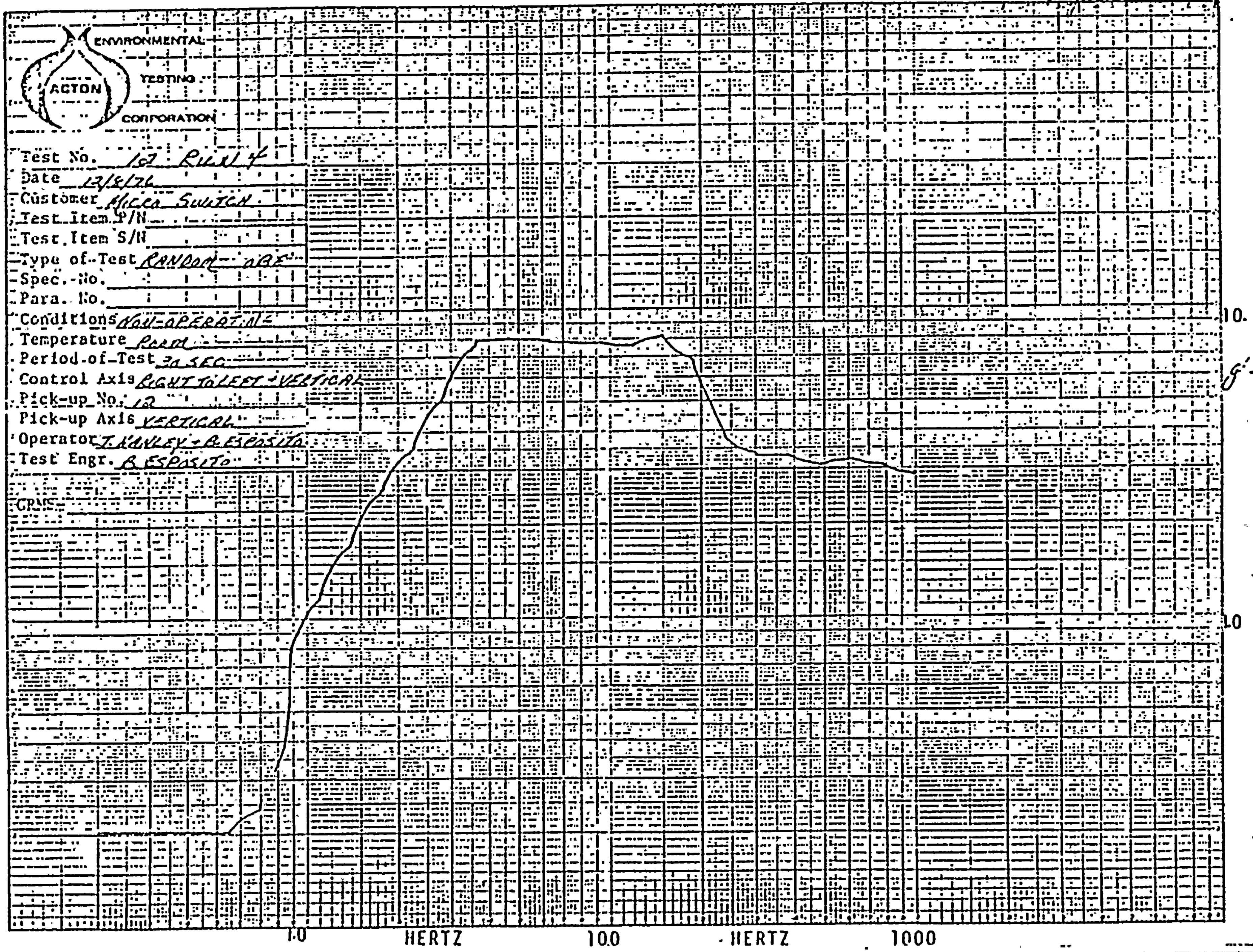
FR 13477 LTR 24407



ENVIRONMENTAL ACTON TESTING CORPORATION

Test No. 107 Run 4
Date 12/8/76
Customer Micro Switch
Test Item P/N
Test Item S/N
Type of Test Random - ABE
Spec. No.
Para. No.
Conditions Non-Operating
Temperature Room
Period of Test 30 SEC
Control Axis Right to Left - Vertical
Pick-up No. 12
Pick-up Axis Vertical
Operator T. Hanley - B. Esposito
Test Engr. B. Esposito

GRMS



44

FR 13477 ATR 24407

ACTON ENVIRONMENTAL TESTING CORPORATION

Test No. 12 RUN 3

Date 12/8/76

Customer MICRO SWITCH

Test Item P/N

Test Item S/N

Type of Test RANDOM OBE

Spec. No.

Para. No.

Conditions NON-OPERATING

Temperature Room

Period of Test 72 SEC

Control Axis RIGHT TO LEFT + VERTICAL

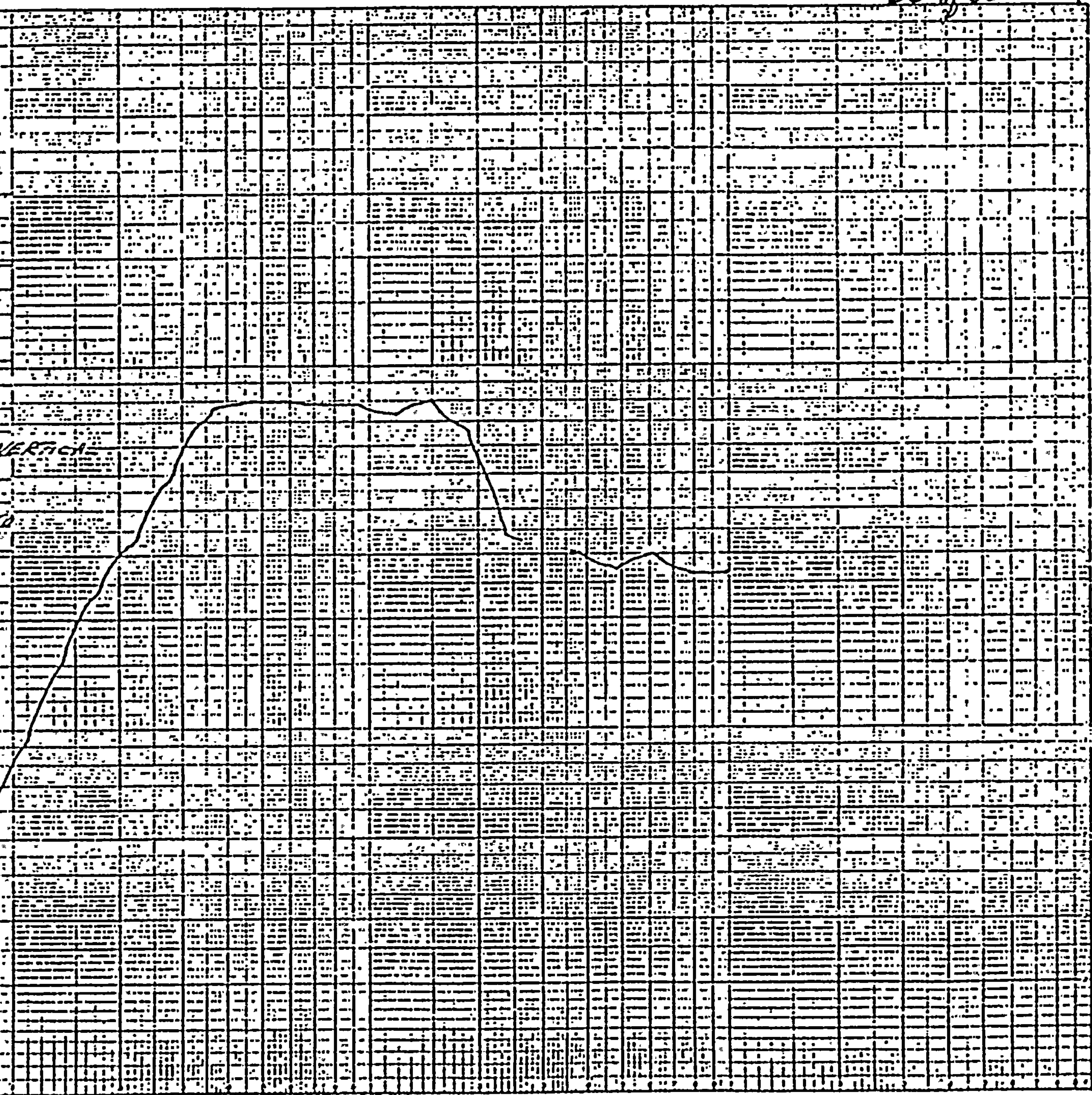
Pick-up No. 12

Pick-up Axis VERTICAL

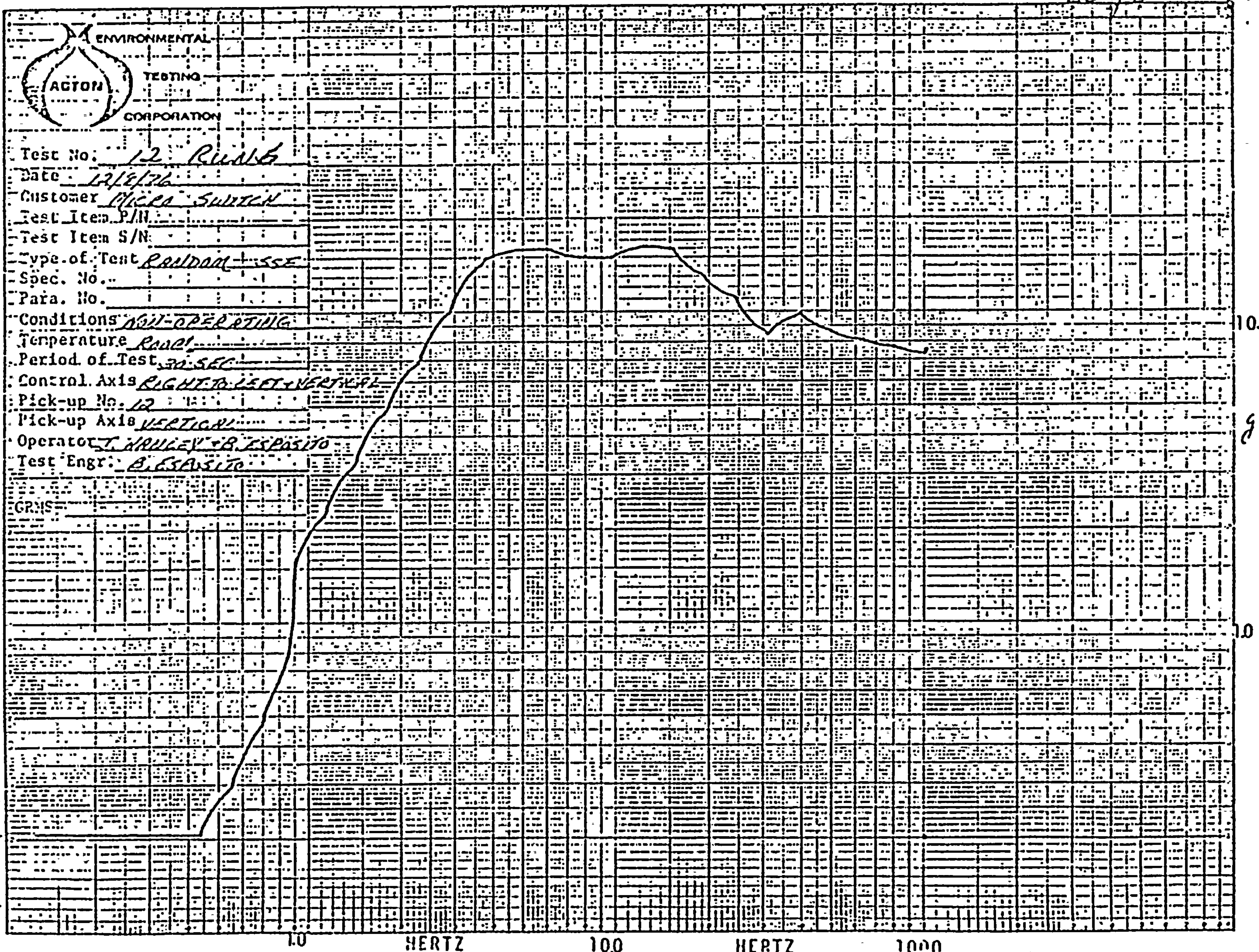
Operator T. HANLEY + B. ESPOSITO

Test Engr. B. ESPOSITO

GRMS



F.R. 13,477 LTR 2440...

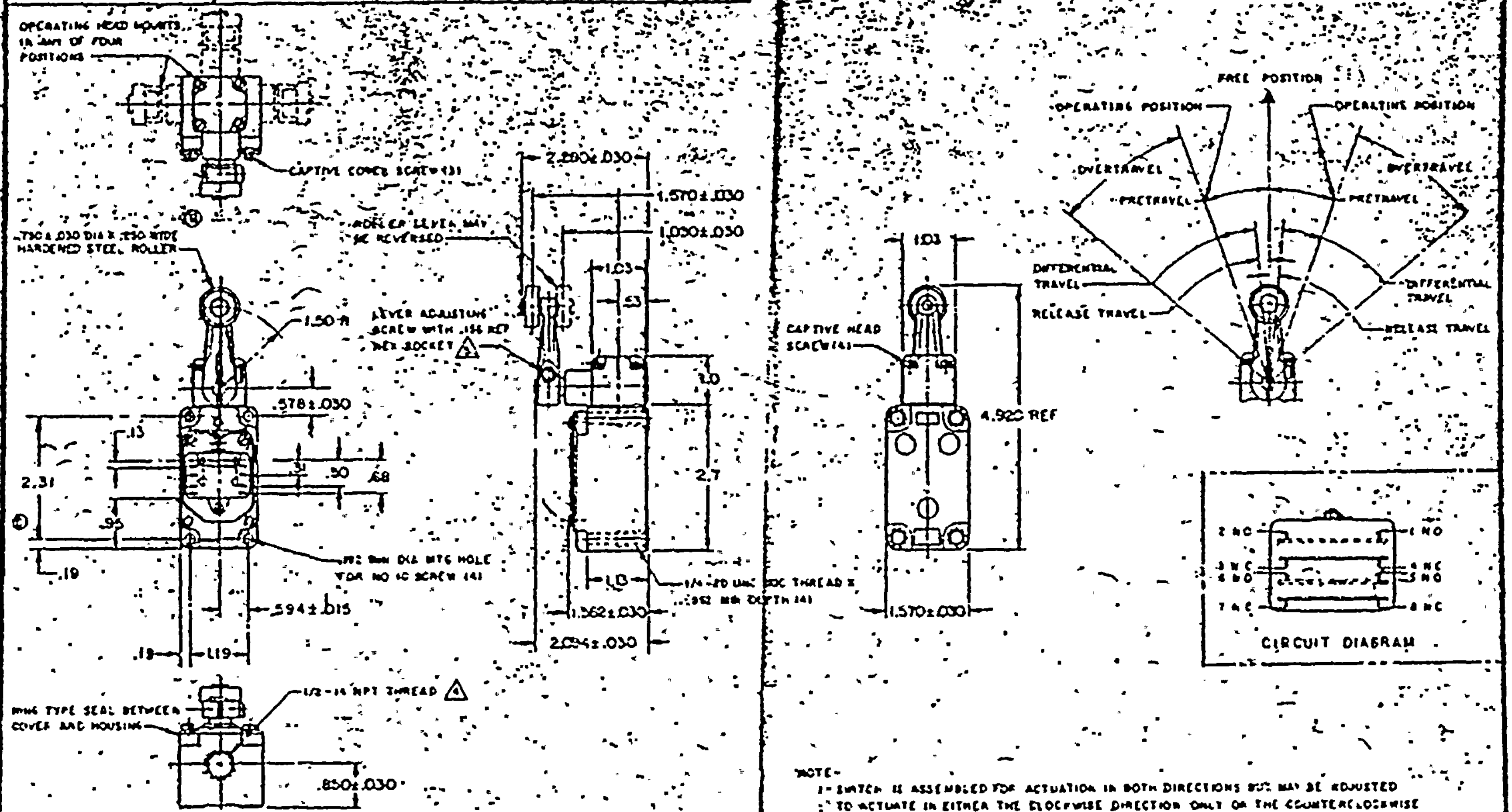


44

MICRO SWITCH
FREEPORT, ILLINOIS U.S.A.

SWITCH - ENCLOSED

1ILS1



NOTE -

1 - SWITCH IS ASSEMBLED FOR ACTUATION IN BOTH DIRECTIONS BUT MAY BE ADJUSTED TO ACTUATE IN EITHER THE CLOCKWISE DIRECTION ONLY OR THE COUNTERCLOCKWISE DIRECTION ONLY

2 - TO CONVERT SWITCH FOR ACTUATION IN EITHER THE CLOCKWISE OR COUNTERCLOCKWISE DIRECTION ONLY, REMOVE ACTUATOR HEAD AND ROTATE THE NOTCHED PLUNGER 90° TO THE RIGHT FOR CLOCKWISE ACTUATION OR 90° TO THE LEFT FOR COUNTERCLOCKWISE ACTUATION

3 - ALUMINUM HOUSING AND COVER FINISHED WITH GRAY PAINT

4 - SEAL TO BE FURNISHED BY USER

5 - ROLLER LEVER MAY BE LOCKED IN ANY POSITION THRU 360°

6 - LEVER FURNISHED UNASSEMBLED IN UNIT PACKING BOX

CHARACTERISTICS	
OPERATING FORCE	3 LB MAX
FULL OVERTRAVEL FORCE	4 LB MAX
RELEASE FORCE	1/2 LB MIN
PRETRAVEL	23° MAX
DIFFERENTIAL TRAVEL	10° MAX
OVERTRAVEL	23° MIN
RELEASE TRAVEL	4° MIN
[illegible] REPLACEMENT	8AS42

ELECTRICAL DATA

CONTACT ARRANGEMENT (SEE CIRCUIT DIAGRAM)

[illegible] 250 VAC

SCALE 1/2 TO 1

DO NOT SCALE PRINT

UNLESS OTHERWISE NOTED DIMENSIONS ARE IN INCHES

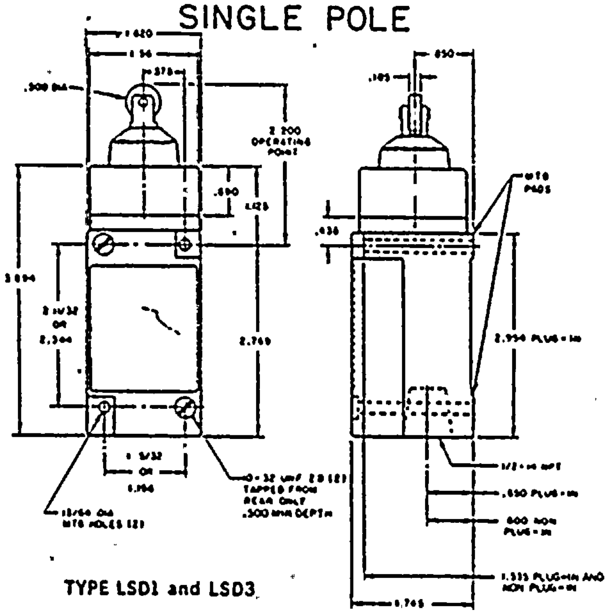
TOLERANCES ARE

WEIGHT 9 OZ

SERIES

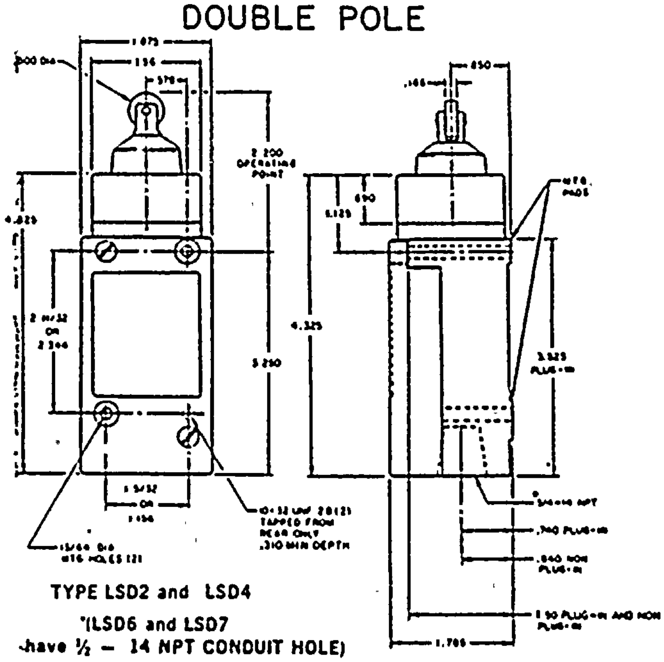
PLUNGER TYPE TOP

SINGLE POLE



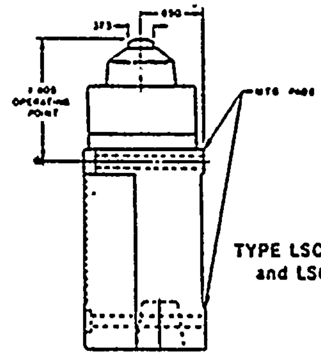
TYPE LSD1 and LSD3

DOUBLE POLE

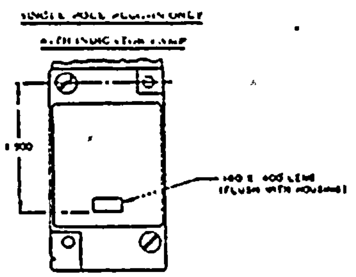


TYPE LSD2 and LSD4

*(LSD6 and LSD7
have ½ – 14 NPT CONDUIT HOLE)

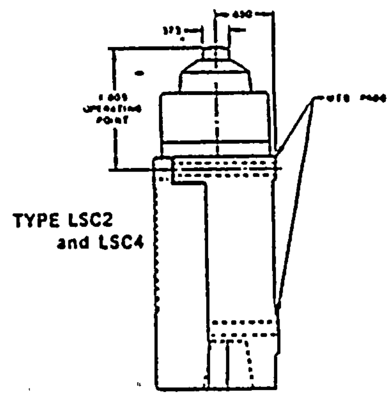


TYPE LSC1
and LSC3

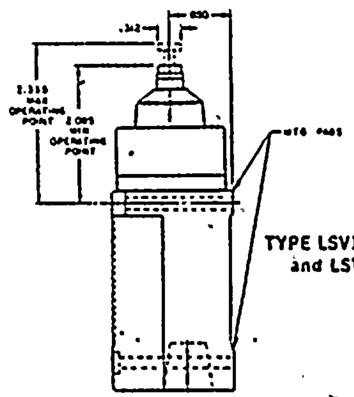


120 LAMP VOLTAGE -
TYPE LSC5, LSD5 or LSV5

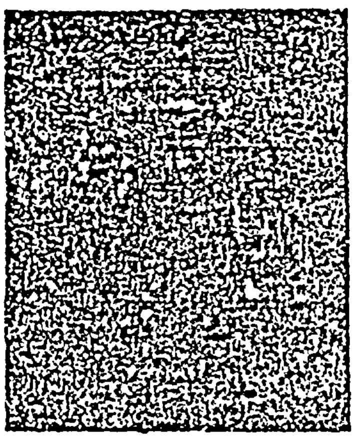
240 LAMP VOLTAGE -
TYPE LSC8, LSD8 or LSV8



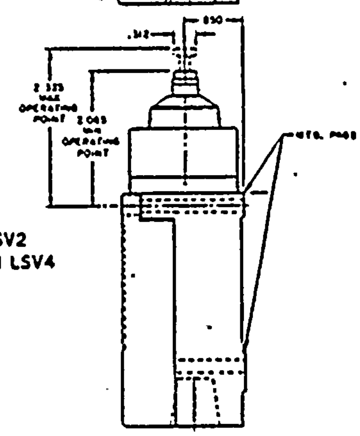
TYPE LSC2
and LSC4



TYPE LSV1
and LSV3



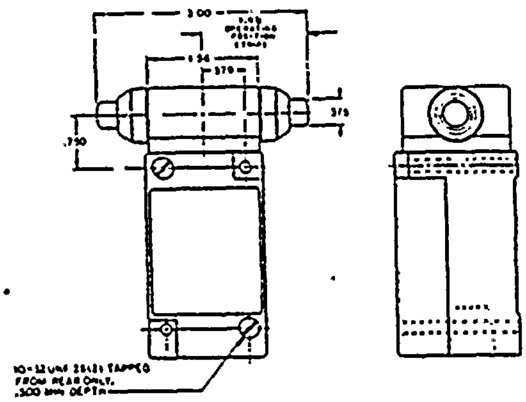
TYPE LSV2
and LSV4



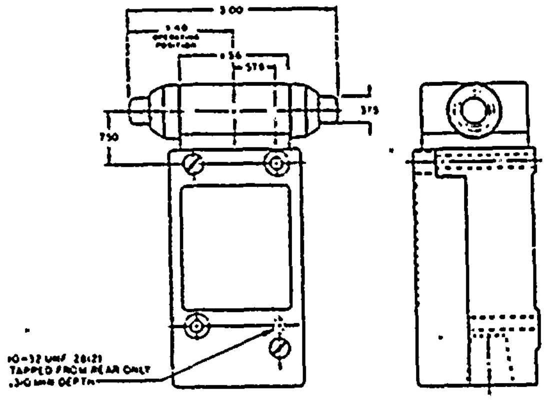
MICRO SWITCH

SWITCH-ENCLOSED

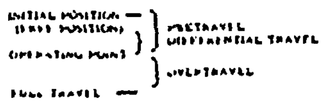
LSA-LSW SERIES



TYPE LSG1 and LSG3



TYPE LSG2 and LSG4



TOP PLUNGER TYPES

OPERATING POINT GIVEN IN RELATION TO TOP MOUNTING HOLE

CHARACTERISTICS	LSG PLUNGER		LSG ROLLER PLUNGER		LSY ADJ PLUNGER	
PRETRAVEL (MAX)	.070		.070		.070	
DIFFERENTIAL TRAVEL (MAX)	SINGLE POLE .015	DOUBLE POLE .020	SINGLE POLE .015	DOUBLE POLE .020	SINGLE POLE .015	DOUBLE POLE .020
OVERTRAVEL (MIN)	.140		.190		.190	
OPERATING FORCE (MAX)	6 lbs		6 lbs		6 lbs	
OPERATING POINT	[illegible]		[illegible]		2.065 MIN	2.335 MAX
FULL OVERTRAVEL FORCE (MAX)	7 lbs		7 lbs		7 lbs	

SIDE PLUNGER TYPES

OPERATING POINT GIVEN IN RELATION TO CENTER OF HEAD

CHARACTERISTICS	LSG PLUNGER	LSF ROLLER PLUNGER	LSW ADJ PLUNGER	LSG PLUNGER MAINTAINED
PRETRAVEL (MAX)	.100	.100	.100	.170
DIFFERENTIAL TRAVEL (MAX)	.045	.045	.045	.090
OVERTRAVEL (MIN)	.190	.190	.190	.000
OPERATING FORCE (MAX)	6 LBS	6 LBS	6 LBS	10 LBS
OPERATING POINT	[illegible]	[illegible]	ADJUSTABLE, FROM [illegible] MIN TO [illegible] MAX	[illegible]
FULL OVERTRAVEL FORCE (MAX)	6 LBS	6 LBS	6 LBS	10 LBS

QUALITY ASSURANCE
RECORD

NUS CORPORATION
CONSULTING DIVISION

RECORD OF SYSTEM/COMPONENT ANALYSES

FILE NO.:	NO. OF PAGES:	NUMBER OF VOLUMES OF COMPUTER OUTPUT:
1961-M302-001	22	NA

CLIENT:	PROJECT NO.:
NIAGARA MOHAWK POWER CORPORATION	1961

ANALYSIS TITLE: Environmental Qualification Analysis for Micro Switch Limit Switch model 11LS1

AUTHOR: Nunu C Wong

PURPOSE OF ANALYSIS: To determine if the design of the limit switch is adequate to assure that the valve will operate on demand to meet the system performance requirement under normal and harsh environment conditions and during design basis events at NMP-1

SUMMARY OF ANALYSIS PROCEDURE AND RESULTS:

Literature search was conducted to obtain time/temperature data, radiation threshold level of the non-metallic components contained in the subject equipment. Arrhenius Theory was used to calculate the expected life of the non-metallic components. MicroSwitch model LSA2B-1D limit switch, which is generic to model 11LS1, was tested.
The 11LS1 limit switch can be qualified; provided any Buna-N seal is replaced with seals made of qualified material.

DATE COMPLETED:	VERIFICATION REQUIRED:
11/25/81	☒ YES ☐ NO

ANALYSIS REVIEWED AND ACCEPTED: (DISCIPLINE MANAGER)	DATE:
C H Hook	12/1/81

ANALYSIS:	BY: (FILE NO.)	DISCIPLINE MANAGER:	DATE:
☐ SUPERSEDED ☐ SUPPLEMENTED			

NUS 202 10 REVISED 0181
(Formerly CD-28 12/77)

NUS CORPORATION
CONSULTING DIVISION

ANALYSIS VERIFICATION CHECKLIST

ANALYSIS TITLE: Environmental Qualification Analysis for Micro Switch (ILS) Limit Switch

ANALYSIS FILE NUMBER: 1961-M302-001

INDICATE "YES, NO, OR N/A (NOT APPLICABLE)," FOR EACH ITEM AND INCLUDE IN ANALYSIS PACKAGE WITH RECORD OF ANALYSIS VERIFICATION	YES	NO	N/A
METHOD OF ANALYSIS			
IS THE METHOD USED APPROPRIATE CONSIDERING THE PURPOSE AND TYPE OF ANALYSIS AND THE USE AND ACCEPTABILITY OF THE RESULTS (i.e., MARGIN TO LIMITS)?	[x]	[ ]	[ ]
IS THE METHOD IN ACCORDANCE WITH CODES, STANDARDS, AND REGULATORY REQUIREMENTS?	[x]	[ ]	[ ]
HAS THE METHOD BEEN EMPLOYED ELSEWHERE IN INDUSTRY OR IN LICENSE APPLICATIONS?	[x]	[ ]	[ ]
ASSUMPTIONS			
ARE ASSUMPTIONS NECESSARY TO PERFORM THE ANALYSIS ADEQUATELY DESCRIBED AND REASONABLE?	[x]	[ ]	[ ]
WHERE NECESSARY, ARE THE ASSUMPTIONS IDENTIFIED FOR SUBSEQUENT RE-VERIFICATIONS WHEN THE DETAILED DESIGN ACTIVITIES ARE COMPLETED?	[x]	[ ]	[ ]
INPUT INFORMATION			
ARE THE INPUTS INTO THE ANALYSIS STATED AND THEIR SOURCE IDENTIFIED?	[x]	[ ]	[ ]
IS THE INPUT INFORMATION FROM THE LATEST AVAILABLE REVISION TO THE DOCUMENT?	[x]	[ ]	[ ]
IS THE STATUS (PRELIMINARY, CONCEPTUAL, ETC.) OF THE INPUT SOURCE IDENTIFIED FOR LATER CONFIRMATION OF THE VALIDITY OF THE INPUT?	[x]	[ ]	[ ]
ARE THE INPUTS SUFFICIENT CONSIDERING THE PURPOSE OF THE ANALYSIS?	[x]	[ ]	[ ]
COMPUTER CODE APPLICATION			
ARE ALL CODES USED IDENTIFIED ALONG WITH SOURCE, COMPUTER TYPE, INPUTS, AND OUTPUTS?	[ ]	[ ]	[x]
HAS THE CODE BEING USED BEEN ADEQUATELY VERIFIED?	[ ]	[ ]	[x]
IS THE CODE SUITABLE FOR THE PRESENT ANALYSIS?	[ ]	[ ]	[x]
DOES THE COMPUTER MODEL (NODING, TIME STEPS, ETC.) ADEQUATELY REPRESENT THE PHYSICAL SYSTEMS?	[ ]	[ ]	[x]
REASONABLENESS OF RESULTS			
IS THE MAGNITUDE OF THE RESULT REASONABLE?	[x]	[ ]	[ ]
ARE THE DIRECTION OF TRENDS REASONABLE?	[x]	[ ]	[ ]

PREPARED BY: [signature]

DATE: 25 Nov 1987

NUS 204 10 REVISED 0181
(Formerly CD-30 Rev. 1)

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

FILE NO.: 1961-M302-001	PAGE 1 OF 2

ANALYSIS TITLE: Environmental Qualification Analysis for Micro Switch model 11LS1 limit switch

AUTHOR:	NO. OF PAGES:	NO. OF VOLUMES OF COMPUTER OUTPUT:
Kwan C Wong	22	NA

VERIFICATION SCOPE (CHECK AS APPLICABLE):

- [x] METHOD OF ANALYSIS
- [x] ASSUMPTIONS
- [x] INPUT INFORMATION
- [ ] COMPUTER CODE APPLICATION
- [ ] CHECK OF SAMPLE CALCULATION
- [x] SPOT CHECK OF MATHEMATICS
- [x] REASONABLENESS OF RESULTS
- [ ] COMPLETE CHECK OF MATHEMATICS
- [ ] PARTIAL INDEPENDENT ANALYSIS

BUDGET: (APPROXIMATE) 1/4 MANDAYS	DESIRED COMPLETION DATE: 12/11/82

DESCRIPTION OF VERIFICATION—ACTIVITIES, FINDINGS AND RESOLUTION:

– none –

NUS 203A 10 REVISED 0181
(Formerly CD-29(1) 12/77)

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

VERIFIER'S SIGNATURE: [signature]	DATE: 25 Nov 1981
ACCEPTANCE BY: (DISCIPLINE MANAGER) [signature]	DATE: 12/1/81

FINAL ANALYSIS REVIEW CHECKLIST

Project #/Project Title 1961 Client NMPC

Date: 11/25/81

Analysis File Title: Environmental Qualification Analysis for Micro Switch 11LS1 Limit Switch

Analysis File Number: 1961-M-02-001

Checklist Item	Yes	N/A
1. Unique Analysis File Number assigned to the file.	✓	
2. Analysis recorded on CD-60	✓	
a. pages numbered	✓	
b. total pages specified	✓	
c. all pages dated	✓	
d. client identified on each page	✓	
e. correct file number on each page	✓	
f. author(s) specified on each page	✓	
g. subject specified on each page	✓	
h. verifier initials on each page	✓	
3. Analysis File includes:		
a. client identification	✓	
b. analysis file number	✓	
c. analysis title	✓	
d. author(s) identification	✓	
e. description of the purpose of the analysis	✓	
f. discussion of the general method of analysis	✓	
g. identification of input information source	✓	
h. identification of input information status	✓	
i. major assumptions used in performing the analysis	✓	

Date: 11/25/81

3. (Continued)

j.	important references, including material properties	✓	
k.	identification of specific versions of codes used	✓	
l.	detailed calculation	✓	
m.	listing of computer input		✓
n.	microfiche of computer output		✓
o.	summary of results	✓	
4.	Record of analysis provided onn CD-28	✓	
5.	All applicable entries on CD-28 correct.	✓	
6.	All referenced NUS internal memos included in analysis file.	✓	
7.	All referenced telecons included in analysis file.	✓	
8.	Separate computer output labeled with analysis file number.		✓
9.	Record of analysis file verification on CD-29.	✓	
10.	All entries on CD-29 completed and correct.	✓	
11.	Item (7) of CD-29 completed and comments numbered	✓	
12.	Verification checklist CD-30 included.	✓	
13.	Computer code used verified per QAI 3.5.		✓
14.	Corrected items crossed out clearly enough to show on Xerox copies.	✓	
15.	List of input information and major assumptions checked for commpleteness.	✓	
16.	Documents Complete (Page Count)	✓	
17.	Documents Legible and Reproducible	✓	
18.	All Documents Identified on Index Received	✓	
19.	Documents Properly Paginated	✓	
20.	Documents Identified to Project/Item	✓	
21.	All Unsatisfactory Conditions Resolved (List)	✓	

Date 11/25/81

22. Remarks:

Reviewed by: [signature] 25 Nov '81
Date

CW 12/1/81

NUS CORPORATION

Page NA of

DATE 11/25/81

CLIENT NMPC FILE NO. 1961-M302-CO1 BY Kevin C. Kelm

SUBJECT Environmental Qualification Analysis Checked By [signature]

ENVIROMENTAL QUALIFICATION ANALYSIS

FOR

MICRO SWITCH 11.LS1

LIMIT SWITCH

FOR USE IN

NIAGARA MOHAWK POWER CORPORATION'S

NINE MILE POINT - UNIT ONE

NUCLEAR POWER GENERATING STATION

PROJECT 1961

NUS CORPORATION

DATE 11/25/81

CLIENT NMPC FILE NO. 1961-N1302-001 BY Kuon C Wong

SUBJECT Environmental Qualification Analysis Checked By JEB

TABLE OF CONTENTS

CLIENT NMPC FILE NO. 1961-N302-001 BY Kevin C Wong

SUBJECT Environmental Qualification Analysis Checked By [signature]

NUS CORPORATION

DATE 11/25/81

CLIENT NMPC FILE NO. 1961-M302-001 BY Kwan C Wong

SUBJECT Environmental Qualification Analysis Checked By [signature]

Section and Title — Page No

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1.0 CLIENT IDENTIFICATION

Niagara Mohawk Power Corporation (NMPC), Nine Mile Point Nuclear Power Station, Unit 1 (NMP-1)

2.0 ANALYSIS FILE NUMBER

1961-M302-001

3.0 ANALYSIS TITLE

Environmental Qualification Analysis for Micro Switch limit switch, model 11LS1

4.0 AUTHOR IDENTIFICATION

Kwan C Wong

5.0 PURPOSE OF ANALYSIS

The purpose of this analysis is to determine if the design of the limit switch is adequate to assure that the limit switch will operate on demand to meet the system performance requirements under normal and harsh environment conditions and during design basis events at NMP-1

6.0 INPUT INFORMATION

6.1 Equipment Identification. (Ref 13.1)

System	Plant I.D.	Model
CIT	68-08	11 LS.1
CIT	68-09	11 LS.1
CIT	68-10	11 LS1

6.2 Material

A list of non-metallic materials contained in the limit switch and their qualification data are presented in Table 6-1. The limit switch

contains Arc Resistant Phenolic case, cover and carrier, Teflon filled Phenolic plunger; Viton A or Neoprene, or Buna-N seal; Epoxy based adhesive; Epoxy based Enamel paint; and Hydrocarbon Grease. (Ref 13.2)

6.3 Safety-Related Function

The safety-related function of the subject equipment is to provide containment isolation (Torus) for vacuum relief system valve position. (Ref 13.3)

6.4 Service Conditions

The normal service condition for the CIT system (Ref 13.4) is 103°F, 0 psig, 10-90% relative humidity (assumed) and 1×10^4 rads radiation. The harsh environment condition for the CIT system is 126°F and 1 psig (fig 6-1) (Ref 13.5), 100% relative humidity, less than 1×10^6 rads radiation (Ref 13.6) and 1 hour duration (specified by NMPC). No operational cycling has been specified.

7.0 METHOD OF ANALYSIS

7.1 Materials

The manufacturer of the subject equipment was contacted and

TABLE 6-1

Non-metallic Material List and Qualification Data for Limit Switch 11LS1

Component Material	Manufacturer's Rating	Radiation		Time/Temperature		
		Material Analyzed	Radiation Threshold (rads)	Material Analyzed	Activation Energy (eV)	Intercept
Seal – Viton A	NA	Viton-A	5×10^6	Viton-A	0.799	-14.481
Seal – Neoprene	NA	Neoprene seal	1×10^7	Neoprene Insulation	1.0421	-23.8443
Hydrocarbon grease	NA	NA	NA	NA	NA	NA
Case, cover, carrier – Arc Resistant Phenolic	NA	Phenolic Resin	1×10^7	Durez 125	0.5284	-6.1163
Plunger – Teflon Filled Phenolic	NA	Phenolic Resin	1×10^7	Durez 152	0.6733	-9.9578
Seal – Buna-N	NA	Buna-N	1.4×10^6	Buna-N O-ring	0.75065	-16.2810
Epoxy Based adhesive and enamal	NA	Epoxy Resin	2×10^8	Epoxy/Fiberglass NEMA FR-4, G-10	1.296	-27.0488

Figure 6-1

REF 13.5

Fig. 4.11

LIMITING TEMPERATURE AND PRESSURE IN OPEN FLOOR AREAS NOT NEAR BREAK LOCATIONS

DATE 11/25/81

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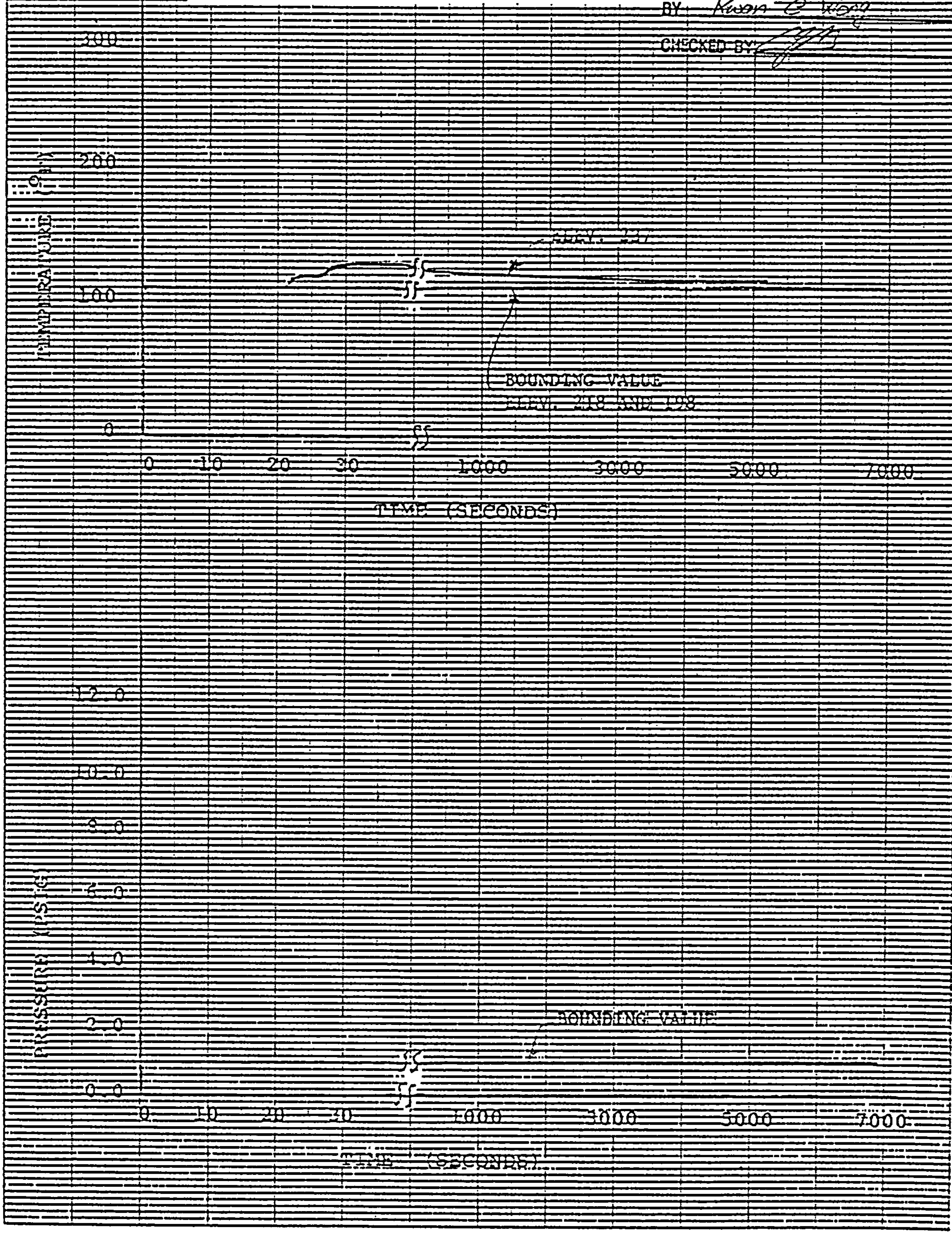

46 1320

K+E 10 X 10 TO 1/2 INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

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a list of the non-metallic components used in the subject equipment was obtained. A literature search was then conducted to obtain radiation threshold level, maximum temperature level and time/temperature aging data for the materials that may be subjected to degradation from those factors.

7.2 Radiation

A literature search was conducted and the manufacturer was contacted to determine the radiation threshold levels for the organic materials used in the subject equipment.

7.3 Time/Temperature Effects

The present state of the art allows acceleration of the aging effects of temperature by subjecting a material to increased temperatures for a relatively short duration. For many non-metallic materials, it is known that the degradation process can be defined by a single temperature-dependent reaction that follows the Arrhenius equation:

$$K = A \exp[-Ea/(K_b T)] \quad (1)$$

Where,

K = Reaction Rate
A = Frequency Factor
exp = Exponent to base e
Ea = Activation Energy
K_b = Boltzman's Constant
T = Absolute Temperature

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Equation (1) can also be expressed in a form which yields an expected lifetime of the material at a specific temperature. This form is:

$$\ln t_i = E_a/(K_b T_i) + I \qquad (2)$$

Where,

$\ln$ = Natural Logarithm
t_i = Expected life at temperature T_i (hours)
T_i = Service Temperature for life t_i (K)
I = Constant

Equation (2) can also be represented in a linear regression line as:

$$Y_i = M X_i + I \qquad (3)$$

where,

$Y_i = \ln t_i$
$X_i = 1/T_i$
$M = E_a/K_b$
I = Constant (Intercept)

For the purpose of this analysis, Equation (2) was used to calculate the expected life of the materials used in the subject equipment. Time/temperature test data were collected from the available literature on each temperature sensitive material and the activation energies and intercepts calculated for the specified failure criteria.

These activation energies and intercepts were then used to calculate the expected life of the materials under the maximum harsh environment temperature conditions. If the life calculated for all materials at the harsh environment conditions exceeded 40 years, no further analysis was done because the maximum harsh environment temperature envelopes

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All other temperature conditions. If the material life as calculated above did not exceed 40 years, then the expected life at ambient conditions was also calculated. A determination of the expected life was made using the combination of 40 years at normal service conditions and the specified duration of a design basis event. The thermal degradation equivalency where a material is exposed to a shorter test duration can be determined by the transformed Arrhenius Theory as follows

$$t_2 = t_1 \exp\left[\frac{E_a}{K_b}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)\right] \qquad (4)$$

where,

- t_1 = Test time at temperature T_1
- t_2 = Equivalent time at temperature T_2
- E_a = Activation Energy
- K_b = Boltzmann's Constant
- T_1 = Test temperature
- T_2 = Qualification Temperature

7.4 Harsh Environment

A MicroSwitch model LSA2B-1D was tested (ref 13.7). The subject equipment, 11LS1, is generic to the test specimen, LSA2B-1D. The test specimen was exposed to three cycles of harsh environment, twice at 257°F for 240 hours and once at 257°F for 261 hours. The relative humidity was 95%.

7.5 Cycling

The test specimen was cycled at 125 VDC or 125 VAC supply and under load (ref 13.7). The test specimen was tested for 47614 cycles before environmental test, 10,000 cycles after environmental test, and 10 cycles after seismic test.

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8.0 MAJOR ASSUMPTIONS

- It is assumed that for the purpose of this analysis, the deterioration of metallic components due to time/temperature effects and radiation exposure is insignificant.

- It is assumed that the organic materials used rather than the inorganic materials will be the limiting materials for time/temperature effects and radiation exposure.

- It is assumed that the time/temperature data obtained for Durez 145 Electric Grade Phenolic, Durez 152 mineral filled phenolic and NEMA Grade FR-4, G-10 Epoxy are applicable to the arc resistant Phenolic, Teflon filled Phenolic, and Epoxy based adhesive and paint, respectively.

- It is assumed that the failure criteria used to obtain the time/temperature data for various materials are applicable to the components used in the subject equipment.

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9.0 DETAILED CALCULATIONS

9.1 Viton A. (Ref 13.8)

slope = 9273.27

Activation Energy = 0.799

Intercept. = -14.481.

Life calculation equation

$$\ln t_i = 927327\left(\frac{1}{T_i}\right) - 14.481.$$

Expected life at maximum environmental conditions, 126°F (325.56 K)

$$\ln t = 9273.27\left(\frac{1}{325.56}\right) - 14.481$$

$$t = 1206287.77 \text{ hr}$$

$$= 137.70 \text{ yr}$$

9.2 Neoprene (Ref 13.9)

slope = 12093.522

Activation Energy = 1.0421

Intercept = -23.8443

Life calculation equation

$$\ln t_i = 12093.522\left(\frac{1}{T_i}\right) - 23.8443$$

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DATE 11/25/81

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Expected life at maximum environmental conditions, 126°F (325.56 K)

$$\ln t = 12093.522 \frac{1}{325.56} - 23.8443$$

$$t = 598708.48 \text{ hr}$$
$$= 68.34 \text{ yr}$$

9.3 Durez 145 Electric Grade Phenolic (Ref 13.10)

Slope = 6132.04
Activation Energy = 0.5284
Intercept = −6.1163

Life calculation equation

$$\ln t_i = 6132.04 \left(\frac{1}{T_i}\right) - 6.1163$$

Expected life at maximum environmental conditions, 126°F

$$\ln t = 6132.04 \frac{1}{325.56} - 6.1163$$

$$t = 334054.89 \text{ hr}$$
$$= 38.13 \text{ yr}$$

Expected life at normal service conditions, 103°F (312.78K)

$$\ln t = 6132.04 \left(\frac{1}{312.78}\right) - 6.1163$$

$$t = 721192.92 \text{ hr}$$
$$= 82.33 \text{ yr}$$

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Equivalent life at normal service conditions, based on 1 hour at maximum environmental conditions.

$$t_2 = 1 \cdot \exp\left[6132.04\left(\frac{1}{312.78} - \frac{1}{325.56}\right)\right]$$

$$= 2.16 \text{ hr.}$$

Expected life as a combination of normal service condition and 1 hour at maximum environmental condition

$$t = 72119292 - 2.16 \text{ hr}$$
$$= 72119276 \text{ hr}$$
$$= 82.33 \text{ yr.}$$

9.4 Durez 152 Mineral Filled, Heat Resistant Phenolic (Ref 13.10)

Slope = 7814.0133
Activation Energy = 0.6733
Intercept = -9.9578

Life calculation Equation

$$\ln t_i = 7814.0133\left(\frac{1}{T_i}\right) - 9.9578$$

Expected life at maximum environmental conditions; 126°F

$$\ln t = 7814.0133\left(\frac{1}{325.56}\right) - 9.9578$$

$$t = 1256651.21 \text{ hr}$$
$$= 143.45 \text{ yr.}$$

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9.5 Epoxy / Fiberglass, -NEMA FR-4, G-10 (Ref 13.11)

Slope = 15043.146
Activation Energy = 1.296
Intercept = -27.0488

Life calculation equation

$$\ln t_i = 15043.146\left(\frac{1}{T_i}\right) - 27.0488$$

Expected life at maximum environment condition, 126°F

$$\ln t = 15043.146\left(\frac{1}{325.56}\right) - 27.0488$$

$$t = 209071088.8 \text{ hr.}$$
$$= 23866.56 \text{ yr}$$

9.6 Buna-N Oring (Ref 13.12)

Slope = 8711.2572
Activation Energy = 0.75065
Intercept = -16.2810

Life calculation equation

$$\ln t = 8711.2572\left(\frac{1}{T_i}\right) - 16.2810$$

Expected life at maximum environment condition, 126°F

$$\ln t = 8711.2572\left(\frac{1}{325.56}\right) - 16.2810$$

$$t = 35481.35 \text{ hr}$$
$$= 4.05 \text{ yrs}$$

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Expected life at normal service environment, 103°F.

$$\ln t = 8711.2572\left(\frac{1}{312.78}\right) - 16.2810$$

$$t = 105880.72 \text{ hr}$$
$$= 12.09 \text{ yr}$$

Equivalent life at normal service condition, based on 1 hour at maximum environment conditions.

$$t_2 = 1 \cdot \exp\left[8711.2572\left(\frac{1}{312.78} - \frac{1}{325.56}\right)\right]$$

$$= 2.98 \text{ hr.}$$

Expected life using the combination of normal service condition and equivalent life based on 1 hour at maximum conditions

$$t = 105880.72 - 2.98 \text{ hr}$$
$$= 105877.74 \text{ hr}$$
$$= 12.09 \text{ yr.}$$

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10.0 RESULTS

10.1 Radiation

Literature search has revealed that the radiation threshold level is 5×10^6 rads for Viton-A, 1×10^7 rads for Neoprene seal, 1×10^7 rads for Phenolic resin, 1.4×10^6 rads for Buna-N O-ring and 2×10^8 rads for Epoxy resin. No radiation data was obtained for Hydrocarbon Grease.

10.2 Time/Temperature Effects

10.2.1 Viton A

Under maximum environment conditions, Viton A has an expected life of 137.70 years.

10.2.2 Neoprene

Under maximum environment condition, Neoprene has an expected life of 68.34 years.

10.2.3 Arc Resistant Phenolic

Durez 145 Electric Grade Phenolic, which has been assumed that the time/temperature data obtained are applicable to Arc Resistant phenolic, has an expected life of 38.13 years under maximum environment conditions, 82.33 years under normal service conditions and a combination of normal service conditions and equivalent life at one hour of maximum environment conditions.

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10.2.4 Teflon Filled Phenolic

Durez 152 mineral filled, heat resistant Phenolic, which has been assumed that the time/temperature data obtained are applicable to Teflon filled Phenolic, has an expected life of 143.45 years under maximum environment conditions.

10.2.5 Buna-N

Buna-N O-ring has an expected life of 4.05 years under maximum environment condition, 12.09 years under normal service life and 12.09 years using a combination of normal service life and one hour at maximum environment conditions.

10.2.6 Epoxy Based Adhesive and Enamel

NEMA Grade FR-4 and G-10 Epoxy on fiberglass, which has been assumed that the time/temperature data are applicable to Epoxy based adhesive and enamel, has an expected life of 23866.56 years under maximum environment conditions.

10.2.7 Hydrocarbon Grease

No time/temperature data was obtained for Hydrocarbon grease.

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10.3 Harsh Environment

The test specimen was subjected to three cycles of harsh environment, Twice at 257°F for 240 hours and once at 257°F for 261 hours. The relative humidity was 95%. The test specimen was operable after the harsh environment test.

10.4 Cycling

The test specimen was cycled at 125 VDC or 125 VAC supply and under load. The test specimen was tested for a total of 57624 cycles. No damage was observed.

11.0 SUMMARY OF RESULTS / CONCLUSION

11.1 Radiation

The lowest radiation threshold level was: 1.4×10^6 for Buna-N O-rings. The radiation dose exceeded the total integrated dose the subject equipment is expected to receive in 40 years of normal service condition and one design basis event. Therefore, the subject equipment can be qualified, based on radiation only.

11.2 Time / Temperature Effect

All nonmetallic materials, except Buna-N O-ring, has an expected life exceeding 40 years. Therefore, these materials can be qualified for 40 years of

normal service conditions and one design basis event, based on time/temperature effect. Buna-N O-ring has an expected life of 12.09 years using a combination of normal service conditions and on design basis event. Therefore, Buna-N cannot be qualified, based on time/temperature effect.

11.3 Harsh Environment

The test specimen remained operable after the harsh environment test. The 95% relative humidity is only slightly lower than the 100% relative humidity specified in the harsh environment conditions. Therefore the subject equipment can be qualified for harsh environment condition operation.

11.4 Cycling

The test specimen was cycled 57,624 times without damage. No operational cycling requirement has been specified. Therefore, no conclusion can be drawn on the cycling qualification for the subject equipment.

12.0 RECOMMENDATIONS

- Replace the Buna-N seals every 12 years or less, or
- Replace the Buna-N seal with seals that are qualified for 40 years.
- Lubricants should be replenished regularly.

Since the calculated life for Buna-N seal is only 12.09 years, the seals should be replaced before failure, that is, 5 - 8 years. Or the seals can be

replaced with materials that are qualified for 40 years. Lubricants should be replenished regularly to ensure smooth operations.

13.0 REFERENCES

13.1 NMPC, NMP-1 on-going Qualification Assessment Summary, Rev 4, dated 11/5/81

13.2 MicroSwitch Non-metallic material part list for LSO4L, dated 7/9/81

13.3 Memo from S.J. Gazda (NUS) to A P Conepa (NUS), CD-ENG-526, dated 11/23/81

13.4 NMPC letter from D Green to DH Bhatia (NUS), dated 3/11/81

13.5 NUS Analysis 1961-SA-A1, NMPC, NMP-1 HELB Pressure and temperature Model – Reactor Building, dated 12/9/80

13.6 NUS Analysis 1961-R-1, NMPC, Radiation Environment Specification for NMP-1, dated 10/25/81

13.7 NUS Qualification Document Review Summary for MicroSwitch Model 11LS1, dated 3/4/81

13.8 NUS Generic Analysis, NUS-LA-V-1. Material Analysis for Vinylidene fluoride hexafluoropropylene, 11/14/81

13.9 NUS Generic Analysis, NUS-LA-C-2, Material Analysis for Chloroprene, 11/15/81

13.10 NUS Generic Analysis, NUS-LA-P-6, Material Analysis for Phenolic. 11/23/81

13.11 NUS Generic Analysis, NUS-LA-E-1, Material Analysis for Epoxy Resin, 11/14/81

13.12 NUS Generic Analysis, NUS-LA-A-1, Material Analysis for Acrylonitrile-Rubber; 11/23/81

QUALITY ASSURANCE RECORD 4

GENERAL ELECTRIC

GENERAL ELECTRIC CO., 6 VREELAND RD., FLORHAM PARK, NEW JERSEY 07932
Phone (201) 822-3960
966-5400

INSTALLATION AND SERVICE ENGINEERING DEPARTMENT

cc: T. M. Crimmins
T. E. Tipton
D. A. Ross

G-EN-0-164

October 16, 1980

RECEIVED

MAY 29 1981

ENGINEERING SERVICES
SOUTHERN OPERATIONS

Mr. Yosh Naigai
Jersey Central Power & Light Company
Madison Avenue at Punchbowl Road
Morristown, NJ 07960

Dear Mr. Naigai:

Enclosed find one (1) copy of Environmental Report, and Non-Metallic Materials information, which is the last page of the Environmental Report.

This Report covers the following motors:

1. Core Spray Pump Motors - Model No. 5K828848C7
   S/N: CC8364478
   CC8364479
   FB8358720
   FB8358721

2. Core Spray Booster Pump Motors - Model No. 5K818841C45
   S/N: EC8365470
   EC8365471
   EC8365472
   EC8365473

3. Containment Spray Pump Motor - Model No. 5K818842A103
   S/N: AC8361224
   AC8361225
   AC8361226
   AC8361227

The above information has been reviewed by San Jose Engineering.

If you have any questions concerning the enclosed information, please do not hesitate to phone this office.

Very truly yours,

Mireille Costandi

G. C. Nelson
Service Manager-Nuclear

GCN:ALA:jmh

W/A

ENVIRONMENTAL REPORT

Furnished to
GE/NEBG
San José, California
Reqn. 529-HR151X
By The
Large Motor & Generator Department
General Electric Company
Schenectady, New York 12345

October 1980

FORWARD

This report is prepared for the sole use of GE/NEBG, its agents and subsidiaries as an aid in the qualification of the General Electric Company motors supplied for use in the Jersey Central Power and Light Company's Oyster Creek Nuclear Power Plant.

Use of the data contained herein by other than GE/NEBG, its agents or subsidiaries or for any other than the indicated purpose is prohibited.

A portion of the data contained herein was extracted from reports prepared for the Large Motor and Generator Department of Schenectady, N.Y. by Dr. W. Nelson and Dr. J. Fleck. These reports which are proprietary cannot be made available in their original form but, upon request, representatives of GE/NEBG may review copies available at the Large Motor and Generator Department.

SCOPE:

This report endeavors to provide information which will assist GE/NEBG in determining the environmental qualification in accordance with NEBG Specification 22A2928 Rev. 2 dated 4/14/71, for the following motors:

GE Model No.	Serial No.	Application
5K828848C7	CC8364478, 479 FB8358720, 721	Core Stray Pump Motor
5K818841C45	EC8365470, 471 EC8365472, 473	Core Spray Booster Pump Motor
5K818842A103	AC8361224, 225 AC8361226, 227	Containment Spray Pump Motor

TABLE OF CONTENTS

SECTION I
DESCRIPTION OF MOTORS

The motors covered by this report are horizontal squirrel cage induction machines manufactured by the Large Motor and Generator Department in Schenectady, New York. The motors have oil ring lubricated sleeve bearings which have served the utility industry for more than 40 years. These bearings are self equalizing with ambient pressure fluctuations. The rotors have rugged dependable aluminum squirrel cages with integral end rings and fans.

The motors are (1) located outside of the containment and the environmental conditions specified are similar to, or perhaps less severe than found in many power plant applications in which General Electric motors have been used for more than 40 years, and (2) similar in design to other General Electric motors supplied for and used in safety related applications of nuclear power plants.

SECTION II
INSULATION SYSTEMS

The motors which are identified with the letter "C" in the model number have been furnished with form wound copper coils and General Electric "Custom Polyseal"* an epoxy vacuum impregnated mica-mat insulation system. A sealed system especially suited for moisture resistance and high humidity. A description of "Custom Polyseal" is contained in a trade bulletin included in the Appendix as Fig. A-1.

This insulation system was evaluated in accordance with IEEE-275 "Evaluation of Systems of Insulating Materials for A-C Electric Machinery Employing Form-Wound Preinsulated Stator Coils". Details of the test are given in Section IV of this report and the results plotted per IEEE-101 as shown on Fig. 5.

The motors which contain the letter "A" in the model number have been built with a random wound stator coil construction which is then impregnated with epoxy varnish and baked to cure the system. These machines although rendering considerable resistance to moisture and humidity are not classified as "sealed" insulation systems. As with any insulation system, sealed or not, periodic measurements of the winding insulation resistance to ground (with power cables disconnected) is recommended. If the resistance is less than the recommended minimum value in

*Registered trade of the General Electric Company.

the instruction manual, corrective action should be initiated. This could include re-impregnation treatments of the winding system.

The motors have been designed with special lower than standard temperature rises so that when operated in the specified high ambient of 148°F (65°C), the winding temperature rise of 35°C at rated load combined with the 65°C ambient does not exceed the total design temperature of 120°C for the ~~Class B insulation system of the "C" model numbers~~. Referring to Fig. #5 at 120°C, insulation life corresponds to 530,000 hours which exceeds 40 year life 24 hours per day, 7 days per week of operation. Aging therefore does not mechanically or electrically degrade the insulation system.

Similarly the "A" model number motors have been designed for a 50°C rise in a 70°C ambient for a total temperature of 120°C but these have been supplied with a Class "F" system which is normally rated at 145°C.

The subsequent sections of this report have been prepared and are made part of the IEEE-323 Topical Reports prepared by LM&G for motors furnished under todays standards for CLIE Safety Related Equipment and are attached to this report for informational value.

SECTION III
RADIATION-RESISTANCE OF THE CLASS IE MOTORS

Radiation resistance data for motor insulation systems, either as complete windings or motorettes, is largely limited to high temperature Class H silicone insulation system used in equipment for military or government applications. Such equipment is usually exposed to accumulated radiation levels in the order of $1x10^9$ rads or greater. The combinations of silicone resins, mica and glass insulation used in these systems have proved themselves in these environments.

The maximum integrated radiation dose over the 40 year operational life of the Class IE motors as covered by this report is $1x10^6$ rads. This is 0.1% of that required of the aforementioned Class H silicone, mica, glass systems. The basic insulation material being used on the Class IE motors is glass and mica. Epoxies are used as impregnating resins, instead of the silicone resins, but individual tests of epoxy resins show radiation tolerance up to $1x10^9$ rads before indication of damage.

As far back as 1970, GE has indicated that the insulation resistance of the components of the "CUSTOM POLYSEAL" Class B Epoxy VPI Mica Mat system is such that no effective damage results from an integrated dosage of $1x10^7$ roentgens (ref. Fig. A-4 of the Appendix).

SECTION III - RADIATION RESISTANCE OF THE CLASS IE MOTORS

Table II shows that the integrated motor design radiation dosage of $1x10^6$ rads over the 40 year life of the plant is below the "threshold damage dose" for the component materials of the insulation system. This conclusion was verified when a section of a typical 460 volt form wound Class B "CUSTOM POLYSEAL" Epoxy/UPI Mica Mat insulated coil with turn insulation consisting of fused filaments of polyester and glass was exposed to a dosage rate of $5x10^5$ rads per hour for an integrated radiation dose of $2x10^8$ rads (GAMMA). This exposure occurred at room temperature (25-20°C) in 60% relative humidity.

After exposure, the sample was examined. No change was detectable in any of the material - the surface of the coil section remained very hard. Voltage breakdown of the ground insulation of the 460 volt coil after $2x10^8$ rads exposure was 14,000 volts which is more than 6 times the voltage endurance level required by NEMA for a new motor having a 460 volt insulation system. This test was conducted in 1972 by the GE Company Nuclear Energy Division at Vallecitos, California.

The component material evaluation and the irradiation test of an insulated coil sample confirms that no mechanical or electrical degradation of the insulation is to be expected from an integrated radiation dose of $1x10^6$ rads. Radiation effects therefore need not be considered in evaluating motor life or the effects of a seismic incident at or near end of life.

TABLE II

MATERIAL	USAGE	THRESHOLD DAMAGE DOSE	REFERENCE
Mica Mat Wrap	Coil Ground Insulation		
Mica Paper		1×10^{8}-1×10^{10} Rads (C)	(1) Page 29
Polyester Film (Mylar)		4.4×10^{6} Rads* (C)	(4) Page 104
Polyester Resin (Unfilled)		5×10^{5} Rads* (C)	(4) Fig. #3
Mica Mat Tape	Coil Ground & Conn. Insulation		
Mica Paper		1×10^{8}-1×10^{10} Rads (C)	(1) Page 29
Glass Fiber		6.5×10^{10} Rads (C)	(1) Table 5
Polyester Resin (Unfilled)		5×10^{5} Rads* (C)	(4) Fig. #3
Polyester Film (Mylar)		4.4×10^{6} Rads* (C)	(4) Page 104
Glass Tape	Coil Armor Tape	6.5×10^{10} Rads (C)	(1) Table 5
Epoxy Resin	Stator Winding Impregnant	2×10^{9} Rads* (C)	(4) Fig. #3
Alkanex Film	Turn Insulation	4.6×10^{7} Rads (C)	(1) Table #4
Polyglass (DPG)	Turn Insulation		
Polyester Filaments (Mylar)		4.4×10^{6} Rads* (C)	(4) Page 104
Glass Filaments		6.5×10^{10} Rads (C)	(1) Table 5
Polyester Glass Laminate	Wedges, Fillers & Separators	9.5×10^{8} Rads* (C)	(4) Table A-41
Permafil Glass Rope	Coil Nose Bracing		
Glass Fibers		6.5×10^{10} Rads (C)	(1) Table 5
Polyester Resin (Unfilled)		5×10^{5} Rads* (C)	(4) Fig. #3
Polyester Resin (Glass Filled)		9×10^{8} Rads* (C)	(4) Fig. #3
Glass Roving	Ties		
Glass Fibers		6.5×10^{10} Rads (C)	(1) Table 5
Formvar Resin			
Polyester Resin (Unfilled)		5×10^{5} Rads* (C)	(4) Fig. #3
Polyester Resin (Glass Filled)		9×10^{8} Rads* (C)	(4) Fig. #3
Dacron Felt	Top Filler & Bracing	8.6×10^{5} Rads*	(2) Table 3
Ethylene Propylene Rubber	Power Cables	1.5×10^{7} Rads* (C)	(4) Table 40-8
Glaskyd Molding Compound	Coil Support Bracing		
Polyester Resin (Glass Filled)		9×10^{8} Rads* (C)	(4) Fig. #3
Light Turbine Oil	Bearing Lube (Sleeve Bearing)	1.5×10^{8} Rads	(5) Page 44-3
Scotchply 1002	Bearing Insulation		
Epoxy Resin		2×10^{9} Rads* (C)	(4) Fig. #3
Glass Filaments		6.5×10^{10} Rads (C)	(1) Tables

* Reported in ERGS G^{-1} (C) and converted to Rads (C).
100 ERGS G^{-1} (C) = 1 Rad Ref. (4) Table 3

TABLE III
REFERENCES

(1) "Radiation Effects Design Handbook" - "Section 3 Electrical Insulating Materials and Capacitors", C.L. Hanks, et al, Battelle Memorial Institute, Columbus, Ohio, U.S. Department of Commerce Publication N71-29776

(2) REIC Report No. 46, "Report on the Effect of Radiation on Electrical Insulating Materials" by C.L. Hanks and D.J. Hamman, to National Aeronautics and Space Administration - Radiation Effects Information Center; Battelle Memorial Institute, Columbus Laboratories, Columbus, Ohio

(3) REIC Report #21 September 1961, "Effect of Nuclear Radiation on Elastomeric and Plastic Components and Materials", Radiation Effects Information Center, Battelle Memorial Institute, Cleveland, Ohio

(4) REIC Report #21 Addendum, August 31, 1964, (see 3 above), Radiation Effects Information Center, Battelle

(5) "Standard Handbook of Lubrication Engineering" by O'Connor and Boyd, McGraw-Hill, 1968

SECTION IV
MOTOR LIFE DATA

A. Induction Motor Failure Analysis

In June of 1966, Dr. J. J. Fleck of the General Electric Research and Development Center issued a report entitled "Analysis of Field Failure Complaints for the Large Generator and Motor Department". This report was commissioned by Mr. R. E. Burris, Jr. then manager of Quality Control for the AC Section of the Large Generator and Motor Department.

Dr. Fleck made an independent analysis of the AC Section's motor failure history to evaluate product quality and report to the department management.

Beginning in 1963, details of motor failures were systematically catalogued and included in a computerized listing. Each failure was coded per the following:

(a) type of motor

(b) year of manufacture

(c) year of failure

(d) failed component

stator

rotor

bearings

end shields

other

(e) failure category

abuse - damage

installation - mis application

true failure

(f) cost

In 1965, Dr. Fleck audited the previous years failure report records and compared them with the coded data stored in the computer. Although some discrepancies in the computer coding were noted, (primarily due to late revisions of the original "failure category"), he concluded that the coding was definately conservative (only one instance of a "true failure" not having been coded was found).

Dr. Fleck also audited the completeness of the data. Some field failures were undoubtedly not reported and therefore not included in the computer listings. At the same time, failures resulting from a design problem (the "sealed random" coils of that period, for example), were included in the computer even though the originating design problem had since been corrected. Dr. Fleck concluded at that time that the extra effort required to correct the data would not significantly affect the result and therefore could not be justified. The report concluded in the presentation of numerous statistical measurements of motor quality based on the failure data stored in the GE computer. Because of the size and nature of this report, it cannot be included on this document, but is available for review in Schenectady upon request.

Dr. Wayne B. Nelson[1], statistician in the Information Sciences Laboratory of the General Electric Company continued the analysis of motor failures and in 1967 issued a report entitled "Estimate of Mean Time to Failure for General Industrial Motors". The computer listing of Dr. Fleck's earlier report was expanded to include 1966 failures and then used by Dr. Nelson to evaluate the MTTF of General Industrial Motors. By definition, General Industrial Motors are motors ranging in horsepower from one hundred to approximately 1500 horsepower.

A total of 15,106 such motors shipped from 1961 thru 1966 were used to evaluate the MTTF. The total motor population studied included:

(a) Motors in almost every type of environment, receiving all degrees of maintenance, but as a whole, less than that provided in a typical electric utility plant.

(b) Motors having insulation rated 440 volt to 6600 volts, ~~Class A, B, F, and H, random and form wound.~~

(c) Motors with sleeve and antifriction bearings.

(d) Open drip-proof, weather protected and totally enclosed motors.

(e) Duty cycles varying from limited to continuous operation.

[1]Dr. Nelson has been active in the field, having published in both the J. Quality Technol. and IEEE Trans. Three of the 16 references listed in IEEE 101, "Guide for the Statistical Analysis of Thermal Life Test Data" are by Dr. Nelson.

Dr. Nelson concluded that the MTTF for this population based on a nominal fit to the data was 174 years. Using the least favorable fit, MTTF was still 33 years. See Fig. 1, the Weibull plot of the data as presented in Dr. Nelson's original report with accompaning MTTF calculation.

These results were based on more or less standard motors shipped during the period of the study. They do not include:

(a) The effects of upgraded quality control inherent in current Class IE safety related motors.

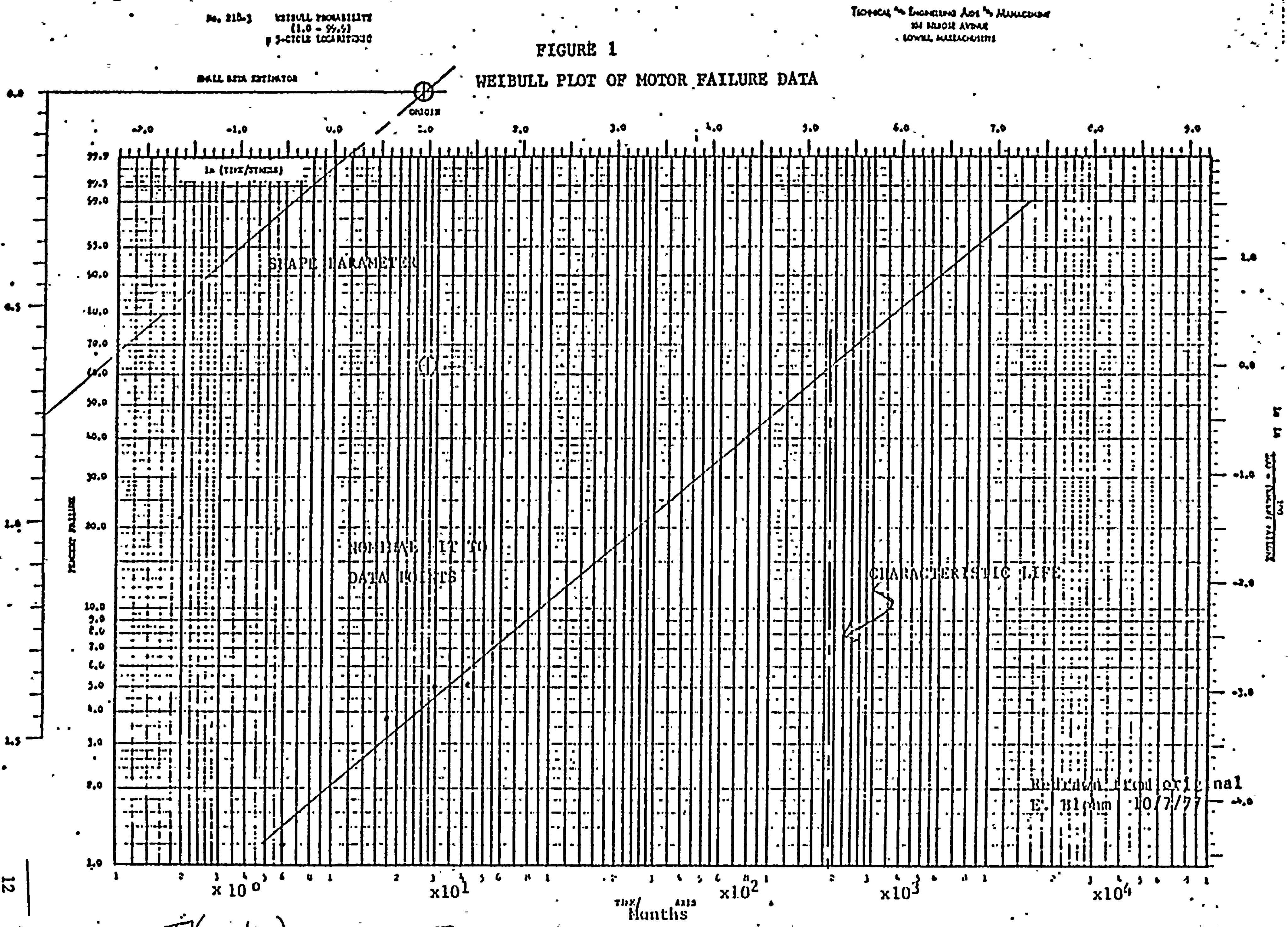
(b) The advantages of redundancy which greatly extends the MTTF for a given function.

(c) The improvements in motor insulations systems since the report was completed - particularly in sealed insulations.

(d) The increase in MTTF afforded by the typical on-going maintenance and test program for the Class IE motor.

FIGURE 1

WEIBULL PLOT OF MOTOR FAILURE DATA



MTTF = $\Gamma\left(1 + \frac{1}{\text{Shape}}\right)$ X Char. Life = Γ (1 + 1.25) X 1840 = 2080 months = 174 years

B. Motor Insulation Life Tests

The statistical Induction Motor Failure Analysis involving some 15,000 medium size motors shipped in the period of 1959 thru 1967 shows that the MTTF of such motors is some 170 years - considerably more than the 40 year life expected for the class 1E motor. ~~The rotors, bearings, end shields and construction of those motors are essentially identical to motors manufactured today, only the insulation systems have changed.~~

Todays motors, and the medium size class IE motors in particular, use ~~a VPI Mica Mat insulation system ("CUSTOM POLYSEAL"*) identical to the VPI Mica Mat system used in the last year or so of the study period.~~ The only change being in the epoxy impregnating resin. As epoxy formulations improved, GE's VPI Mica Mat system was revised to incorporate the best of the available resins. A weight loss comparison of the current epoxy impregnating resin with the epoxy impregnating resin of the statistical study is presented in Table VI of this report.

The Induction Motor Failure Analysis covered a period of time in which rapid changes in insulation technology were reflected in the insulation systems supplied on the motors of the period. When the study began Class A systems were the popular systems. Within the utility industry, Class B compounded mica coils were the forerunners of Class B temperature rises.

Class "B" Mica Mat coils were gradually replacing Class A coils when the industry swing to sealed insulation systems began. Silicone rubber

*Registered Trademark of the General Electric Company

sealed systems briefly introduced were ultimately replaced by epoxy-Mica Mat systems which are the forerunners of our current epoxy VPI Mica Mat sealed system - "CUSTOM POLYSEAL"*. These systems, representing the insulation used on the motors of the Induction Motor Failure Analysis, are briefly described in the following:

* Registered Trademark of the General Electric Company

TABLE IV
INSULATION SYSTEMS USED IN MOTORS OF THE
INDUCTION MOTOR FAILURE ANALYSIS STUDIES

Mylar Class A System	
Turn Insulation	Paper, cotton, and formex resin
Ground Insulation	Mylar tape and wrapper
Varnish	9470 - Asphaltic varnish
Fillers and Separators	Polyester glass laminate
Wedges	Cotton phenolic laminate
Compound Mica Class B System	
Turn Insulation	Alkanex resin or polyglass
Ground Insulation	Glass backed mica tapes
Varnish	9470 - Asphaltic varnish
Fillers and Separators	Melamine glass laminate
Wedges	Melamine glass laminate
Mica Mat Class B System	
Turn Insulation	Alkanex or polyglass
Ground Insulation	Mica Mat tapes and wrappers
Varnish	9470 - Asphaltic varnish
Fillers and Separators	Melamine glass laminate
Wedges	Melamine glass laminate
Sealed Polyex - Silicone Rubber Class B System	
Turn Insulation	Alkanex or polyglass
Ground Insulation	Glass supported silicone rubber tape
Varnish	None
Fillers and Separators	Polyester glass laminate
Wedges	Polyester glass laminate
VPI Mica Mat - Class B Sealed System	
Turn Insulation	Alkanex or polyglass
Ground Insulation	Mica Mat tapes and wrappers
Varnish	Epoxy resin
Fillers and Separators	Polyester glass laminate
Wedges	Polyester glass laminate

Figures #2, #3 and #4 show the results of Thermal Life Tests taken prior to 1971 on our Class A Mylar, VPI Mica Mat, and compound Mica Coil insulating systems respectively.

The tests were conducted in accordance with AIEE #511, (the predecessor of IEEE 275) and the data analyzed and reported in accordance with AIEE #1F (predecessor to IEEE #101). The motorettes were in accord with Figs. #6, #7 and #8 which show the model coil and frame used.

Each of the three figures (#2, #3, & #4) show:

(a) The mean life of the system tested.

(b) The 95% confidence limits on either side of the mean life.

(c) The implied mean life of Class A, Class B, or Class F insulations system (show in broken lines) based on 10 cycles of thermal exposure per Table #1 of IEEE 275.

Comparing the two Class B systems at their maximum rated temperature of 130°C, the average life is:

F VPI Mica Mat System	2.2×10^5 hours.	(Fig 3 - mean life.)
Compound Mica System	1.5×10^4 hours.	(Fig 4 mean life)

At its rated temperature, 105°C, the Class A Polyex System indicates an average life of 1.3×10^5 hours. Fig 2

The superiority of the epoxy VPI Mica Mat system based on IEEE-275 type

evaluations is apparent. It can also be concluded that the epoxy VPI Mica Mat should be considerably better than a similiar Mica Mat system employing multiple dips and bakes in conventional varnishes. IEEE 275 motorette test data supporting this conclusion is not available, but comparative test data on complete motors subjected to conditions similiar to those modeled by IEEE-275 is available. The results are shown on Table V.

Open drip-proof motors rated at 100 horsepower, 1200 RPM and 2300 volts were assembled using (a) the varnished dip & baked Mica Mat insulation and (b) the epoxy VPI Mica Mat insulation system. Both insulation systems used were identical to those used in the period of the Induction Motor Failure Analysis, in fact, the actual tests were taken in 1962 thru 1964.

Each test motor was subjected to the following cycle:

A. Stand in 100% humidity & dew for 168 hours.

B. Test at 3000 Volts AC RMS for 1 minute.

C. Start motor on reversing stand immediately after completing A and B above.

D. Motors (nominally unloaded) operated on the reversing stand (automatically) 24 hours a day for 5 days. Operation consisted of:

   1. Continuous reversals with each reversal consisting of 4.5 seconds of operation in one direction under power followed by 4.5 seconds coasting in that direction.

   2. A thermocouple located on the end turn of the winding at six o'clock controlled the motor temperature.

TABLE V

PERFORMANCE OF 6-POLE - 100 HP TEST MOTORS (FORM COIL) ON REVERSING - HUMIDITY CYCLE

Motor No.	Description	Water Test IR Megs	1st Cycle 100% RH IR Megs	First Cycle 100% RH IR Megs	Number of Complete Cycles	Hours Operated *	Number of Reversals	Reversals Per Hour Operation	Remarks
1962-5	Mica-Mat 9470 varnish old standard	Not made	.91	.38	1	98.4	14,356	146	Failed 3000 volts to ground after 2nd RH cycle. Motor operated for 1.6 hours on 2nd reversing cycle. All cycles 140°C.
1964-1	VPI epoxy Mica-Mat	2.4	4800	0	35	3338.7	396,339	117	Failed 3000 volts to ground after 36th RH cy(Failed to start on 36th reversing cycle Motor operated 20 cycle at 14(12 @ 160°C, 3 @ 180°C

* Actual clock hours by timer include effects of equipment down time etc.

When the desired motor temperature, as seen by the thermocouple was exceeded, the motor was allowed to run for cooling before reversals continued.

3. Twice during the reversals, approximately 1/2 pint of 4% solution of Sodium Nitrate was sprayed into the motors inlet air opening.

4. Insulation resistance was measured after completion of the one week of reversals.

Table V shows that the Mica Mat varnish treated motor failed before completing two of the above cycles at a controlled maximum end turn temperature of 140°C. The epoxy VPI Mica Mat motor failed after 35 cycles and then only after the control temperature on the winding end turns was increased from 140 to 160°C and then to 180°C. The vast superiority of the epoxy VPI insulation system is of course attributed to the strong bias of the test cycle towards moisture sealing features - as does IEEE-275.

No similar insulation life test data is available for comparing the silicone rubber insulation system used in motors of the failure analysis with the VPI Mica Mat of the period. The superiority of the VPI Mica Mat over the silicone rubber insulation is well documented in history by (a) the relatively short period that silicone rubber systems were offered by the industry and (b) by the rapid transition from silicone rubber to epoxy VPI Mica Mat systems for all sealed insulation applications. The fact that a significant percentage of the motors included in the Induction Motor Failure Analysis were silicone rubber insulated is of itself evidence to many that the resulting MTTF is conservative.

The preceding pages have compared the VPI Mica Mat system of the Induction Motor Failure Analysis with the other insulation systems also used in motors of the study and has shown the superiority of the VPI Mica Mat system.

The Class IE motors currently being supplied utilize the same basic insulation system as the VPI Mica Mat system of the study, except that the epoxy impregnating resin has been improved. IEEE 275 life testing of the current VPI Mica Mat system began early in 1975 and was just recently completed. A total of 35 motorette coils per Fig. 7 were installed in 6 motorettes per Fig. 8.

Because the system was felt to have Class F or better capability and in order to keep the test time within reasonable limits, the following aging cycles and temperature from Table #1 IEEE #275 were chosen:

190°C	28 day cycle	12 coils
210°C	7 day cycle	12 coils
230°C	2 day cycle	11 coils

The results of this IEEE 275 test were analyzed in accordance with IEEE 101 and the results are shown on Fig. 15.

The ground insulation (less impregnating resin) is the same as the original VPI Mica Mat system which has performed quite well in the field and demonstrated Class F type performance in past IEEE #275 life testing.

Tests conducted to compare the two resins, such as the Weight Loss test summarized below, definately indicate that the new resin is superior to the old VPI resin.

10 Gram samples of each resin were cured and subjected to the following heat aging in an air circulating oven.

TABLE VI
WEIGHT LOSS OF EPOXY RESINS

Resin Identification	Aging Temp °C	% Weight Loss	Aging Time Hrs
Old Epoxy VPI	160	1.6	2016
Old Epoxy VPI	180	3.9	2016
Current Epoxy VPI	160	0.3	2016
Current Epoxy VPI	180	2.1	2016

The weight loss of the current epoxy VPI resin after 180°C aging compares favorably with the weight loss of the old resin at 160°C, indicating an approximate 20°C thermal advantage for the current VPI resin. Its thermal stability as a Class B or F resin is shown by the insignificant weight loss at 160°C.

The Weight Loss Test above and the recent IEEE 275 Life Test (see Fig. #5) both show the superiority of the new impregnating resin. Thermal capability and life at operating temperature have been increased. The Implied IEEE 275 Life at Class F operating temperatures has been increased approximately 50%.

Summarizing, the tests presented above indicate that the current VPI Mica Mat coil insulation has at least equivalent and very probably greater life and thermal capacity than does the old VPI Mica Mat system, the best of the insulation systems used in the motors of the Failure Analysis Study which demonstrated a 174 year MTTF. It is therefore concluded that the current VPI Mica Mat windings using the improved impregnating resin will have MTTF of 174 years or more.

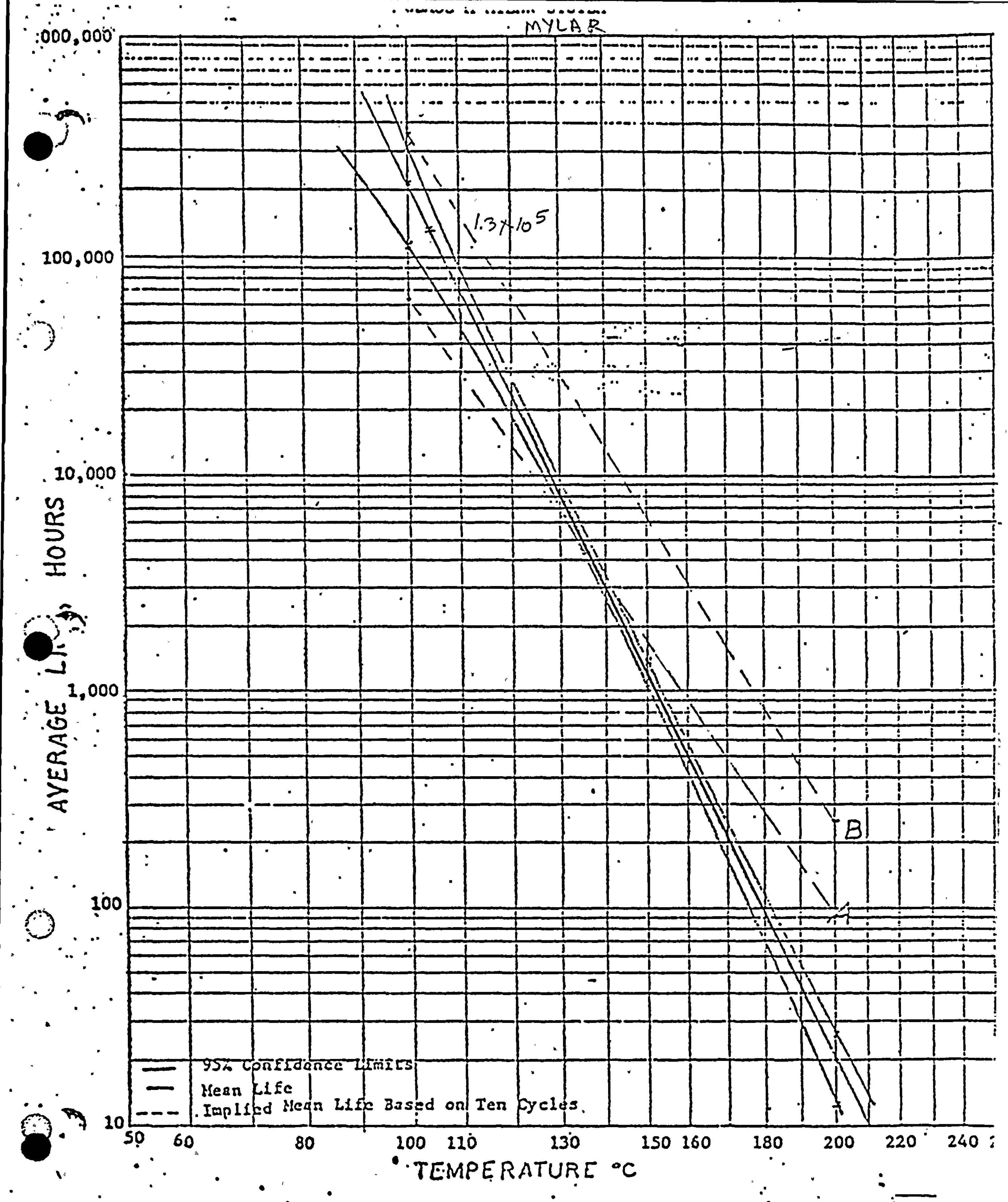
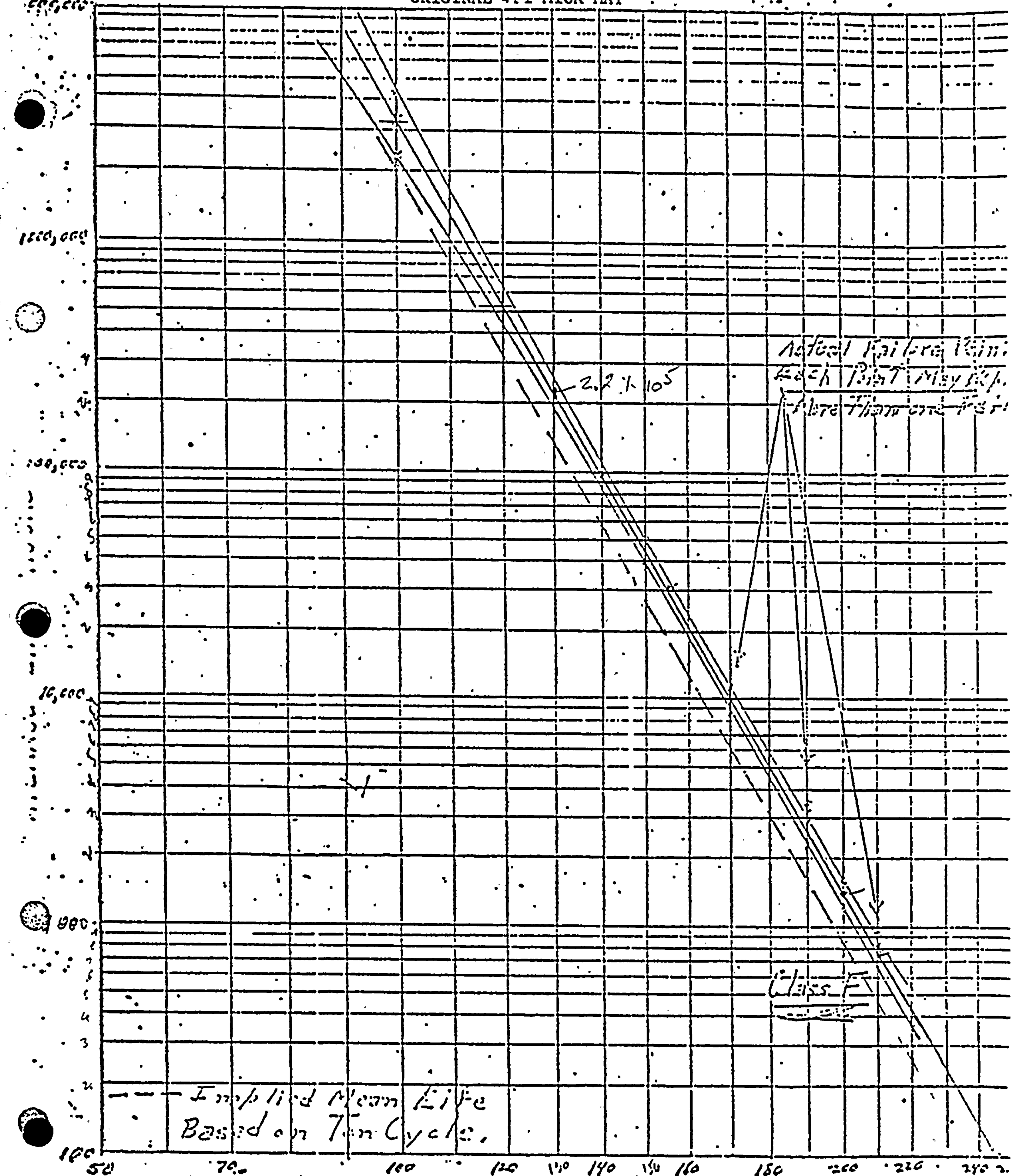

MYLAR
000,000
100,000
10,000
1,000
100
10
AVERAGE LIFE HOURS
1.3×10^5
A
B
95% Confidence Limits
Mean Life
Implied Mean Life Based on Ten Cycles
50
60
80
100
110
130
150
160
180
200
220
240
TEMPERATURE °C

FIG. 2

ORIGINAL VPI MICA MAT



TEMPERATURE °C

FIG. 3

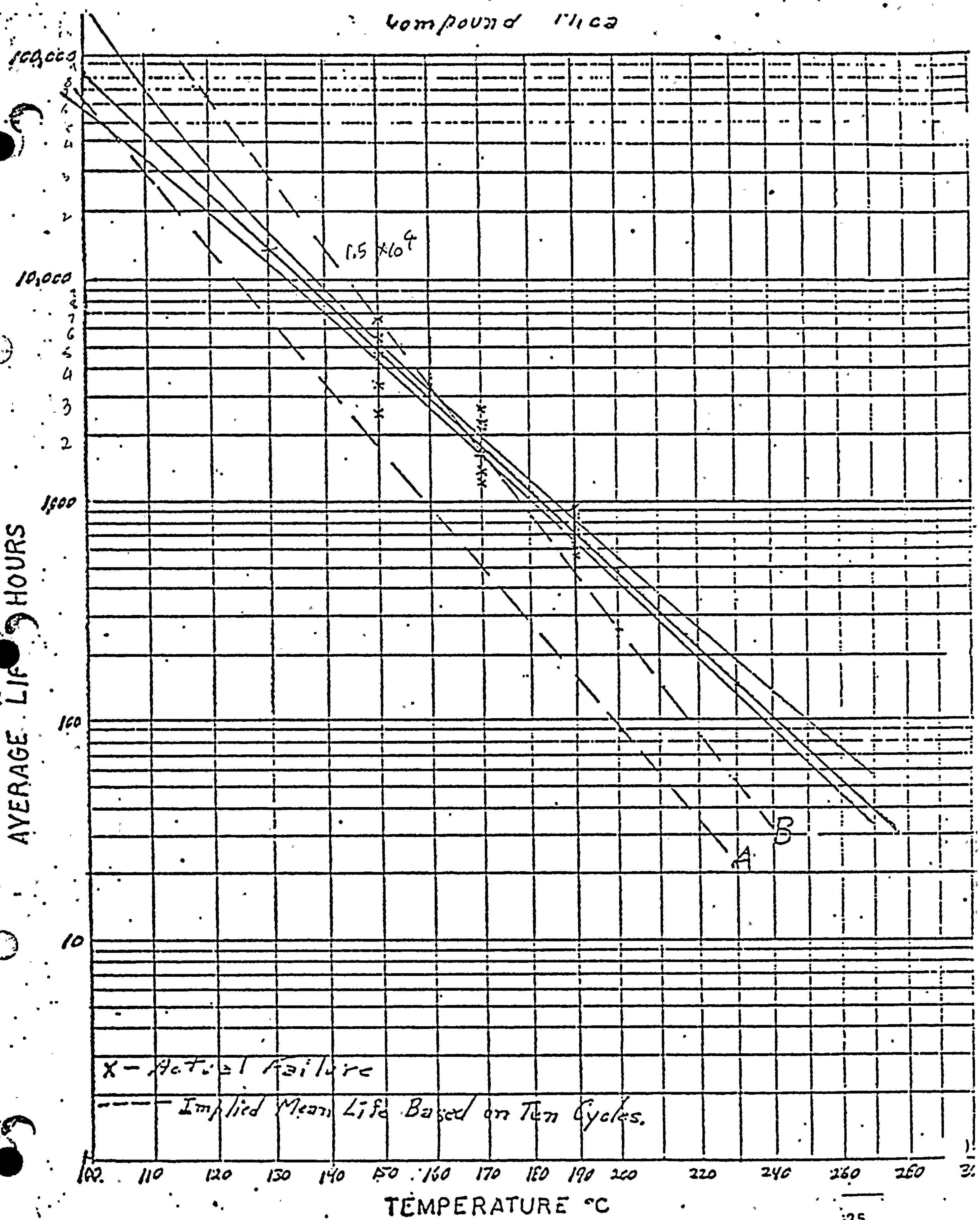
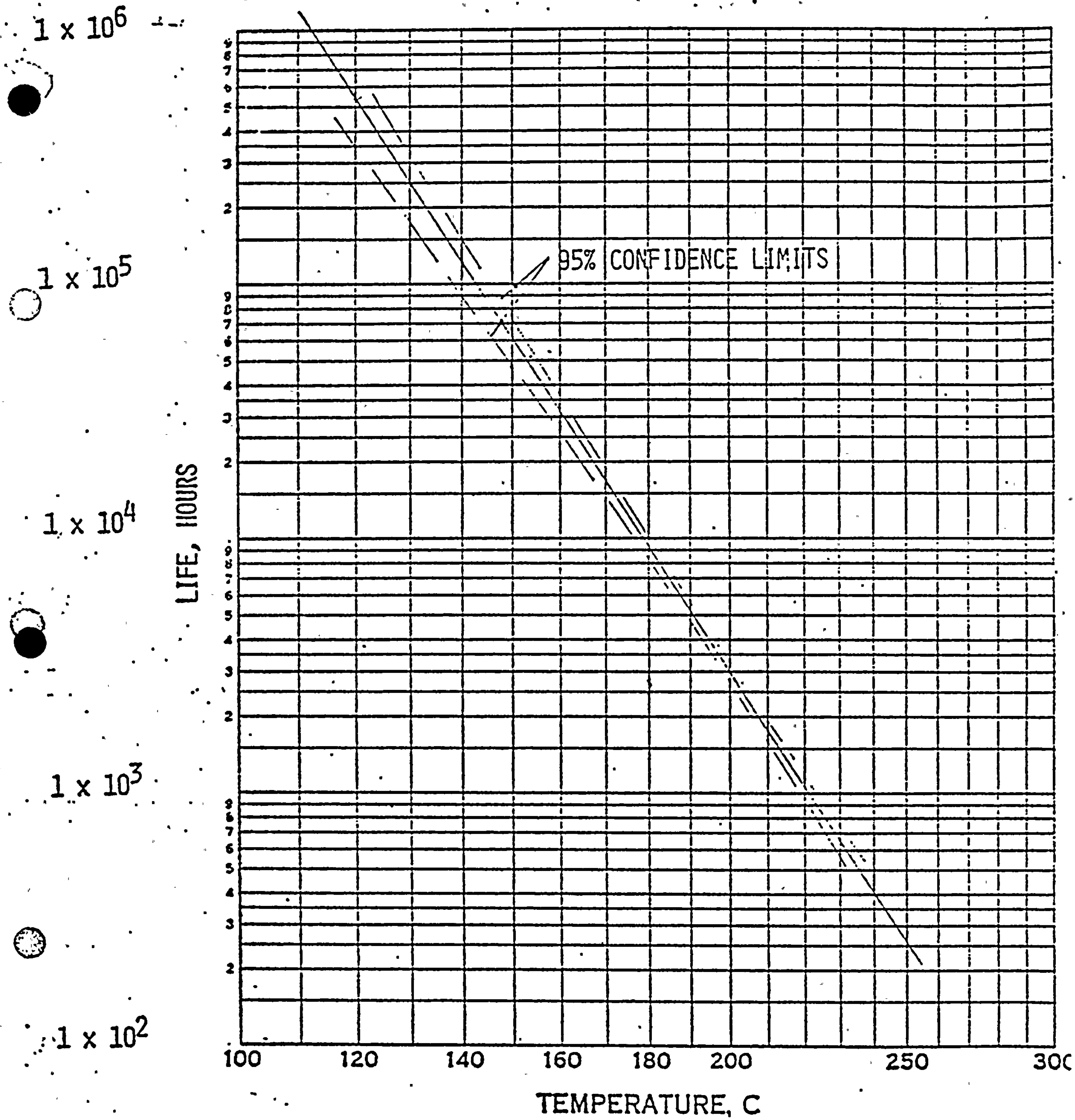


FIG. 4

K.H.C.
11-1-71



IEEE 275 TEST RESULTS

GENERAL ELECTRIC VPI MICA MAT GROUND INSULATION

FIGURE #5

E. G. BLOHM
10/7/77

DWG. 716-7004 SUB. 1 2 3/4 FINISH CHART

ITEM	DESCRIPTION — MATERIAL — REF. DWG. DIMENSIONS IN INCHES		STYLE NO.	PAT. NO.	REQ.	TOOL RECORD SPA
1	SHEET STEEL 8 X 3.81 X .19				6	
2	SHEET STEEL 8X4.50X.19				6	
3	SHEET STEEL 16 X 17.5 X .12				1	
4	SHEET STEEL 20.5X8X.12				1	
5	.38-16X.88 GALV. HEX STL BOLT		8500-1	REF	12	
6	.38-16 GALV HEX STL NUT		8500-7	ONLY	12	
7	SHEET STEEL 8X1.38X.19					

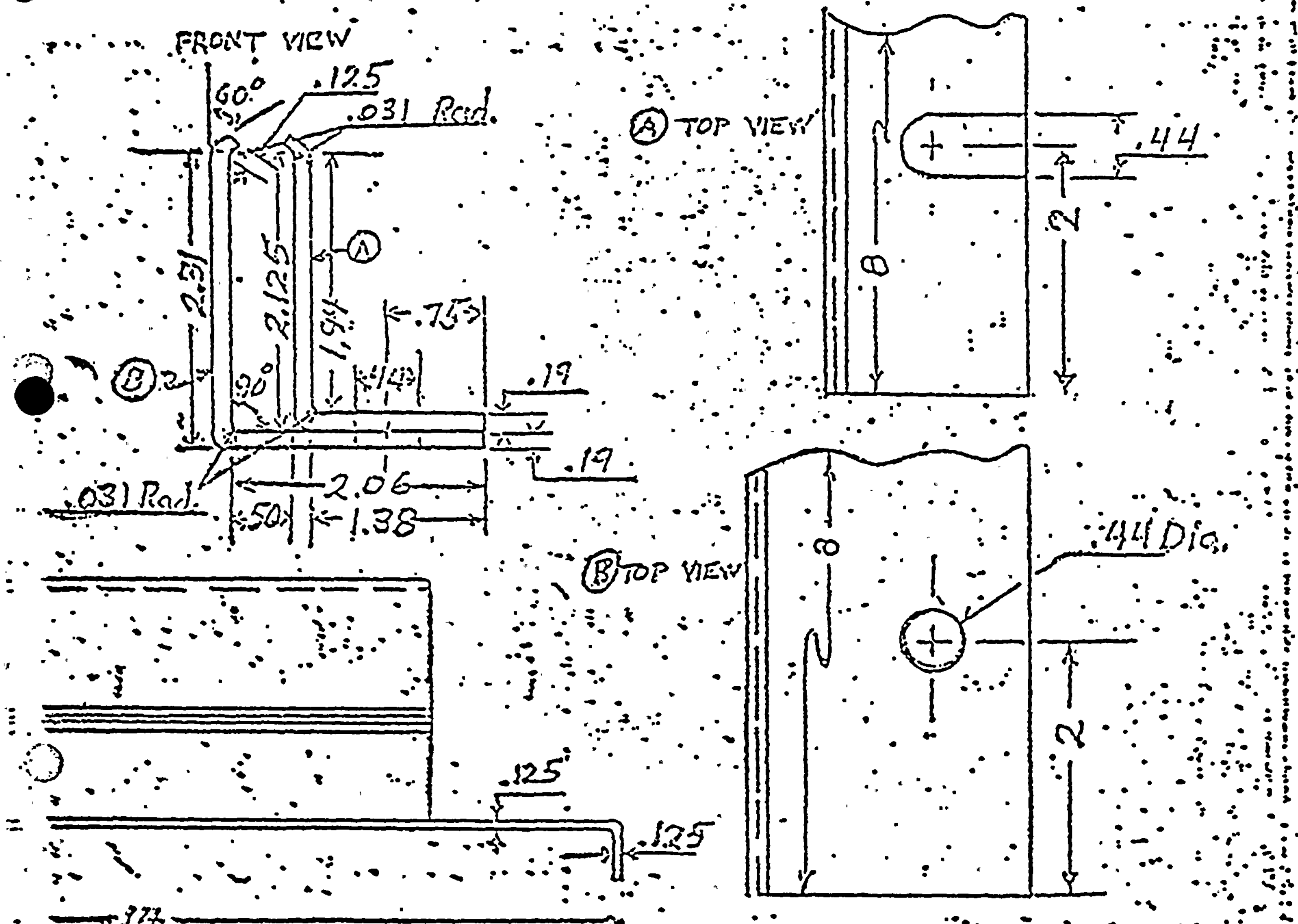
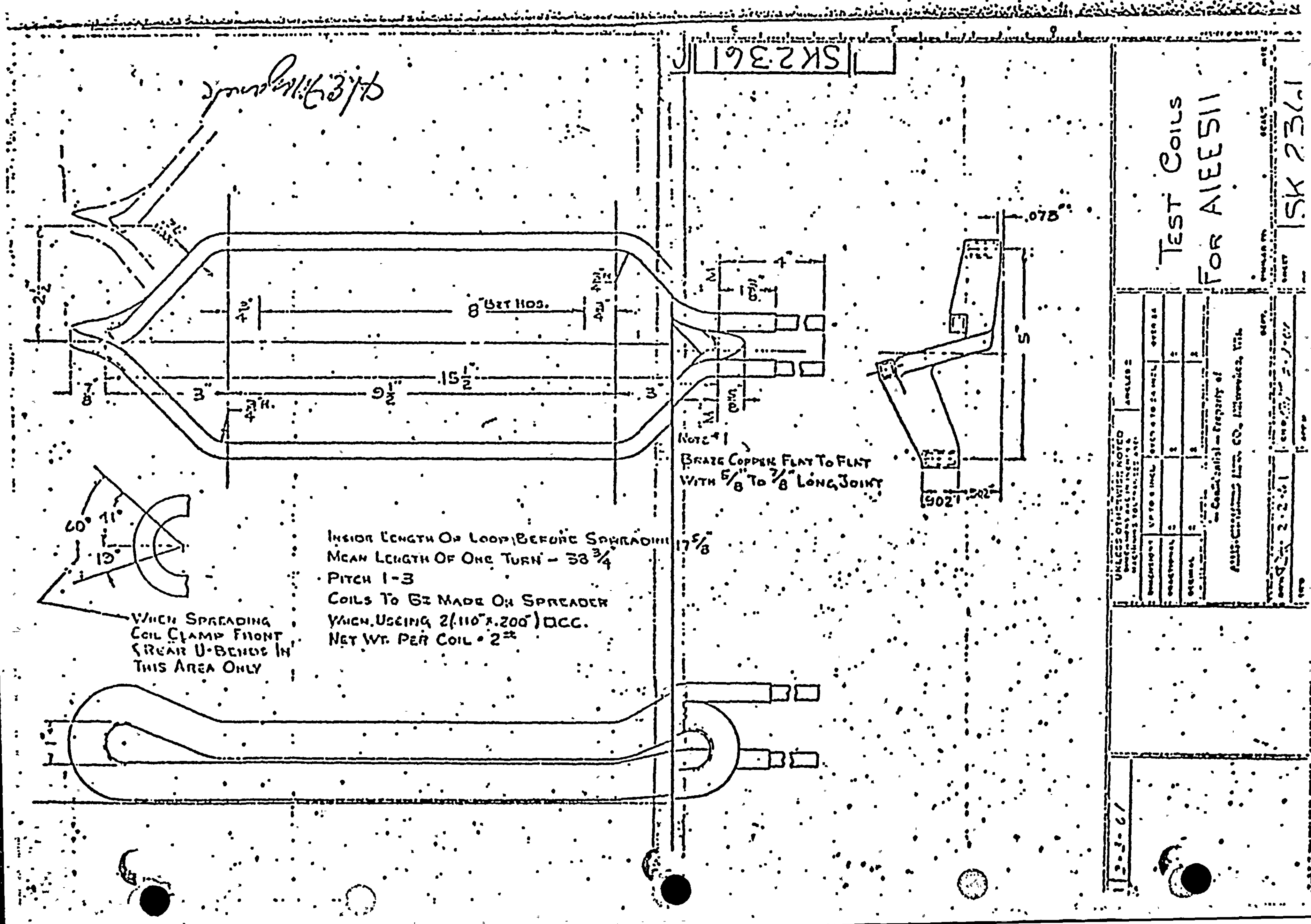


FIG: 6

WESTINGHOUSE ELECTRIC CORPORATION

TITLE MODEL MOTOR FRAME for FORM WOUND COIL
SF 718 451AB

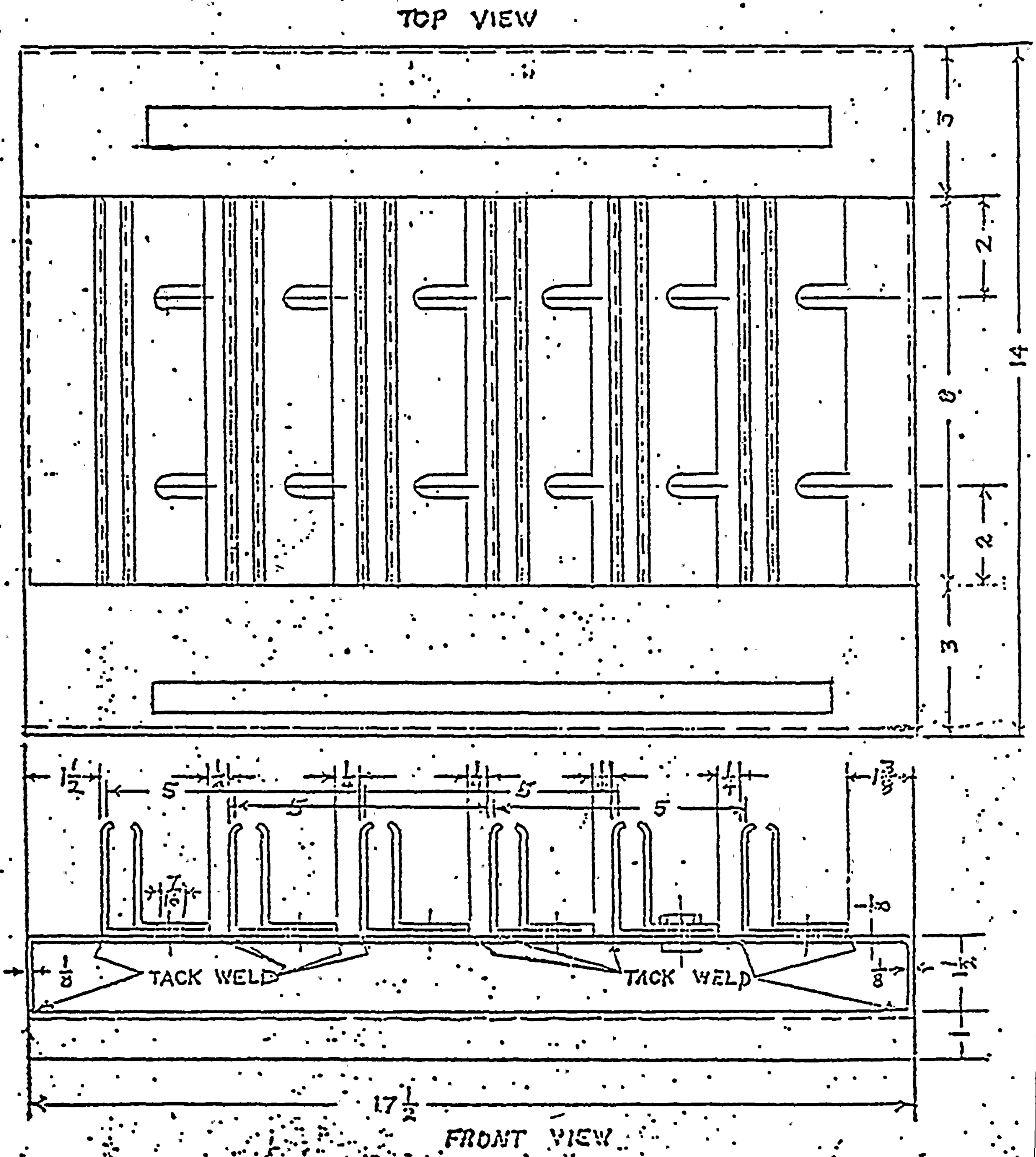
DIMENSIONS IN INCHES—SCALE 1/4 Scale



SK 2361
TEST COILS
FOR AIEE 511
SK 2361
8" BET HOS.
15 1/2"
3"
9 1/2"
3"
2 1/2"
7/8"
4"
5"
.078"
.902"
NOTE #1
BRAZE COPPER FLAT TO FLAT
WITH 5/8" TO 7/8" LONG JOINT
60°
71°
13°
WHEN SPREADING
COIL CLAMP FRONT
& REAR U-BENDS IN
THIS AREA ONLY
INSIDE LENGTH OF LOOP BEFORE SPREADING 17 5/8"
MEAN LENGTH OF ONE TURN - 38 3/4
PITCH 1-3
COILS TO BE MADE ON SPREADER
WHEN USING 2(.110" x .200") DCC.
NET WT. PER COIL - 2#

FIG. 7

CURVE No. 432064



FRAME OF MODEL MOTOR FOR TESTING FORM WOUND COILS

FIG. 8

SECTION V
GENERAL ELECTRIC COMPANY MOTORS IN NUCLEAR APPLICATION'S

Table VII is a listing of some 300 General Electric Class IE Nuclear Safety Related motors now installed in nuclear plants, awaiting installation, or currently being built for nuclear plants. The motors on this list are primarily vertical motors driving containment spray pumps, core spray pumps and residual heat removal pumps. Table VIII shows additional Class I and non-safety related horizontal and vertical motors for a variety of applications in nuclear plants.

These two tables show that the General Electric Company has had substantial experience in building motors for nuclear power plants.

TABLE VII G.E. MOTORS IN NUCLEAR CLASS 1 SAFETY - RELATED APPLICATIONS

(*) - OPERATING NUCLEAR STATIONS

NUCLEAR STATION	POWER CO. OR COUNTRY	# OF MOTORS
OYSTER CREEK*	JERSEY CENTRAL POWER & LIGHT	-
TARAPUR*	INDIA	24
MILLSTONE 1*	NORTHEAST UTILITIES	10
BROWNS FERRY 1*, 2*, & 3*	TVA	18
TSURUGA*	JAPAN ATOMIC POWER CO.	6
PEACHBOTTOM 2*& 3*	PHILA. ELECTRIC CO.	10
MONTCELLO*	NORTHERN STATES POWER	6
QUAD CITIES 1* & 2*	COMMONWEALTH EDISON CO.	8
DRESDEN 1*, 2* & 3*	COMMONWEALTH EDISON CO.	8
BRUNSWICK 2*	CARALINA POWER & LIGHT CO.	12
COOPER*	CONSUMER PUBLIC POWER CO.	2
DUANE ARNOLD*	IOWA ELECTRIC CO.	8
FITZPATRICK*	POWER AUTHORITY OF NEW YORK	6
PILGRIM *	BOSTON EDISON CO.	10
VERMONT YANKEE*	VERMONT YANKEE NUCLEAR POWER CO.	2
ENRICO FERMI #2	DETROIT EDISON CO.	8
HATCH 1*& 2	GEORGIA POWER CO.	12
HOPE CREEK	PUBLIC SERVICE ELECTRIC & GAS OF NEW JERSEY	16
LASALLE 1 & 2	COMMONWEATH EDISON CO.	6
LIMERICK 1 & 2	PHILA. ELECTRIC CO.	24
SHOREHAM	LONG ISLAND LIGHTING CO.	7
ZIMMER	CINCINNATI GAS & ELECTRIC CO.	9
BAILEY	NORTHERN INDIANA PUBLIC SERVICE	5
HANFORD 2	WASHINGTON PUBLIC POWER SUPPLY SYSTEM	5
SUSQUEHANNA 1 & 2	PENN. POWER & LIGHT CO.	16
CHIN-SHAN 1 & 2	TAIWAN POWER CO.	16
SURRY 1* & 2*	VIRGINIA POWER AND LIGHT CO.	5
NORTH ANNA 1 & 2	VIRGINIA POWER & LIGHT CO.	2
BEAVER VALLEY *	DUQUESNE POWER CO.	2
LAGUNA VERDE	MEXICAN NATIONAL UTILITY	10
COFRENTES	SPAIN	5
~~NINE MILE POINT 1* & 2~~	~~NIAGARA MOHAWK POWER CO.~~	5
ALLENS CREEK 1 & 2	HOUSTON POWER & LIGHT	6
CLINTON 1 & 2	ILLINOIS POWER CO.	10
PROJECT 17-22	TVA	30

TABLE VIII
SHEET 1 of 2

G.E. MOTORS IN NUCLEAR APPLICATIONS. - SERVICE WATER AND OTHER APPLICATIONS WHICH MAY OR MAY NOT BE CLASS 1 NUCLEAR

(*) - KNOWN OPERATING NUCLEAR STATIONS

NUCLEAR STATION	POWER CO. OR COUNTRY	APPROX. # OF MOTORS
DUANE ARNOLD *	IOWA ELECTRIC LIGHT & POWER CO.	1
HATCH 1*& 2	GEORGIA POWER CO.	11
MILLSTONE 1*, 2, & 3	NORTHEAST NUCLEAR ENERGY CO.	7
CHIN-SHAN 1 & 2	TAIWAN POWER CO.	10
FARLEY	ALABAMA POWER CO.	12
TROJAN	PORTLAND GE. ELECTRIC CO.	3
DAVIS-BESSE	TOLEDO EDISON CO. & CLEVELAND ELECTRIC CO.	5
NORTH ANNA	VIRGINIA ELECTRIC POWER CO.	2
SALEM	SALEM COUNTY NEW JERSEY	2
ST. LUCIE	FLORIDA POWER & LIGHT CO.	5
BROWNS FERRY 1, 2, & 3	TVA	4
MIDLAND PLANT 1 & 2	CONSUMERS POWER CO.	2
SAN ONOFRE*	SOUTHERN EDISON CO.	8
3 MILE ISLAND	METROPOLITAN EDISON CO.	2
OCONEE	DUKE POWER CO.	2
BEAVER VALLEY*	DUQUESNE POWER CO.	2
HANFORD 2	WASHINGTON PUBLIC POWER CO. SUPPLY SYSTEM	5
QUAD CITIES 1* & 2*	COMMONWEALTH EDISON CO.	1
SEQUOYAH 1 & 2	TVA	10
SUMMER	SOUTH CARALINA ELECTRIC & GAS CO.	1
ZIMMER	FLORIDA POWER & LIGHT CO.	5
LIMERICK 1 & 2	PHILADELPHIA ELECTRIC CO.	3
SUSQUEHANNA 1 & 2	PENN. POWER & LIGHT CO.	8
BRUNSWICK 2*	CAROLINA POWER & LIGHT CO.	4
ARKANSAS 1 & 2	ARKANSAS POWER & LIGHT CO.	3
		119

LM&G DEPARTMENT NUCLEAR JOBS (EXCL APED)

PROJECT	CUSTOMER	# MACHINES
Nine Mile Point #2	Niagara Mohawk	3
Millstone #3	Northeast Utilities	18
St. Lucie #2	Florida Power & Light	12
Hartsville	TVA	18
[illegible]	So. Calif. Edison	4

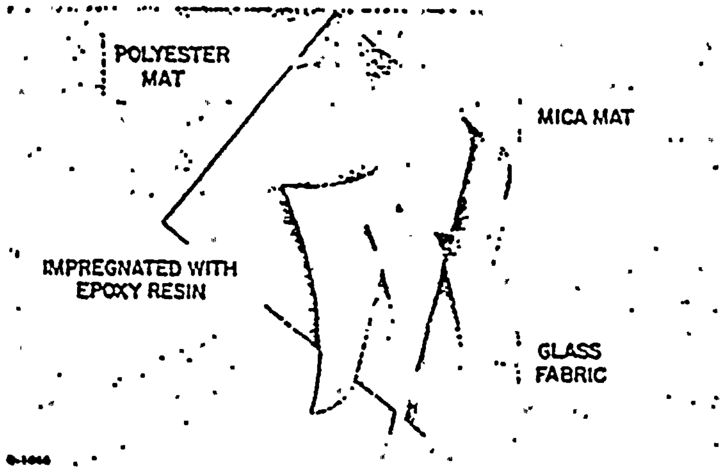
TABLE VIII . SHEET 2 of 2

LM&G DEPARTMENT
NUCLEAR JOBS (EXCL APED)
-Continued-

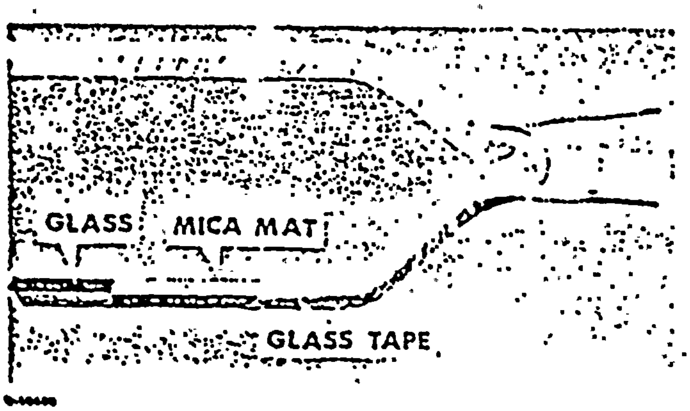
PROJECT	CUSTOMER	# MACHINES
San Onofore	So. Calif. Edison	2
Shearon Harris #1-4	Carolina Power & Light	8
(306-32934)	?	4
Snupps	4 Utility Companies	30
Peachbottom #2, 3	Philadelphia Electric	2
North Anna & Surrey	Virginia Electric Power	31
Boardman #1	Portland GE	4
Three Mice Island	Jersey Central	10
Project 81	Duke Power	18
Summer #1	So. Carol. Elec. & Gas	8
Bellefonte	TVA	8
Marble Hill	Public Service of Indiana	10
Clinton #1, 2	Illinois Power	6
Comanche Peak #1, 2	Texas Util. Gen.	8
Limerick #1, 2	Philadelphia Electric	6
Perry #1, 2	Cleveland Elec. Illum.	4
Waterford #3	Louisiana Power & Light	6
Pilgrim #2	Boston Edison	4
Fuku Shima #III, IV, V, VI, VII	Tokyo Electric	9
Hamoaka #II	Chuba Electric	2
Fermi #2	Detroit Edison	5
Ginna	Rochester Gas & Electric	2
Hutchinson #1	Florida Power & Light	1
Hatch #2	Georgia Power	6
Catawba #1, 2	Duke Power	6
Forked River #1	Jersey Central Power & Light	6
Midland #1, 2	Consumers Power	18
Indian Point	White Ind. Power (ALCO Div.)	2
Onagawa #1	Tohoku Electric Power	2
Vernon #3	?	4
Chin-San	Taiwan Power	24
Nuclear #1	Arkansas Power & Light	4

CLASS B VPI INSULATION (7000 VOLTS AND BELOW)

THIS INSULATION SYSTEM for large motors meets the stringent mechanical and thermal requirements of today's applications, in addition to providing the necessary electrical insulation. Since any one material alone does not have all the properties needed, General Electric uses a vacuum-pressure-impregnation (VPI) process to unite superior insulation materials into a complete insulation system, creating a nearly void-free structure and assuring long life and reliability in large a-c machines.



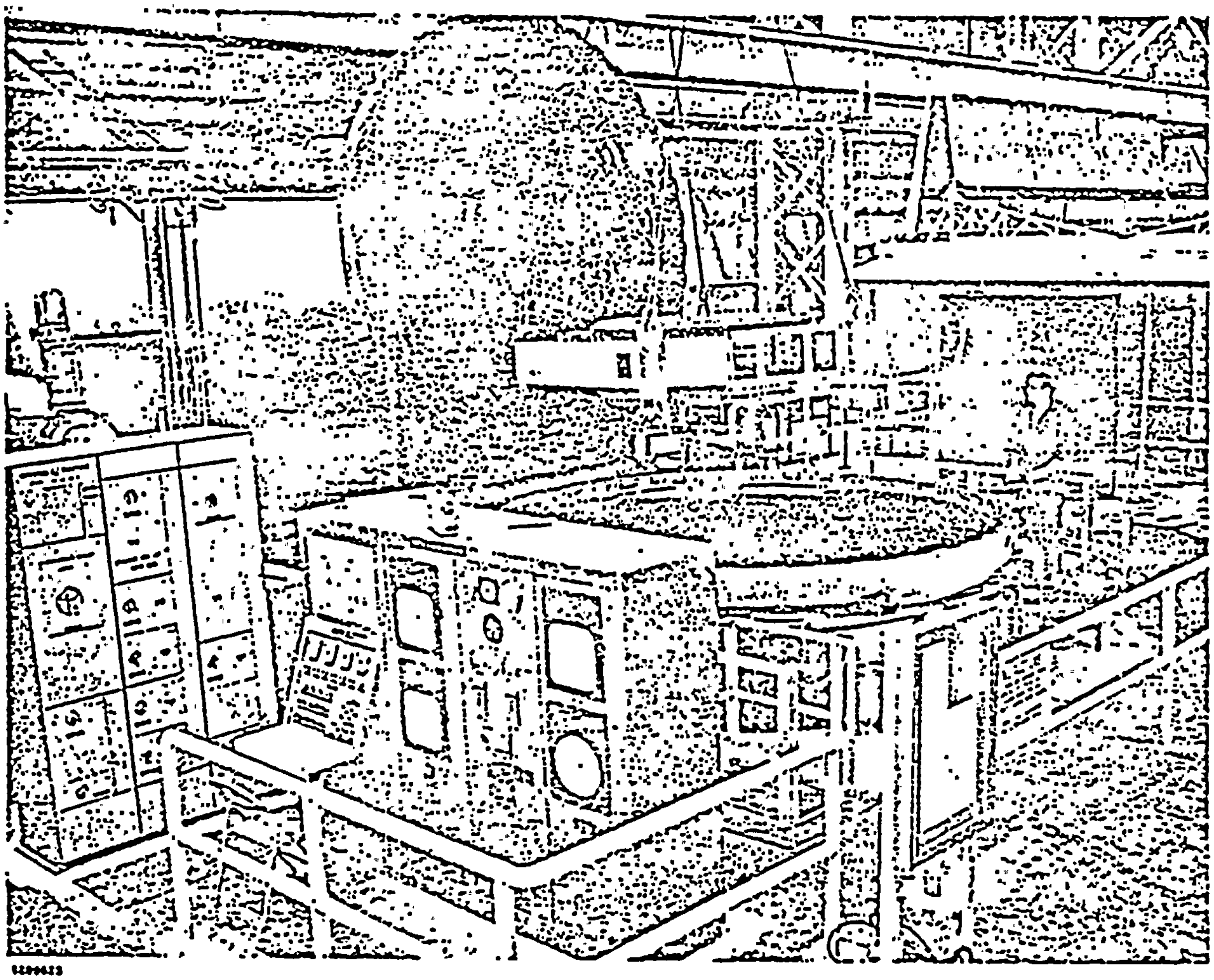
TYPICAL MICA-MAT COMPOSITE



TYPICAL CLASS B SYSTEM

THE INSULATION begins with turn-insulation materials selected for the individual machine design on the basis of expected surge levels, operating temperature and system compatibility. The materials range from Alkanex®, polyester insulation or double polyglass insulation to micaceous tape covering each turn or conductor group. The ground insulation is MICA-MAT insulation in either wrapper or tape form on all stator coils. The backing materials and specific resin impregnant are selected for the voltage level and temperature rating. The homogeneous nature of the mica in the MICA-MAT insulation ensures uniform ground insulation with dielectric strength superior to mica flake tapes and wrappers. The coils receive a protective armor of heavy glass tape for protection against mechanical shock and abrasion. On systems 6000 volts and above, a semi-conducting paint is applied to the slot portion and graded beyond the core to provide corona protection. The epoxy resin binding agent used is selected for chemical compatibility, thermal and dimensional stability and electrical properties.

PRIOR TO APPLICATION of ground insulation, the slot sections of coils are molded under heat and pressure to bond the strands and turns together, thus assuring the dimensional accuracy of the finished coil. After application of the MICA-MAT ground wall insulation, the entire coil is overtaped with heavy glass armor. Special care is taken at the coil lead termination during taping to assure the filling of all voids at this critical point. The coils are inserted into the stator slots and the end connections are brazed and taped. Coil-lock bracing is employed to support the coils and to rigidly consolidate the entire structure. The vacuum-pressure-impreg-



VACUUM-PRESSURE-IMPREGNATION FACILITY CAPABLE OF PROCESSING MACHINES OVER TWELVE FEET IN DIAMETER

nation process completely fills voids in the coils as the resin penetrates the insulation and connection tapes, assuring a solid, homogeneous structure of unequalled ther- r l and mechanical strength.

THE TEMPERATURE AND TIME of impregnation in the VPI tank as well as the subsequent baking of the core assembly to cure the resin are controlled within close tolerances. Many tests are made during the manufacture of the windings to assure that each machine meets the high standards set for quality materials and workmanship. High-potential tests are conducted at various stages. Prior to insertion of the coils, each coil is subjected to an impulse test of the turn insulation. Extra coils are made so that a destructive ground insulation breakdown voltage test can be conducted as a further precaution. Finally, prior to shipment, the standard IEEE high-potential test of twice rated voltage plus 1000 volts is applied to the completed stator.

cess, an asbestos-filled winding compound is applied to bond the copper together. A final varnish treatment completes the system.

C. SEALED ROTOR

When a sealed machine is required, an epoxy sealant is applied to the wound pole. Sealed machines are not available with strip-wound fields.

5.04.04 Special Motor Treatments

For unusual environmental conditions (such as those listed in the following paragraphs) special treatments are available.

A. ABRASION

In atmospheres where abrasive dusts (such as fly ash) are present, a polyurethane over-coating is applied to the insulation system. The toughness and resilience of the coating makes it highly resistant to all forms of abrasion.

B. FUNGUS

In highly humid atmospheres (such as are encountered in the tropics or the Canal Zone), a fungus-resistant treatment of the winding will inhibit the growth of fungus. Essentially, the varnish is primarily effective for storage purpose only because it rapidly deteriorates with operation at normal winding temperatures.

5.05 SPECIAL OR EXTREME CONDITIONS

See Part 4.02, Tables 4-1 through 4-4.

5.06 EFFECTS OF RADIATION

Radiation can cause insulation degradation if it is present in sufficient amounts. Where motors are exposed to the more common types of atomic radiation, nearly all standard insulations may be used if the radiation is below the following values:

Class A - 10^6 Roentgens

Class B - 10^7 Roentgens

Class H - 10^7 Roentgens

Where radiation exceeds these values, specific information should be included in the requisition, proposition, or specifications.

5.07 GLOSSARY OF STATOR WINDING AND INSULATION TERMS

Voltage Endurance is a measure of the life of an insulation system as a function of applied voltage. Basically, it is the system's ability to maintain its dielectric strength over a period of time with voltage applied. It is an integration of dielectric strength, dielectric constant, insulation resistance, and insulation power factor.

Thermal Endurance is the ability of an insulation system to retain its mechanical and electrical properties over long periods of time at the temperatures which will be encountered during motor operation.

Mechanical Endurance is a measure of the ability of an insulation system to withstand the mechanical stresses encountered during motor starting, reversals, and normal running operation. Mechanical strength and endurance are measured in the laboratory by resistance to cut-through, tensile strength, elongation tests, etc.

Environment Endurance is a measure of the ability of an insulation system to withstand operation in various ambients or atmospheres. For example, stator windings subjected to large amounts of moisture must be of the sealed type to be reliable. Motors are sometimes run in controlled moist atmospheres to test the environment endurance of the stator insulations. Likewise, motor windings exposed to carbon black in a rubber mill, abrasives in a cement mill, or chemical fumes in process plants must have a good environment endurance if the motor is to give reliable service.

Of course, windings can be protected from moisture, chemicals, and abrasives by special motor enclosures if the insulation cannot withstand the ambient.

Insulation Dielectric Strength is a measure of the amount of voltage stress an insulating material will stand before electrical breakdown. It may be expressed in volts per mil of material thickness or as the total voltage that a system will withstand.

Insulation Dielectric Constant is a measure of the capacitance of an insulation wall, related to the capacitance of an equivalent wall thickness of air.

Insulation Resistance is the d-c resistance of an insulation system measured in ohms or megohms.

Insulation Power Factor is a measure of the energy dissipated as losses in the insulation system

NON-METALLIC MATERIALS

MODEL 5K818841C65

Insulation System
- Polyester Film (wire enamel)
- Micamat
- Glass
- Dacron Felt
- Epoxy Varnish
- Melamine Glass
- Polyester Glass
- RTV Rubber
- Silicone Rubber
- Ethylene Propalene Rubber-Cables

Space Heater Kit
- Rubber - Gaskets
- Silicone Rubber - Cables
- Rubber Bushings
- Mox Tape

Gits Sight Gauge
- Glass

--

MODEL 5K818842A103

Insulation System
- Polyester Film (wire enamel)
- Nomex
- Epoxy Varnish
- Melamine Glass
- Glass Cloth
- Permafil Glass Rope
- Acrylic Glass
- Silicone Rubber Cables

Space Heater Kit
- Rubber Gaskets
- Silicone Rubber Cables
- Rubber Bushings
- Mox Tape
- Cotton Cloth-Phenolic (term board strip)

Gits Sight Gauge
- Glass

Bearing Gasket
- Nitrile Rubber

Screens
- PVC (edging)

MODEL 5K828848C7

Insulation System
- Polyester Film (wire enamel)
- Micamat
- Glass
- Dacron Felt
- Epoxy Varnish
- Melamine Glass
- Polyester Glass
- RTV Rubber
- Silicone Rubber
- Permafil Glass
- Ethylene Propalene Rubber-Cables

Space Heater Kit
- Rubber Gaskets
- Silicone Rubber - Cables
- Rubber Bushings
- Mox Tape

Gits Sight Gauge
- Glass

Bearing Insulation
- Phenolic ASTM D709
- Fiber Sheet ASTM D710
- Epoxy Resin
- Glass Filaments

529-ER151X
DMS 10/10/80

NUS CORPORATION
CONSULTING DIVISION

RECORD OF SYSTEM/COMPONENT ANALYSES

FILE NO.:	NO. OF PAGES:	NUMBER OF VOLUMES OF COMPUTER OUTPUT:
1961-R369-002-R1	29	N/A

CLIENT:	PROJECT NO.:
Niagara Mohawk Power Corporation	1961

ANALYSIS TITLE: Environmental Qualification of Rosemount 1151 DP Transmitters

AUTHOR: M. A. Ippolito

PURPOSE OF ANALYSIS: To determine if the design of the Rosemount 1151 DP Transmitter is adequate to assure that they will operate on demand to meet system performance requirements during normal and harsh environment conditions

SUMMARY OF ANALYSIS PROCEDURE AND RESULTS:

An analysis was conducted based on information obtained from Rosemount Test Reports. It was learned that the subject equipment contains type 741 operational amplifiers (I/C's) which are not radiation hardened. They also contain teflon tape, teflon insulation, and Buna N O-rings. Qualification of the subject equipment to the conditions specified could not be demonstrated based on information available at this time. Further assessment is recommended.

DATE COMPLETED:	VERIFICATION REQUIRED:
2/25/82	☒ YES ☐ NO

ANALYSIS REVIEWED AND ACCEPTED: (DISCIPLINE MANAGER)	DATE:
[signature]	2-25-82

ANALYSIS:	BY: (FILE NO.)	DISCIPLINE MANAGER:	DATE:
☐ SUPERSEDED ☐ SUPPLEMENTED			

NUS 202 10 REVISED 0181
(Formerly CD-28, 12/77)

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

FILE NO.: 1961-R369-002-R1	PAGE 1 OF 2

ANALYSIS TITLE: Environmental Qualification of Rosemount 1151 DP Transmitters

AUTHOR:	NO. OF PAGES:	NO. OF VOLUMES OF COMPUTER OUTPUT:
M. A. Ippolito	29	N/A

VERIFICATION SCOPE (CHECK AS APPLICABLE):

- [x] METHOD OF ANALYSIS
- [x] ASSUMPTIONS
- [x] INPUT INFORMATION
- [ ] COMPUTER CODE APPLICATION
- [ ] CHECK OF SAMPLE CALCULATION
- [x] SPOT CHECK OF MATHEMATICS
- [x] REASONABLENESS OF RESULTS
- [ ] COMPLETE CHECK OF MATHEMATICS
- [ ] PARTIAL INDEPENDENT ANALYSIS

BUDGET: (APPROXIMATE) 1/4 MANDAYS	DESIRED COMPLETION DATE: ASAP

DESCRIPTION OF VERIFICATION—ACTIVITIES, FINDINGS AND RESOLUTION:

None

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

VERIFIER'S SIGNATURE: [signature]

DATE: 2/25/82

ACCEPTANCE BY: (DISCIPLINE MANAGER) [signature]

DATE: 2-25-82

NUS CORPORATION
CONSULTING DIVISION

ANALYSIS VERIFICATION CHECKLIST

ANALYSIS TITLE: Environmental Qualification of Rosemount 1151DP Transmitters

ANALYSIS FILE NUMBER: I9LI-R369-002-R1

INDICATE "YES, NO, OR N/A (NOT APPLICABLE)" FOR EACH ITEM AND INCLUDE IN ANALYSIS PACKAGE WITH RECORD OF ANALYSIS VERIFICATION	YES	NO	N/A
METHOD OF ANALYSIS			
IS THE METHOD USED APPROPRIATE CONSIDERING THE PURPOSE AND TYPE OF ANALYSIS AND THE USE AND ACCEPTABILITY OF THE RESULTS (i.e., MARGIN TO LIMITS)?	☒	☐	☐
IS THE METHOD IN ACCORDANCE WITH CODES, STANDARDS, AND REGULATORY REQUIREMENTS?	☒	☐	☐
HAS THE METHOD BEEN EMPLOYED ELSEWHERE IN INDUSTRY OR IN LICENSE APPLICATIONS?	☒	☐	☐
ASSUMPTIONS			
ARE ASSUMPTIONS NECESSARY TO PERFORM THE ANALYSIS ADEQUATELY DESCRIBED AND REASONABLE?	☒	☐	☐
WHERE NECESSARY, ARE THE ASSUMPTIONS IDENTIFIED FOR SUBSEQUENT RE-VERIFICATIONS WHEN THE DETAILED DESIGN ACTIVITIES ARE COMPLETED?	☒	☐	☐
INPUT INFORMATION			
ARE THE INPUTS INTO THE ANALYSIS STATED AND THEIR SOURCE IDENTIFIED?	☒	☐	☐
IS THE INPUT INFORMATION FROM THE LATEST AVAILABLE REVISION TO THE DOCUMENT?	☒	☐	☐
IS THE STATUS (PRELIMINARY, CONCEPTUAL, ETC.) OF THE INPUT SOURCE IDENTIFIED FOR LATER CONFIRMATION OF THE VALIDITY OF THE INPUT?	☒	☐	☐
ARE THE INPUTS SUFFICIENT CONSIDERING THE PURPOSE OF THE ANALYSIS?	☒	☐	☐
COMPUTER CODE APPLICATION			
ARE ALL CODES USED IDENTIFIED ALONG WITH SOURCE, COMPUTER TYPE, INPUTS, AND OUTPUTS?	☐	☐	☒
HAS THE CODE BEING USED BEEN ADEQUATELY VERIFIED?	☐	☐	☒
IS THE CODE SUITABLE FOR THE PRESENT ANALYSIS?	☐	☐	☒
DOES THE COMPUTER MODEL (NODING, TIME STEPS, ETC.) ADEQUATELY REPRESENT THE PHYSICAL SYSTEMS?	☐	☐	☒
REASONABLENESS OF RESULTS			
IS THE MAGNITUDE OF THE RESULT REASONABLE?	☒	☐	☐
ARE THE DIRECTION OF TRENDS REASONABLE?	☒	☐	☐

PREPARED BY: [signature]

DATE: 2/25/82

NUS 204 10 REVISED 0181
(Formerly CD-30 Rev. 1)

FINAL ANALYSIS REVIEW CHECKLIST

Project #/Project Title Client

Date: 2/25/82

Analysis File Title: Environmental Qualification of Rosemount 1151DP Transmitters

Analysis File Number: 1961-R369-002-R1

Checklist Item	Yes	N/A
1. Unique Analysis File Number assigned to the file.	X	
2. Analysis recorded on CD-60	X	
a. pages numbered	X	
b. total pages specified	X	
c. all pages dated	X	
d. client identified on each page	X	
e. correct file number on each page	X	
f. author(s) specified on each page	X	
g. subject specified on each page	X	
h. verifier initials on each page	X	
3. Analysis File includes:		
a. client identification	X	
b. analysis file number	X	
c. analysis title	X	
d. author(s) identification	X	
e. description of the purpose of the analysis	X	
f. discussion of the general method of analysis	X	
g. identification of input information source	X	
h. identification of input information status	X	
i. major assumptions used in performing the analysis	X	

Date: *2/25/82*

3.	(Continued)		
	j. important references, including material properties	X	
	k. identification of specific versions of codes used	X	
	l. detailed calculation	X	
	m. listing of computer input		X
	n. microfiche of computer output		X
	o. summary of results	X	
4.	Record of analysis provided onn CD-28	X	
5.	All applicable entries on CD-28 correct.	X	
6.	All referenced NUS internal memos included in analysis file.		X
7.	All referenced telecons included in analysis file.		X
8.	Separate computer output labeled with analysis file number.		X
9.	Record of analysis file verification on CD-29.	X	
10.	All entries on CD-29 completed and correct.	X	
11.	Item (7) of CD-29 completed and comments numbered	X	
12.	Verification checklist CD-30 included.	X	
13.	Computer code used verified per QAI 3.5.		X
14.	Corrected items crossed out clearly enough to show on Xerox copies.		X
15.	List of input information and major assumptions checked for commpleteness.	X	
16.	Documents Complete (Page Count)	X	
17.	Documents Legible and Reproducible	X	
18.	All Documents Identified on Index Received	X	
19.	Documents Properly Paginated	X	
20.	Documents Identified to Project/Item	X	
21.	All Unsatisfactory Conditions Resolved (List)	X	

Date 2/25/82

22. Remarks: None

Reviewed by: [signature] 2/25/82
Date

NUS CORPORATION

Page N/A of N/A

DATE 2/25/83

CLIENT NMPC FILE NO. 1961-R369-002-R2 BY M. A. Esposito

SUBJECT Analysis of Rosemount 1151 DP Transmitters Checked By [signature]

Environmental Qualification of

Rosemount 1151DP Transmitters

CLIENT NMPC FILE NO. 1961-R369-002-R1 BY M.A. Spoelstra

SUBJECT Analysis of Rosemount 1152DP Transmitters Checked By [initials]

Table of Contents

NUS CORPORATION

DATE 2/25/82

CLIENT NMPC. FILE NO. 1961-R369-002-R1 BY M.A. Spagnolo

SUBJECT Analysis of Rosemount 1151DP Transmitter Checked By [illegible]

Table of Contents (Cont'd)

CLIENT NMPC FILE NO. 1961-R369-002-R1 BY M. A. Esposito
SUBJECT Analysis of Rosemount 1151DP Transmitter Checked By. [signature]

Table of Contents (Cont'd)

List of Tables

List of Figures

CLIENT NMPC FILE NO. 1961-R369-002-R1 BY M. A. Ippolito

SUBJECT Analysis Rosemount 1151 DP Transmitter Checked By [signature]

1.0 Client Identification

Niagara Mohawk Power Corporation

2.0 Analysis File Number

NUS-1961-R369-002-R1

3.0 Analysis Title

Environmental Qualification of Rosemount 1151 DP Transmitters

4.0 Author Identification

M. A. Ippolito

5.0 Purpose of Analysis

The purpose of this Analysis is to determine if the design of the Rosemount 1151DP Transmitter is adequate to assure that they will operate on demand to meet the system performance requirements under normal and harsh environmental conditions at NMP-1.

CLIENT NMPC FILE NO. 1961-R369-0047-R1 BY M. A. Ippolito

SUBJECT Analysis of Rosemount 1151 DP Transmitters Checked By RJS

6.0 Support Information

6.1 Equipment Identification

The equipment to be considered in this analysis are Rosemount 1151 DP Transmitters used at NMP1 in the following systems. (Ref. 13.12)

System	I.D. NO	Type
AOS	ID-33A	1151DP-6B22LMMB-5659
AOS	ID-33B	1151 DP-6B22LMMB-11025
CS	58-05, 06	1151DP-4B22RLMME
CS	RY-26A	1151DP-5B22MBBE-1
RVI	36-03(A-D)	1151DP-4E22T0003PB
RVI	36-04(A-D)	1151DP-4E22T0003PB
AI	01-26(A-H)	1151DP-7E22T0003PB
EC	36-06(A-D)	1151DP-7E22T0003PB
COS	201.2-47(A-D)	1151DP-4E22T0003PB
RVI	36-05(A-D)	1151DP-5E22T0003PB
RVI	36-07(A-D)	1151DP-9E22T0003PB
RVI	36-08(A-D)	1151DP-9E22T0003PB

6.2 Materials

The Rosemount type 1151 Transmitters is not class 1E equipment and as such there is no formal material traceability. However, the Rosemount type 1152 Transmitter does have material traceability and it was learned that the 1151 and 1152 transmitters are mechanically identical except for the following differences (Ref. 13.2)

A. The wire in the 1152 is insulated with Kapton rather than teflon.

CLIENT NMPC FILE NO. 1961-R369-002-R1 BY M. A. Esposito
SUBJECT Analysis of Rosemount 1151 DP Transmitters Checked By [illegible]

B. The drain plug pipe seal in the 1152 is made with a sealant (Leak-Lok) rather than teflon tape.

C. The O-ring material in the 1152 is ethylene propylene rather than Buna-N.

It was further learned that the 1151DP Transmitters used at NMP-1 were made special for General Electric and contain "E" electronics (Ref 13.1). It was learned further that these transmitters contain type 741 Operational Amplifiers. See Table 1 for a partial list of materials.

6.3 Safety Related Function

Table 2 is a list of the safety related function for the subject equipment.

6.4 Service Conditions

Table 3 is a list of the normal and harsh environment conditions for the subject equipment.

Table 1

Material List* and Qualification Data for 1151 DP Transmitters.

Component Material	Manufacture Rating	Radiation Threshold: Material Analyzed	Radiation Threshold: Radiation Threshold (Rads)	Radiation Threshold: Ref. No.	Aging Data: Material Analyzed	Aging Data: Activation Energy (eV)	Aging Data: Intercept	Aging Data: Ref. No.
1.0 O-rings								
BUNA-N	Unknown	Buna-N	1.75×10^6	13.8	Buna-N	0.7506	-16.2810	13.8
2.0 Wire Insulation and Tape								
Teflon	Unknown	TFE Teflon	3.4×10^4	13.9	TFE Teflon	1.72	-27.9	13.9
3.0 Amplifier (IC Boards) Type 741	Unknown	(Not radiation hardened.)		13.15	Type 741	0.9	—	13.7 13.15

* This table does not contain all of the materials in the 1151 DP Transmitter. It contains only those which were determined from an evaluation of the reference reports.

NUS CORPORATION

DATE 2/25/82

CLIENT NMPC FILE NO. 1961-R369-002-R1 BY M. A. Ippolito

SUBJECT Analysis of Rosemount 1151 DP Transmitters Checked By [illegible]

Table 2 (Ref. 13.14)

Safety-Related Functions For Rosemount 1151 DP Transmitters Used At NMP-1

System	I.D. No.	Safety Function
ADS	ID-33A ID-3B	Main Steam Input to Feedwater Control System. (C-18002-C)
CS	58-05, 58-06	Monitors Torus Water Level (C-18007-C)
CS	RV-26A	Monitors Flow For Core Spray Pumps
RVI	36-03(A-D)	Initiates RPS, Scram Reactor/Trip Turbine Stop Valve on Reactor High or Low Level. (C-18015-C)
RVI	36-04(A-D)	Initiates RPS, Closes Main Steam Isolation Valve on Reactor Low Level. (C-18015-C)
RVI	36-05(A-D)	Initiates RPS, Auto Depressurizes High Drywell Pressure on Reactor Low-Low Level. (C-18015-C)
RVI	36-07(A-D)	Initiates RPS, Scram Reactor/Trip Turbine Stop Valve On Reactor Low-Low Level. (C-18015-C)
RVI	36-08(A-D)	Initiates RPS, Actuates Emergency Cooling on Reactor High Pressure (C-18015-C)
AI	01-26(A-H)	Main Steam Line High Flow Detection. Signal to RPS To Isolate Main Steam Line On A MSLB. (C-18002-C)

CLIENT NMPC FILE NO. 1961-R369-002-R1 BY M. A. Ippolito
SUBJECT Analysis of Rosemount 1151DP Transmitter Checked By RJB

Table 1 (Cont'd)

System	I.D. No.	Safety Related Function
EC	36-06(A-D)	Initiates RPS, Closes Emergency Condenser Isolation Valves OF High Flow Line Break. (C-18015-C)
CoS	201.2-476 (A-D)	Monitors High Drywell Pressure. Initiates RPS TO Actuate Containment Spray, Core Spray, Drywell Isolation, ADS. (C-18012-C, 2)

Table 3
Service Condition For Rosemount 1151DP Transmitters

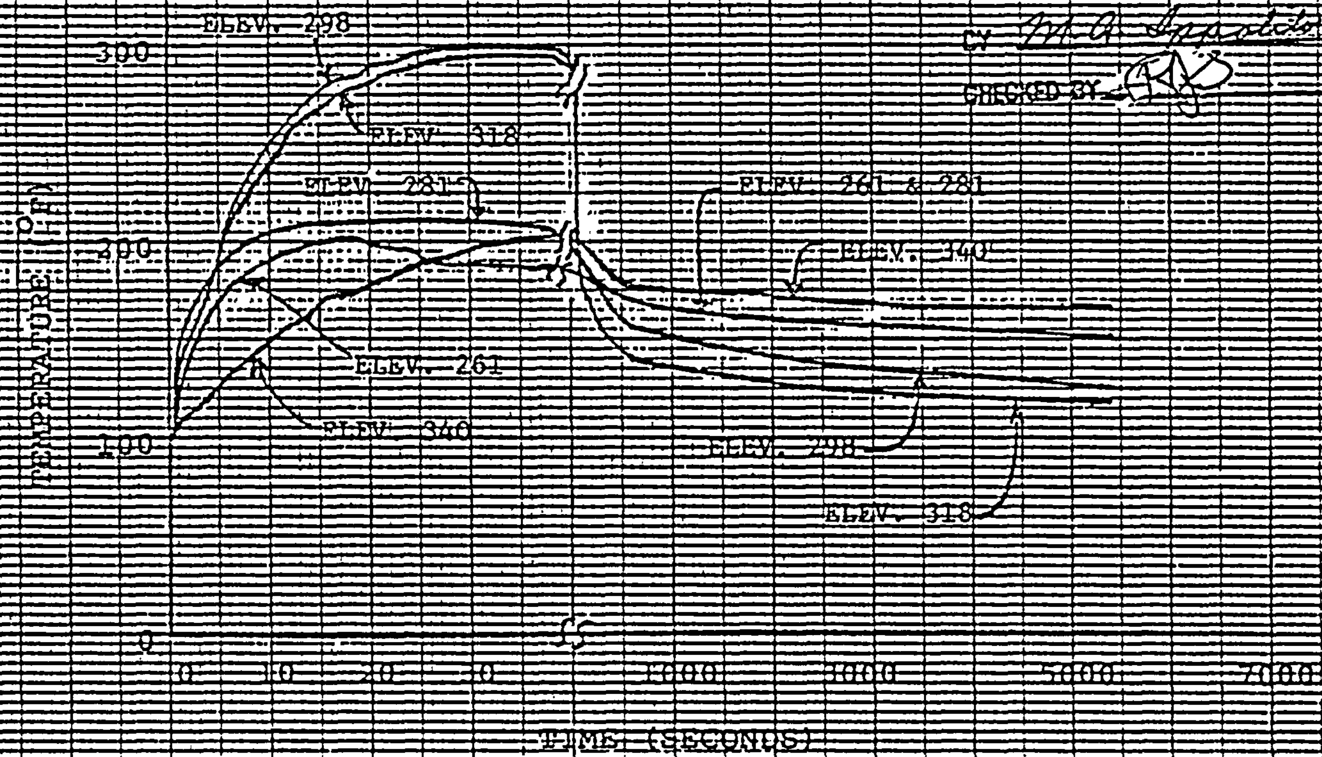
		Normal Service Conditions				Peak Harsh Environment Conditions					
System	I.D. NO.	Temp[1] (°F)	Pressure[2] (PSIG)	R.H.[2] (%)	Radiation[2] (Rads)	Temp[3] (°F)	Pressure[3] (psig)	R.H.[3] (%)	Radiation[4] (Rads)	Duration[3] (hrs)	Figure[3]
ADS	1033A	103	0	50-90	1×10^4	165	1	100	$<10^6$	1	3
ADS	10-33B	103	0	50-90	1×10^4	165	1	100	$<10^6$	1	3
CS	58-05	103	0	50-90	1×10^4	110	1	100	$<10^6$	28	2
CS	58-06	103	0	50-90	1×10^4	110	1	100	$<10^6$	28	2
CS	RV-26A	103	0	50-90	1×10^4	165	1	100	$<10^6$	28	3
AI	(01-26A-H)	103	0	50-90	1×10^4	165	1	100	$<10^6$	1	3
RVI	36-03(A-D)	103	0	50-90	1×10^4	212	1	100	$<10^6$	1	1
RVI	36-04(A-D)	103	0	50-90	1×10^4	212	1	100	$<10^6$	1	1
RVI	36-05(A-D)	103	0	50-90	1×10^4	212	1	100	$<10^6$	1	1
RVI	36-07(A-D)	103	0	50-90	1×10^4	212	1	100	$<10^6$	1	1
RVI	36-08(A-D)	103	0	50-90	1×10^4	212	1	100	$<10^6$	1	1
EC	36-06(A-D)	103	0	50-90	1×10^4	212	1	100	$<10^6$	28	1
COS	201.2-476 (A-D)	103	0	50-90	1×10^4	212	1	100	$<10^6$	1	1

(1) Reference 13.10
(2) Assumed
(3) Reference 13.5
(4) Reference 13.11

FIGURE 1 (Ref 13.5)

PAGE 11 OF 29
DATE 2/25/82
FILE NO. 1961-R369-002-R2
BY M A Ippolito
CHECKED BY

LIMITING TEMPERATURE AND PRESSURE IN OPEN FLOOR AREAS NOT NEAR BREAK LOCATIONS



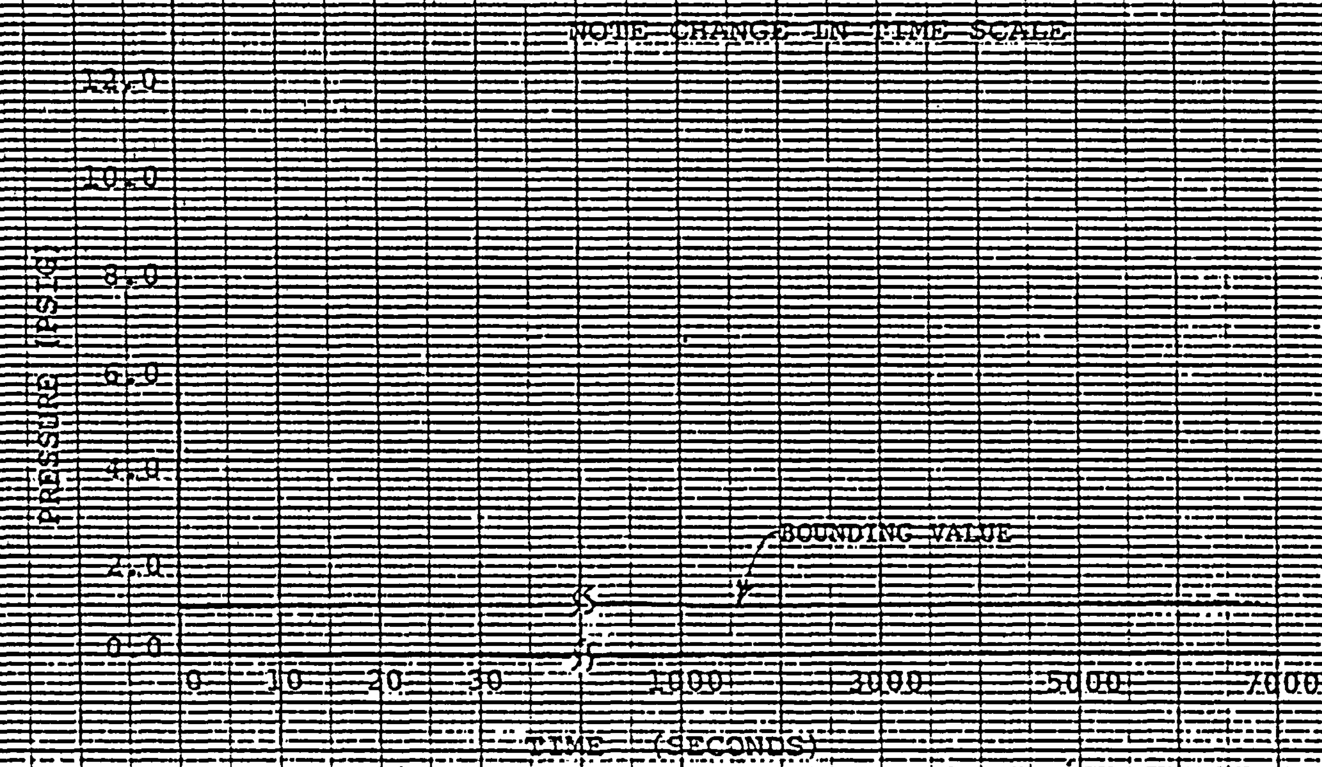


FIGURE 2 Ref (13.5)

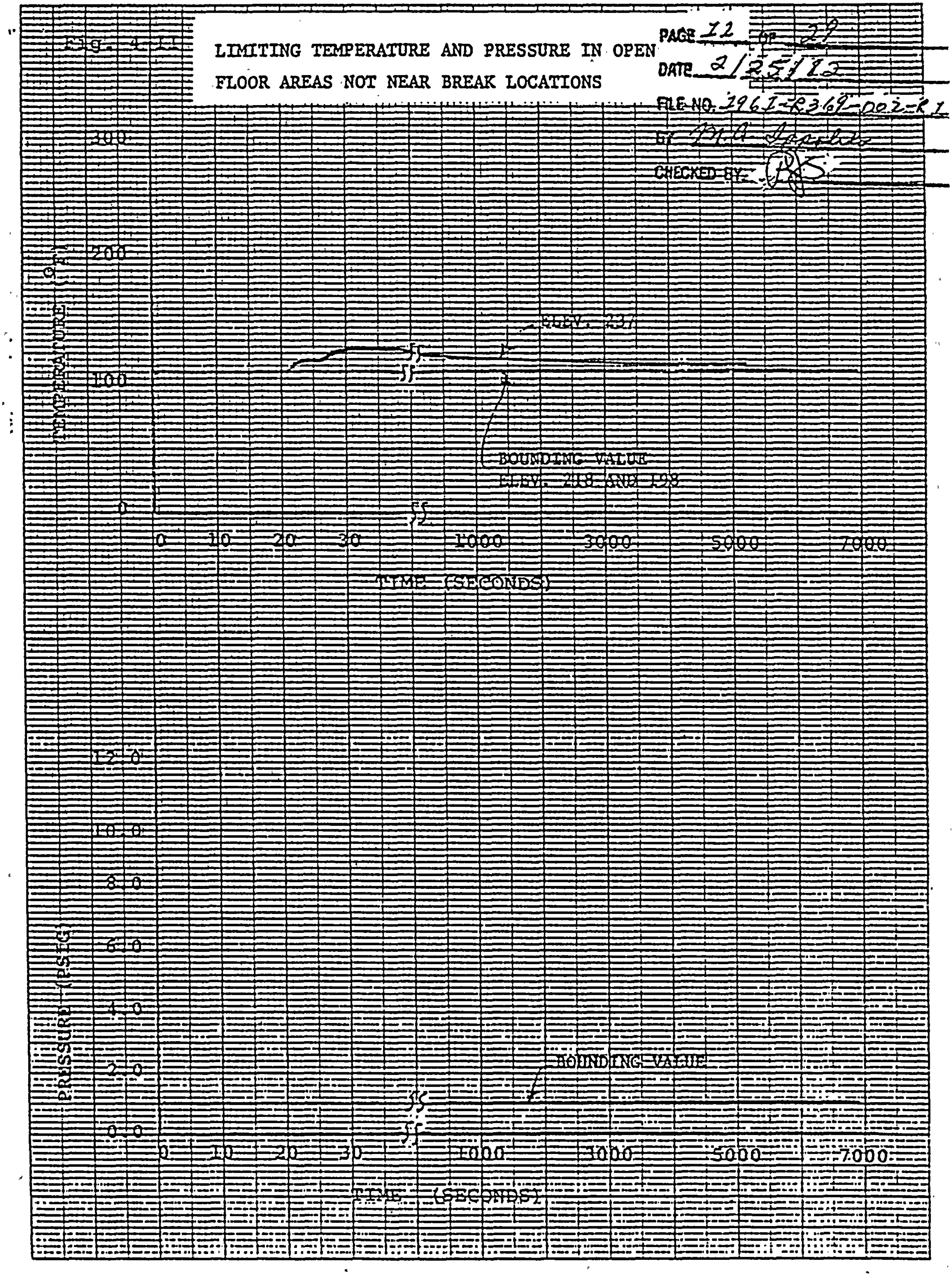


FIGURE 3

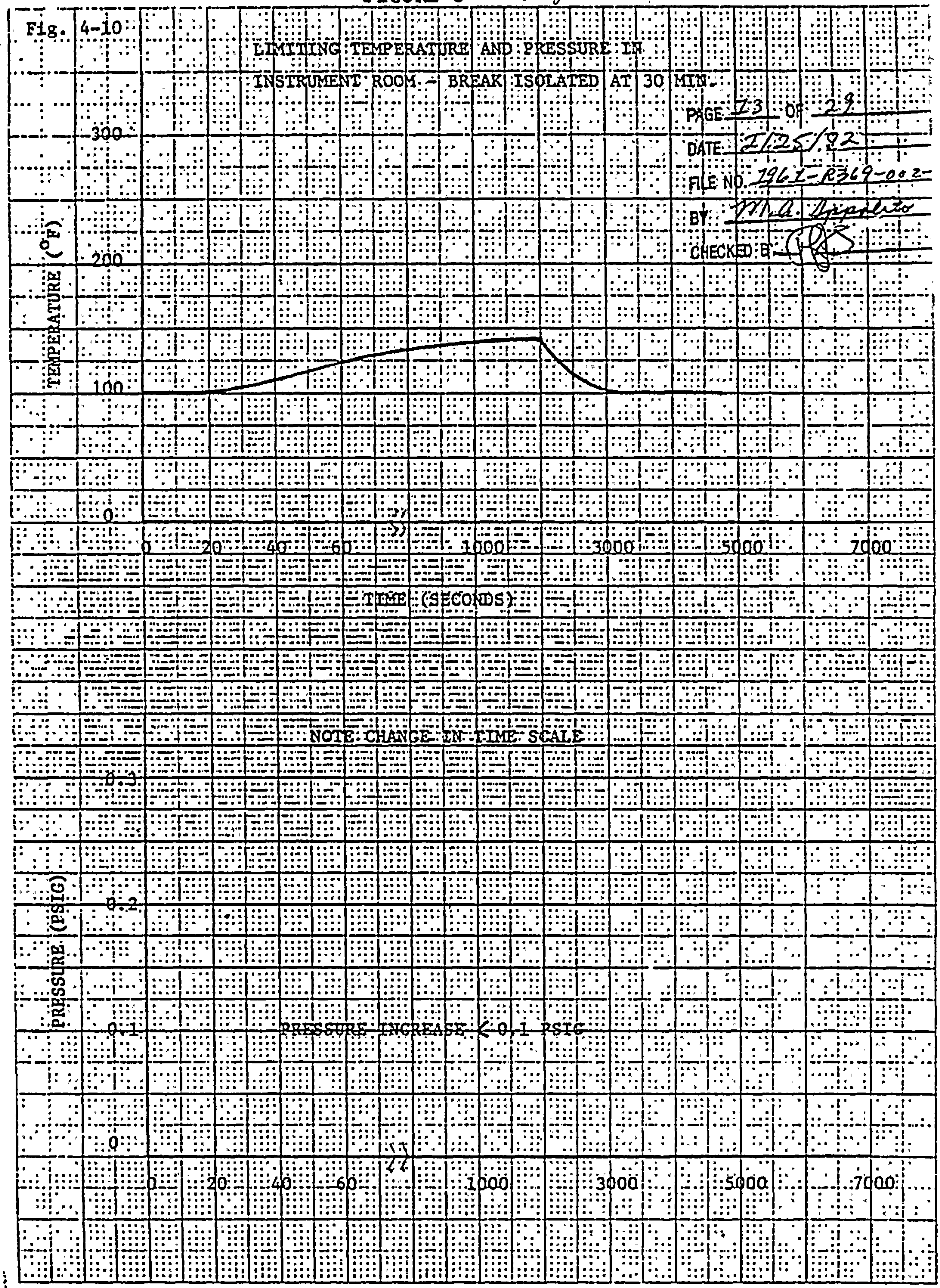


Fig. 4-10
LIMITING TEMPERATURE AND PRESSURE IN
INSTRUMENT ROOM - BREAK ISOLATED AT 30 MIN.
PAGE 73 OF 29
DATE 1/25/92
FILE NO. 1961-R369-002-
BY M.A. Ippolito
CHECKED B
TEMPERATURE (°F)
300
200
100
0
0
20
40
60
1000
3000
5000
7000
TIME (SECONDS)
NOTE CHANGE IN TIME SCALE
PRESSURE (PSIG)
0.3
0.2
0.1
PRESSURE INCREASE < 0.1 PSIG
0
0
20
40
60
1000
3000
5000
7000

7.0 Method of Analysis

7.1 Materials

The manufacturer of the subject equipment was contacted to obtain a list of the non-metallic materials. It was subsequently learned that no formal material traceability existed. It was learned, however, that the subject equipment was made special for General Electric with "E" electronics (Ref 13.1) Furthermore, it was learned that the 1151 transmitters contain teflon insulated wire, teflon tape, and Buna-N O-rings (Ref 13.2). A literature search was then conducted to obtain radiation threshold, temperature threshold and time/temperature aging data for these materials.

7.2 Radiation

A literature was conducted to determine the radiation thresholds for the organic materials used in the subject equipment.

7.3 Time/Temperature Effects

The present state of the art allows acceleration of the aging effects of temperature by subjecting a material to increased temperatures for a relatively short duration. For many non-metallic materials, it is

known that the degradation process can be defined by a single temperature-dependent reaction that follows the Arrhenius equation:

$$K = Ae^{-(Ea/K_B T)} \qquad (1)$$

Where,

K = Reaction rate
A = Frequency factor
e = Exponent to base e
Ea = Activation energy
K_B = Boltzmann's Constant
T = Absolute temperature

Equation (1) can also be expressed in a form which yields an expected lifetime of the material at a specific temperature. This form is:

$$LN(X) = Ea/K_B(1/T_i) + I \qquad (2)$$

Where,

LN = Natural logarithm
t_i = Expected life at temperature T_i (hours)
T_i = Service temperature (°K)
I = constant (intercept).

Equation (2) can also be represented in a linear regression line as:

$$Y_i = MX_i + I \qquad (3)$$

Where,

$$Y_i = \ln(t_i)$$
$$X_i = 1/T_i$$
$$M = E_a/K_B$$
$$I = \text{Constant (Intercept)}$$

For the purpose of this analysis, Equation (2) will be used to calculate the expected life of the materials used in the subject equipment. Time / temperature test data were collected from the available literature on each temperature sensitive material and the activation energies and intercepts calculated for the specified failure criteria.
The activation energies and intercepts will then be used to calculate the expected life of the materials under the maximum harsh environment temperature conditions. If the life calculated for all the materials exceeds 40 years no further analysis will be done because the maximum harsh environment temperature envelopes all other temperature conditions. If the material life as calculated above did not exceed 40 years, then the expected life at ambient conditions will be calculated and a determination of the expected life will be made using the combination of 40 years at normal service conditions and the specified duration of a design basis event.

CLIENT NMPC FILE NO 1961-R369-002-R1 BY M. A. Ippolito
SUBJECT Analysis of Rosemount 1151DP Transmitters Checked By [signature]

7.4 Harsh Environment

A Rosemount 1151DP transmitter with B output was successfully tested at 300°F for 4 hours. (Ref 13.16) Other harsh environment tests have been conducted on Rosemount 1152 transmitters with "E" electronics. However, these transmitters contained LM-308 amplifiers and the subject equipment contains type 741 amplifiers. For this reason it is felt that these tests are not applicable to the subject equipment.

7.5 Radiation

An 1151 transmitter with "A" output was tested to 2×10^6 rads of gamma radiation (Ref. 13.4, 13.6).

7.6) Operational Cycling

Pressure Cycling has been determined, by Rosemount, to be the most significant operational aging mechanism. Pressure cycling results in metal fatigue of the isolator and center sensing diaphragms. During the early design phase of the model 1151 Alphaline transmitter development program, fatigue life of the center diaphragm was studied. It was concluded that the unit had a fatigue life greater than 100,000 cycles at 20 to 80% full scale pressure cycling (Ref. 13.15) It is estimated that the subject equipment will experience 2 cycles/day which is equivalent to 29,200 cycles in a 40 year desired life.

8.0) Major Assumptions

- It is assumed for the purpose of this analysis, the deterioration of metallic components due to time/temperature effects and radiation exposure is insignificant.

- It is assumed that the organic materials will be the limiting materials for time/temperature effects and radiation exposure.

CLIENT: NMPC FILE NO: 1962 R369-002-R-1 BY: M.A. Ippolito

SUBJECT: Analysis of Rosemount 1151 DP Transmitters Checked By: [signature]

- It is assumed that all the 1151DP transmitters at NMP-1 contain type 741 amplifiers and "E" electronics.

- It is assumed that the teflon used in the 1151DP Transmitters is similar enough to TFE Teflon to allow use of TFE Teflon test data in this analysis.

CLIENT NMPC FILE NO. 1961-R369-002-R1 BY M. A. Sppolito
SUBJECT Analysis of Rosemount 1151 DP Transmitters Checked By

- It is assumed that any deleterious effects caused by relative humidity are accounted for in the harsh environment test.

- It is assumed that even though the time/temperature data is not for the exact material used in the subject equipment it is still applicable.

- It is assumed that any test done on 1152 transmitters that are not detrimental to the differences between the 1152 and 1151 can be used to qualify the 1151 transmitter.

- It is assumed that adequate margins have been included in the specifications supplied by NMPC to account for variations in service conditions. Therefore, the levels herein specified will be the qualification levels and no further conservatisms will be applied.

- It is assumed that all the 1151DP transmitters at NMP1 contain type 741 amplifiers and "E" electronics.

9.0 Detailed Calculations

The expected life for each of the materials will be evaluated using the following procedure:

1.) The expected life will be calculated at the harsh environment temperature using the arrhenius equation from the NUS Generic Analysis for the respective material. If the expected life is greater than 40 years no further analysis is needed. If the expected life is less than 40 years proceed to step 2

2.) The expected life will be calculated for the ambient temperature. If the expected life is greater than 40 years proceed to step 3. If the expected life is less than 40 years proceed to step 4.

3.) Subtract 40 years from the expected life at ambient conditions calculated in step 2. Convert the remaining life to its respective life at the harsh environment temperature using the following equation:

$$t_1 = t_2 \exp[(E_A/K_B)(1/T_1 - 1/T_2)] \qquad (4)$$

t_1 = expected life at harsh environment (yrs)
t_2 = life at ambient conditions minus 40 years (y
T_1 = harsh environment temperature (°K)
T_2 = Ambient temperature (°K)

E_a = Activation energy for respective material (eV)
K_B = Boltzmann's Constant (8.617×10^{-5} eV/°K)

If the life at harsh environment (t_1) is greater than the expected harsh environment duration the material is qualified for a 40 year life.

4.) Convert the specified harsh environment duration to its respective life at ambient conditions using equation (4) rearranged as follows:

$$t_2 = t_1 \exp[(E_a/K_B)(1/T_2 - 1/T_1)] \qquad (5)$$

Where,
t_2 = life at ambient temperature (hrs)
t_1 = specified duration of harsh environment (hrs)

The qualified life is determined as follows:

$$t_q = t - t_2$$

Where,
t_q = qualified life
t = life at ambient conditions
t_2 = Harsh environment duration converted to respective life at ambient temperature.

CLIENT NMPC FILE NO. 1961-R369-002-R1 BY M.A. Spoleto

SUBJECT Analysis of Rosemount 1152DP Transmitter Checked By [initials]

9.1 Calculations

9.1.1. O-rings

Material: Buna-N
Failure Criteria: 1500 psi for 3-1 minute cycles.

Step 1:

$$LN(t) = 0.7506/8.617\times10^{-5}\,(1/T) - 16.2810 \quad \text{(Ref. 13.}$$

at harsh environment temperature of 212°F (373°K)
$t = 1178.56$ hours $\times$ 1yr/8760hrs = 0.1345 years

Step 2: at ambient temperature of 103°F (312.44°K)
$t = 1.08897\times10^{5}$ hours $\times$ 1yr/8760hrs = 12.43 years

Since the expected life is less than 40 years, proceed to to step 4

Step 4: The specified harsh environment durations are 28 hours and 1 hour

$$t_2 = 28 \exp[(0.7506/8.617\times10^{-5})(1/312.44 - 1/373)]$$

$t_2 = 2588.17$ hours $\times$ 1year/8760 hrs = 0.29545 years.

for a 1 hour specified harsh environment duration

$t_2 = 2578.17/28 \times$ 1yr/8760 hrs = 0.01055 years

Qualified life is determined as follows:

for 28 hr duration: $t_q = 12.43 - 0.29545 =$ **12.13 years**
for 1 hr duration: $t_q = 12.43 - 0.01055 =$ **12.42 years**

CLIENT NMPC FILE NO. 1961-R369-002 - R1 BY M. A. Ippolito
SUBJECT Analysis of Rosemount 1151DP Transmitter Checked By [signature]

9.1.2 Wire Insulation and Tape

Material: Teflon (TFE)
Failure Criteria: Unknown

Step 1:

$$\ln(t) = 1.720/8.617 \times 10^{-5} (1/T) - 27.9 \quad \text{(Ref 13.9)}$$

at harsh environment temperature of 212 °F (373°K)
$t = 1.329 \times 10^{11}$ hrs × 1yr/8760 hrs = 1.518×10^{7} years

Since the material has a life greater than 40 years at harsh environment temperatures, the material is qualified for a 40 year life and no further analysis is required.

9.1.3 I/C Boards (amplifiers)

The expected life of the I/C boards will be evaluated as follows:

1.) The analysis will be based on tests conducted on a 1151DP transmitter with "B" output electronics. It is assumed that since the device tested was an 1151 that it contained a type 741 operational amplifier. Since the amplifier is considered to be the crucial design component (Ref 13.15), the analysis of the I/C boards will be based on it. The 1151DP transmitter was tested for 4 hours at 300°F. Using an activation energy 0.9 eV (Ref 13.7),

CLIENT NMPC FILE NO. 1961-R369-002-R1 BY M. Q. Ippolito

SUBJECT Analysis of Rosemount 1151DP Transmitter Checked By [signature]

and equation (5) the following relationship can be setup:

$$t_2 = t_1 \exp[(E_a/k_B)(1/T_2 - 1/T_1)] \quad (6)$$

Where,

$t_1 = 4$ hrs.

T_2 = Ambient temperature 103°F (312.44 °k)

T_1 = 300°F = 422 °k

t_2 = life at ambient temperature

E_a = activation energy (0.9 eV) (Ref. 13.7, 13.15)

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

substituting into equation (6), the expected life at ambient conditions

$t_2 = 2.35 \times 10^4$ hrs × 1 yr/8760 hrs = 2.6835 years.

2.) Using step 4, the specified duration for harsh environment will be converted to its respective life at ambient conditions.

for a 28 hr harsh environment

$$t_2 = 28 \exp[(0.9/8.617\times10^{-5})(1/312.44 - 1/373)]$$

$t_2 = 6.372 \times 10^3$ hrs × 1 yr/8760 hrs = 0.7274 years

t_q = 2.6835 − 0.7274 = 1.956 years

for 1 hr harsh environment

t_q = 2.6835 − 0.7274/28 = 2.66 years.

CLIENT NMPC FILE NO. 1961-R369-002-R1 BY M.A. Ippolito
SUBJECT Analysis of Rosemount 1151DP Transmitter Checked By RJS

10.0 Results

10.1 Radiation

An 1151DP transmitter was tested at 2×10⁶ rads (Ref. 13.4). This transmitter contained "A" output electronics (Ref 13.6) and it is assumed therefore that it contained all the critical materials in an 1151DP transmitter. However, Rosemount is very adamant that the 1151DP transmitters should be replaced (Ref 13.6)
A radiation analysis of the materials revealed the following:

Buna-N	1.75×10^6 rads	(Ref 13.9)
Teflon	3.4×10^4 rads	(Ref 13.9)
(I/C's) Operational Amplifier*	(not radiation hardened)	

* The operational amplifiers were determined by Rosemount to be a radiation problem because they are not radiation hardened. (Ref 13.15)

10.2 Time/Temperature Effects

The qualified life of the materials is as follows:

	Qualified Life
Buna-N	12 years
Teflon	40 years
Operational Amplifier**	2 years

** Rosemount recommends replacement every 5 years (Ref 13.

CLIENT NMPC FILE NO. 1961-R369-002-R1- BY M. A. Ippolito

SUBJECT Analysis of Rosemount 1151DP Transmitter Checked By: RS

10.3 Harsh Environment

An 1151DP transmitter was succesfully tested for 4 hours at 300°F.

10.4 Cycling

It was concluded that the isolator and center diaphragm has a fatigue life greater than 100,000 cycles. (Ref 13.15)

11.0 Summary of Results/Conclusions

11.1 Radiation

Since the operational amplifiers are not radiation hardened, and since teflon has a low radiation threshold the 1151DP transmitters are not qualified for radiation.

11.2 Time Temperature Effects

	Qualified Life
Buna-N	12 years
Teflon	40 years
Operational Amplifier*	2 years

The Buna-N O-rings and Operational amplifier (I/C boards) will have to be replaced on a regular schedule within the qualified life presented above.

CLIENT NMPC FILE NO. 1961-R369-002-R1 BY M. A. Ippolito
SUBJECT Analysis of Rosemount 1151DP Transmitters Checked By [signature]

11.3 Harsh Environment

Since the peak harsh environment temperature of 212 °F is only for a short time (approximately 1 minute) and since an 1151 was successfully tested for 4 hours at 300°F (Ref 13.16), the 1151DP Transmitters are qualified for their expected harsh environment conditions.

11.4 Cycling

The 1151 transmitters have a cycle life of 100,000 cycles. It is assumed that the subject equipment will only experience 2 cycles per day (29,200 cycles in a 40 year life.) Since the 1151 DP Transmitters have a cycle life greater than three times the cycle aging expected, they are qualified for cycle aging.

12.0 Recommendations

Qualification of the subject equipment to the conditions specified cannot be demonstrated based on the information available at this time. Further assessment is recommended.

CLIENT NMPC FILE NO: 1961-R369-002-R1 BY M.A. Ippolito

SUBJECT Analysis of Rosemount 1151DP Transmitter Checked By [illegible]

13.0 References

13.1 G.E. NEDO Document No 24290-01, "Results of Qualification Data Search For Nine Mile Point Station Unit 1, Response To IE Bulletin 79-01 + 79-01B (Supplement 1)" dated 10/80

13.2 Rosemount Report 117622, "Qualification Test Report Model 1152GP9 Pressure Transmitter" Rev. A dtd 11/25/76

13.3 Rosemount Report No. 67710A, "Rosemount "E" Output Option Model 1151, 1152 Environmental Qualification" dated 6/13/77.

13.4 Rosemount Report No 127227 (Title unknown) As referenced in Rosemount Report No. 37327B titled "Qualification of Differential Pressure Transmitters for General Electric, San Jose for Essential Service Rosemount Model 1151DP" dated 3/28/73

13.5 NUS Analysis File, NUS-1961-SA-A1, "Niagara Mohawk Power Corporation Nine Mile Point Unit 1 HELB Pressure and Temperature Model - Reactor Building." dated 12/9/80

13.6 Contact Report M.A. Ippolito (NUS)/ Gary Hamilton Rosemount), dated 7/21/81

CLIENT NMPC FILE NO. 1961-R369-002-R1 BY M. A. Ippolito
SUBJECT Analysis of Rosemount 1151DP Transmitter Checked By [signature]

13.7 EPRI Report NP-1558, Project 890-1, "A review of Equipment Aging Theory and Technology" dated 9/80, Appendix B page B-7.

13.8 NUS Generic Analysis, NUS-LA-A-1, Material Analysis of Acrylonitrile Rubber", dated 11/23/81

13.9 NUS Generic Analysis, NUS-LA-T-1, "Determination of Aging Parameters for Tetrofluoroethylene", dated 11/7/81

13.10 Memo From Dave Green (NMPC) To Deepak Bhatia (NUS), "NMPC Supplied Normal Service Conditions", dtd 3/11/81

13.11 NUS Analysis File, NUS-1961-R-1, "Radiation Environment Specification For NMP-1". dtd 10/25/81

13.12 Niagara Mohawk Power Corporation Nine Mile Point Unit 1 On Going Qualification Assessment Summary Rev. 4 dtd 11/5/81.

13.14 Memo CD-ENG-926 S. J. Gazda (NUS) To Al Conepa (NUS), dtd 11/23/81.

13.15 Rosemount RPT NO. 57820 "Nuclear Equipment Analysis Report, Rosemount model 1153 Series B Pressure Transmitter" Rev D. dtd 8/28/78

13.16 Rosemount Rpt 37327B ; See ref 13.4.

QUALITY ASSURANCE RECORD

NUS CORPORATION
CONSULTING DIVISION

RECORD OF SYSTEM/COMPONENT ANALYSES

FILE NO.:	NO. OF PAGES:	NUMBER OF VOLUMES OF COMPUTER OUTPUT:
1961-F080-001-R1	22	N/A

CLIENT:	PROJECT NO.:
Niagara Mohawk Power Corporation	1961

ANALYSIS TITLE: Environmental Qualification Assessment of Fenwal 17002-40 Temperature Switches for Use in NMPC's Nine Mile Point Unit-1 Nuclear Power Generating Station

AUTHOR: D. N. Berkey

PURPOSE OF ANALYSIS: To assess the ability of Fenwal 17002-40 temperature switches to perform their safety related function in Normal and harsh environments at NMP-1

SUMMARY OF ANALYSIS PROCEDURE AND RESULTS:

Test data as well as analysis of materials, using the Arrhenius Theory were used to determine if the Fenwal Model 17002-40 Temperature switches could perform their safety related function in normal and harsh environments at NMP-1. It was concluded that the temperature switches could withstand a total integrated radiation dose of 1×10^6 rad; could withstand a temperature of 322 °F and a pressure of 78 PSIG for approximatly 5 minutes. Based on the Arrhenius theory it was concluded that age related degradation will not prohibit the switches from completing their function during an end of life LOCA or HELB

DATE COMPLETED:	VERIFICATION REQUIRED:
12/10/81	☒ YES ☐ NO

ANALYSIS REVIEWED AND ACCEPTED: (DISCIPLINE MANAGER)	DATE:
[signature]	12-17-81

ANALYSIS:	BY: (FILE NO.)	DISCIPLINE MANAGER:	DATE:
☐ SUPERSEDED ☐ SUPPLEMENTED			

NUS 202 10 REVISED 0181
(Formerly CD-28 12/77)

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

FILE NO.: 1961-F080-001-R1	PAGE 1 OF 2

ANALYSIS TITLE:
Environmental Qualification Assessment of Fenwal 17002-40 Temperature switches for use in NMPC's Nine Mile Point - Unit 1 Nuclear Power Generating Station.

AUTHOR:	NO. OF PAGES:	NO. OF VOLUMES OF COMPUTER OUTPUT:
D. M. [signature]	22	None

VERIFICATION SCOPE (CHECK AS APPLICABLE):

- [x] METHOD OF ANALYSIS
- [x] ASSUMPTIONS
- [x] INPUT INFORMATION
- [ ] COMPUTER CODE APPLICATION
- [ ] CHECK OF SAMPLE CALCULATION
- [ ] SPOT CHECK OF MATHEMATICS
- [x] REASONABLENESS OF RESULTS
- [x] COMPLETE CHECK OF MATHEMATICS
- [ ] PARTIAL INDEPENDENT ANALYSIS

BUDGET: (APPROXIMATE)	DESIRED COMPLETION DATE:
1/4 MANDAYS	ASAP

DESCRIPTION OF VERIFICATION—ACTIVITIES, FINDINGS AND RESOLUTION:

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

1961-F080-001-R1

PAGE 2 OF 2

Only changed pages were inspected - [signature]

VERIFIER'S SIGNATURE: [signature]

DATE: 10/11/87

ACCEPTANCE BY: (DISCIPLINE MANAGER) [signature]

DATE: 12-17-87

NUS CORPORATION
CONSULTING DIVISION

ANALYSIS VERIFICATION CHECKLIST

ANALYSIS TITLE: Environmental Qualification Assessment of Fenwal 17002-40 Temperature Switches for use in NMPC's NMP-1 Nuclear Power Generating Station	ANALYSIS FILE NUMBER: 19C1-F080-001-R1		
INDICATE "YES, NO, OR N/A (NOT APPLICABLE)," FOR EACH ITEM AND INCLUDE IN ANALYSIS PACKAGE WITH RECORD OF ANALYSIS VERIFICATION	YES	NO	N/A
METHOD OF ANALYSIS			
IS THE METHOD USED APPROPRIATE CONSIDERING THE PURPOSE AND TYPE OF ANALYSIS AND THE USE AND ACCEPTABILITY OF THE RESULTS (i.e., MARGIN TO LIMITS)?	☑	☐	☐
IS THE METHOD IN ACCORDANCE WITH CODES, STANDARDS, AND REGULATORY REQUIREMENTS?	☑	☐	☐
HAS THE METHOD BEEN EMPLOYED ELSEWHERE IN INDUSTRY OR IN LICENSE APPLICATIONS?	☑	☐	☐
ASSUMPTIONS			
ARE ASSUMPTIONS NECESSARY TO PERFORM THE ANALYSIS ADEQUATELY DESCRIBED AND REASONABLE?	☑	☐	☐
WHERE NECESSARY, ARE THE ASSUMPTIONS IDENTIFIED FOR SUBSEQUENT RE-VERIFICATIONS WHEN THE DETAILED DESIGN ACTIVITIES ARE COMPLETED?	☑	☐	☐
INPUT INFORMATION			
ARE THE INPUTS INTO THE ANALYSIS STATED AND THEIR SOURCE IDENTIFIED?	☑	☐	☐
IS THE INPUT INFORMATION FROM THE LATEST AVAILABLE REVISION TO THE DOCUMENT?	☑	☐	☐
IS THE STATUS (PRELIMINARY, CONCEPTUAL, ETC.) OF THE INPUT SOURCE IDENTIFIED FOR LATER CONFIRMATION OF THE VALIDITY OF THE INPUT?	☑	☐	☐
ARE THE INPUTS SUFFICIENT CONSIDERING THE PURPOSE OF THE ANALYSIS?	☑	☐	☐
COMPUTER CODE APPLICATION			
ARE ALL CODES USED IDENTIFIED ALONG WITH SOURCE, COMPUTER TYPE, INPUTS, AND OUTPUTS?	☐	☐	☑
HAS THE CODE BEING USED BEEN ADEQUATELY VERIFIED?	☐	☐	☑
IS THE CODE SUITABLE FOR THE PRESENT ANALYSIS?	☐	☐	☑
DOES THE COMPUTER MODEL (NODING, TIME STEPS, ETC.) ADEQUATELY REPRESENT THE PHYSICAL SYSTEMS?	☐	☐	☑
REASONABLENESS OF RESULTS			
IS THE MAGNITUDE OF THE RESULT REASONABLE?	☑	☐	☐
ARE THE DIRECTION OF TRENDS REASONABLE?	☑	☐	☐
PREPARED BY: [signature]	DATE: Dec 11, 1990		

NUS 204 10 REVISED 0181
(Formerly CD-30 Rev. 1)

FINAL ANALYSIS REVIEW CHECKLIST

Project #/Project Title: 1961 / Component Analysis   Client: Niagara Mohawk Power Corp.

Date: 12/10/81

Analysis File Title: Environmental Qualification Assessment of Final 17002-40 Temperature Switches used in NMPC's Nine Mile Point Unit I Nuclear Power Generating Station

Analysis File Number: 1961-F080-001-R1

Checklist Item	Yes	N/A
1. Unique Analysis File Number assigned to the file.	✓	
2. Analysis recorded on CD-60	✓	
a. pages numbered	✓	
b. total pages specified	✓	
c. all pages dated	✓	
d. client identified on each page	✓	
e. correct file number on each page	✓	
f. author(s) specified on each page	✓	
g. subject specified on each page	✓	
h. verifier initials on each page	✓	
3. Analysis File includes:		
a. client identification	✓	
b. analysis file number	✓	
c. analysis title	✓	
d. author(s) identification	✓	
e. description of the purpose of the analysis	✓	
f. discussion of the general method of analysis	✓	
g. identification of input information source	✓	
h. identification of input information status	✓	
i. major assumptions used in performing the analysis	✓	

Date: 12/10/81

3. (Continued)

	j. important references, including material properties	✓	
	k. identification of specific versions of codes used	✓	
	l. detailed calculation	✓	
	m. listing of computer input		✓
	n. microfiche of computer output		✓
	o. summary of results	✓	
4.	Record of analysis provided on CD-28	✓	
5.	All applicable entries on CD-28 correct.	✓	
6.	All referenced NUS internal memos included in analysis file.	✓	
7.	All referenced telecons included in analysis file.	✓	
8.	Separate computer output labeled with analysis file number.		✓
9.	Record of analysis file verification on CD-29.	✓	
10.	All entries on CD-29 completed and correct.	✓	
11.	Item (7) of CD-29 completed and comments numbered	✓	
12.	Verification checklist CD-30 included.	✓	
13.	Computer code used verified per QAI 3.5.		✓
14.	Corrected items crossed out clearly enough to show on Xerox copies.	✓	
15.	List of input information and major assumptions checked for commpleteness.	✓	
16.	Documents Complete (Page Count)	✓	
17.	Documents Legible and Reproducible	✓	
18.	All Documents Identified on Index Received	✓	
19.	Documents Properly Paginated	✓	
20.	Documents Identified to Project/Item	✓	
21.	All Unsatisfactory Conditions Resolved (List)		

Date 12/10/81

22. Remarks:

Reviewed by: [signature] 12/11/81
Date

NUS CORPORATION

DATE 12/10/81

CLIENT NMPC FILE NO. 1961-F080-001-R1 BY D. M. [signature]

SUBJECT Environmental Qualification for Fenwal Model 17002-40 Temperature Switches Checked By [signature]

Table of Contents

CLIENT NMPC FILE NO. 1961-F080-001-R1 BY D. M. [signature]

SUBJECT Environmental Qualification for Fenwal Model 17002-40 Temperature Switches Checked By [signature]

1.0 Client Identification

Niagara Mohawk Power Corporation (NMPC)

2.0 Analysis File Number

1961-F080

3.0 Analysis Title

Environmental Qualification Assessment of Fenwal 17002-40 Temperature Switches for use in NMPC's Nine Mile Point - Unit 1 Nuclear Power Generating Station

4.0 Author Identification

D. N. Perkey

5.0 Purpose of Analysis

The purpose of this analysis is to determine if the design of the Fenwal Model 17002-40 temperature switch is adequate to assure that the switches will operate on demand, to meet the system performance requirements, under normal and harsh environmental conditions and during design basis events at NMP-1

CLIENT NMPC FILE NO. 1961-F080-001-R1 BY D. N. [illegible]

SUBJECT Environmental Qualification for Fenwal Model 17002-40 Temperature Switches Checked By [illegible]

6.0 Input Information

6.1 Equipment Identification

All of the Fenwall Model 17002-40 temperature switches at NMP-1 that are within the scope of this analysis are located in the Alternate Instrument System (Ref. 1). The following is a list of the NMP-1 Plant Identification numbers for the subject temperature switches:

1B10A	1B10E	1B10J	1B10N
1B10B	1B10F	1B10K	1B10P
1B10C	1B10G	1B10L	1B10Q
1B10D	1B10H	1B10M	1B10R

6.3 Materials

A list of the non-metallic components, obtained from the manufacturer (Ref 2), for the Fenwal Model 17002-40 temperature switch is presented in Table 1. The organic materials used in the switch are TAGT leadwire insulation and Dow Corning 991 Silicone Varnish. The TAGT insulation is manufactured by Anaconda Corporation. It consists of a layer of Teflon tape and a layer of asbestos, covered with a fiberglass braid (Ref. 6). It is assumed that the Dow Corning 991 Silicone varnish is used as a protective coating in the temperature switch.

The inorganic materials used in the switch include Mica insulation, braided fiberglass sleeving, graphite and glass.

6.4 Safety Related Function

The following are the safety related functions for the subject Fenwal temperature switches (Ref. 11)

ID No.	Safety Function
1B10A 1B10B 1B10E 1B10F 1B10J 1B10K 1B10N 1B10P	Main steam line high temperature Detection. Used to detect Main Steam line break or leak. Initiates RPS to isolate the break and shut down the reactor.
1B10C 1B10G 1B10L 1B10Q	Main steam line area high temperature detection near turbine Stop + Control Valve Manifold. Initiates RPS to isolate break and Shut down the reactor.
1B10D 1B10H 1B10M 1B10R	Main steam line area high temperature detection near turbine bypass control valve Manifold. Initiates RPS to isolate the break and Shut down the reactor.

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SUBJECT Environmental Qualification for Fenwal 17002-40 Temperature Switches Checked By [signature]

6.5 Service Conditions

The normal service conditions as specified by NMPC (Ref 7) for all of the subject switches are as follows.

Temperature	98°F
Pressure	0 psig
Relative Humidity	10-90% (Assumed)
Radiation	1×10^4 rads (Assumed)
Duration	40 years

The harsh environment conditions to which the subject switch may be exposed during a design basis event (HELB or LOCA) were obtained from NUS Analyses ~~1961-SA-2~~ (Ref 8) and 1961-R-1 (Ref 9). Temperature and Pressure Plots for a design basis event are presented in Figures 1. The maximum conditions that the Fenwal switches may be subjected to are as follows:

Temperature	308°F
Pressure	17.3 psig
Relative Humidity	100% (assumed)
Radiation	$< 1 \times 10^6$ rad

CLIENT NWWPC FILE NO. 1961-F080-001-R1 BY D. M. Bailey

SUBJECT Environmental Qualification for Fenwal 17002-40 Temperature Switch Checked By [illegible]

Duration	< 10 seconds at maximum conditions

7.0 Method of Analysis

7.1 Materials

The manufacturer of the Fenwal Model 17002-40 temperature switch was contacted and a list of the non-metallic components used in the switch was obtained. A literature search was then conducted to obtain radiation and temperature threshold levels and time/temperature aging data for those materials that may be subject to degradation from those factors.

7.2 Radiation

A literature search was conducted and the manufacturer was contacted to determine the radiation thresholds for the organic materials used in the Fenwal Model 17002-40 temperature switch.

7.3 Time/Temperature effects

The present state of the art allows acceleration of the aging effects of temperature by subjecting a material to increased temperatures for a relatively short duration. For many non-metallic materials, it is known that the degradation

process can be defined by a single temperature-dependent reaction that follows the Arrhenius equation:

$$K = A\exp-(E_a/K_B T) \qquad (1)$$

where,

- K = reaction rate
- A = frequency factor
- exp = exponent to base e
- E_a = activation energy
- K_B = Boltzmann's Constant
- T = absolute temperature

Equation (1) can also be transformed into a form which yields an expected life of the material at a specific temperature. This form is:

$$\ln t_i = \frac{E_a}{K_b}\left(\frac{1}{T_i}\right) + I \qquad (2)$$

where,

- ln = Natural logarithm
- t_i = Expected life at temperature T_i (hours)
- T_i = Service temperature for life t_i (°K)
- I = Constant.

Equation (2) can also be represented in a linear regression line as:

$$Y_i = M X_i + I \qquad (3)$$

Where,

$Y_i = \ln t_i$
$X_i = 1/T_i$
$M = E_a/K_B$
I = constant (Intercept)

For the purpose of this analysis the Arrhenius equation is used to calculate the expected life of the materials used in the Fenwal model 17002-40 temperature switch. Time/temperature test data was collected from the available literature on each temperature sensitive material and the activation energies and intercepts calculated for the specified failure criteria (Ref 4 and 5). These Activation Energies and intercepts were then used to calculated the expected life of the materials under the maximum harsh environment temperature conditions. If the life calculated for all materials at the harsh environment condition exceeds 40 years no further analysis was done, because the maximum harsh environment temperature envelopes all other temperature conditions. If the material life as calculated above does not exceed 40 years then the expected life at ambient conditions was also calculated

and a determination of the expected life was made under the combination of 40 years at normal service conditions and the specified duration of a design basis event.

7.4 Harsh Environment - Design Basis Event

A Fenwal model 17002-40 was exposed to design basis event conditions in a test conducted on electrical connectors (Ref 10). The switch was also subject to a steam impingement test (Ref 10).

7.5 Cycling:

At this time cycling information for the Fenwal Model 17002-40 temperature switch has not been obtained.

8.0 Computer Codes

Computer codes were not used in this analysis.

9.0 Major Assumptions

9.1 It is assumed that for the purpose of this analysis the deterioration of metallic components due to time/temperature effects and radiation exposure is insignificant

9.2 It is assumed that the organic materials used rather than the inorganic materials will be the the limiting materials for time/temperature effects and radiation exposure.

9.3. It is assumed that the typical test curve used for Teflon (tetrafluroethylene) insulation in reference 4, is applicable to the TGAT (Teflon, asbestos and glass) insulation used in the Fenwal temperature Switch.

9.4 It is assumed that the curved electrode test performed on the Dow Corning 991 Silicone varnish (Ref. 5) is applicable to the use of the Same Varnish in the Fenwal Model 17002-40 Temperature Switch

9.5 It is assumed, based on similar composition (Ref 12), that the radiation threshold of Dow Corning 997 Silicone Resin can be applied to the Dow Corning 991 Silicone varnish used in the Fenwal temperature switches.

CLIENT NMPC FILE NO. 1961-F080-D01-R1 BY D. M. [illegible]

SUBJECT Environmental Qualification of Fenwal Model 17002-40 Temperature Switch Checked By [illegible]

10.0 Detailed Calculations

Life Calculation for TGAT Leadwire Insulation at 308°F

$308°F = 426°K$

$\ln t_i = E_a / k_b (1/T_i) + I$

$\ln t_i$ = ln life in hours
$E_a = 1.720$ eV
$k_b = 8.617 \times 10^{-5}$ eV/°K
$T_i = 426°K$
$I = -27.9$ hrs

$$\ln t_i = \frac{1.720 \text{ eV}}{8.617 \times 10^{-5} \text{ eV/°K}} \left(\frac{1}{426°K}\right) - 27.9 \text{ hrs}$$

$\ln t_i = 18.95$

$t_i = 1.7 \times 10^{8}$ hr. $\approx 1.9 \times 10^{4}$ years

CLIENT NUPC FILE NO. 1961-F080-001-R1 BY D. M. [signature]

SUBJECT Environmental Qualification of Fenwal Model 17002-40 Temperature Switch. Checked By [signature]

Life Calculation for Dow Corning 991 Silicone Varnish at 308°F (Harsh environment)

308°F = 426°K

$\ln t_i = E_a/k_b (1/T_i) + I$

t_i = expected life in hours
E_a = 1.172 eV
k_b = 8.617×10^{-5} eV/°K
T_i = 426°K
I = -19.448

$$\ln t_i = \frac{1.172\ eV}{8.617 \times 10^{-5} eV/°K}\left(\frac{1}{426°K}\right) - 19.448$$

$\ln t_i = 12.47$

$t_i = 2.6 \times 10^5$ hrs = 30 years

Life Calculation for Dow Corning 991 silicon Varnish at 98°F (ambient condition)

98°F = 310°K

$\ln t_i = E_a/k_b (1/T_i) + I$

t_i = expected life in hours
E_a = 1.172 eV
k_b = 8.617×10^{-5} eV/°K
T_i = 310°K
I = -19.448 eV

CLIENT NMPC FILE NO. 1763-F050-C01-R1 BY D. M. Pinkey

SUBJECT Environmental Qualification of Fenwal Model 17002-40 Temperature Switch Checked By [illegible]

$$\ln t_i = \frac{1.172\,eV}{8.617 \times 10^{-5}\,eV/^{\circ}K}\left(\frac{1}{310}\right) - 19.448$$

$$\ln t_i = 24.4$$

$$t_i = 4.0 \times 10^{10}\ \text{hrs} = 4.6 \times 10^{6}\ \text{years}.$$

11.0 Results

11.1 Radiation

As indicated in Table 1 the Teflon used in the TGAT leadwire insulation is the most radiation sensitive material. Correspondence with the vendor indicate that this type of insulation is able to withstand a radiation exposure of 1×10^6 rad (Ref 3). The Dow Corning Silicone Varnish is able to withstand an exposure of 3.1×10^7 rad (Ref 5)

11.2 Time / Temperature effects

It has been determined that Dow Corning Silicone varnish is the most time / temperature sensitive material used in the Fenwal 17002-40 temperature switch. Using the Arrhenius equation it was calculated that the expected life of this material under ambient conditions 98°F is 4.6×10^6 years. At the maximum harsh environment temperature 308°F the expected life was calculated to be 30 years.

11.3 Harsh Environment

A Fenwal 17002-40 Temperature Switch was placed in a pressure/temperature chamber in a saturated steam environment and the temperature was stabilized at 150°F for 1 hour (Ref. 10) The temperature was then increased to 322°F at 78 PSIG for 5 minutes. The pressure was then decreased at a rate of 0.7 PSIG / minute for 1 hour to 36 PSIG and 282°F. The pressure was then quickly decreased to 15 PSIG at 250°F. Next, pressure and temperature were decreased, 1 PSIG / hour for 15 hours to 212°F and 0 PSIG after which the temperature was decreased more than 5°F / hour for 8 hours. The temperature and Pressure profile for this test is presented in Figure 2)

The Fenwal 17002-40 temperature switch was also subjected to a steam impingement test (Ref. 10) where the temperature was increased to a peak of 575°F for a short period of time and then reduced quickly to 150°F. This Sequence was repeated 5 times

No Failures involving the Fenwal Model 17002-40 temperature switch were indicated in either the harsh environment test or the steam impingement test.

11.4 Cycling

Cycling data was not obtained

12.0 Summary of Results and Conclusions

12.1 Radiation

Documentation recieved from Fenwal qualifies the TAGT leadwire insulation for 1×10^6 rad. This value is greaterthan the $<1 \times 10^6$ rad exposure that the switches will recieve during a design basis event.

12.2 Time/Temperature Effects

Based on an analysis of the moste age sensitive material (Silicone varnish) using the Arrhenius theory it is expected that the subject switches have a qualified life well in excess of 40 yeas at ambient conditions (4.6×10^6 years) and 30 years at the maximum harsh environment temperature. It can then be concluded based on the above estimated life values that age related degradation will not prohibit the switches from completing their function during an end of life HELB or LOCA

It should be noted however that contact contamination, pitting and set point changes were not addressd in this analysis and a reliable maintainance schedule should be established.

CLIENT NMPC FILE NO. 1961-F0?0-001-R1 BY D. M. [signature]

SUBJECT Environmental Qualification of Fenwal Model 17002-40 Temperature Switches Checked By [signature]

12-3. Harsh Environment

Based on the design Basis Test (Ref 10) the Fenwal Model 17002-40 temperature switches are qualified for a harsh environment of 322°F, 78 PSIG Pressure and 100% R.H. These values are in excess of the 308°F, 17.5 PSIG and 100% R.H. harsh environment conditions to which the subject switches could be exposed at NMP-1

13.0 References.

1. Niagara Mohawk Power Corporation Nine Mile Point 1, On-Going Qualification Assessment Summary Revision, dated November 5, 1981

2. Fenwal letter from Koscialk to G. Miller (NUS) dated March 10, 1981

3. Fenwal letter from S. C. Mac Donald to J. E. Brown (NUS) dated March 3, 1981

4 NUS Analysis NUS-LA-T-1, "Determination of Aging Parameters for Tetrafluorethylene

5 NUS Analysis NUS-LA-S-1 "Determination of Aging Parameters for Silicone Resins

CLIENT NMPC FILE NO. 1961-F020-001-R1 BY D. M. [illegible]

SUBJECT Environmental Qualification of Fenwal Model 17002-40 Temperature Switches Checked By [illegible]

6. NUS Telecon G. Jenkins (Anaconda) and G. Miller (NUS) dated March 9, 1981

7. NMPC Supplied Normal service conditions Dated March 11, 1981

8 NUS Analysis 1961-SA-2 "Nine Mile Point Unit 1 Steam Tunnel/Turbine Building High Energy Line Break Analysis"

9. NUS Analysis 1961-R-1 "Radiation Environment specifications for NMP-1

10. Wyle Laboratories Report No. 43854-1 Qualification Test for Electrical Connectors used at Browns Ferry Nuclear Power Plant, Units 1, 2 and 3, Volume 1".

11 NUS Internal Memo S.J. Gazda to A.P. Canepa, CD-ENG-926 Dated November 23, 1981, "NMPC SER Response, Project 1961, Qualified Components Safety Function Identification

12 NUS Telecon B. Cutbert (Dow Corning) and R. Steinberg (NUS) dated December 10, 1981.

Figure 1

LIMITING TRANSIENT TEMPERATURE AND PRESSURE IN STEAM TUNNEL

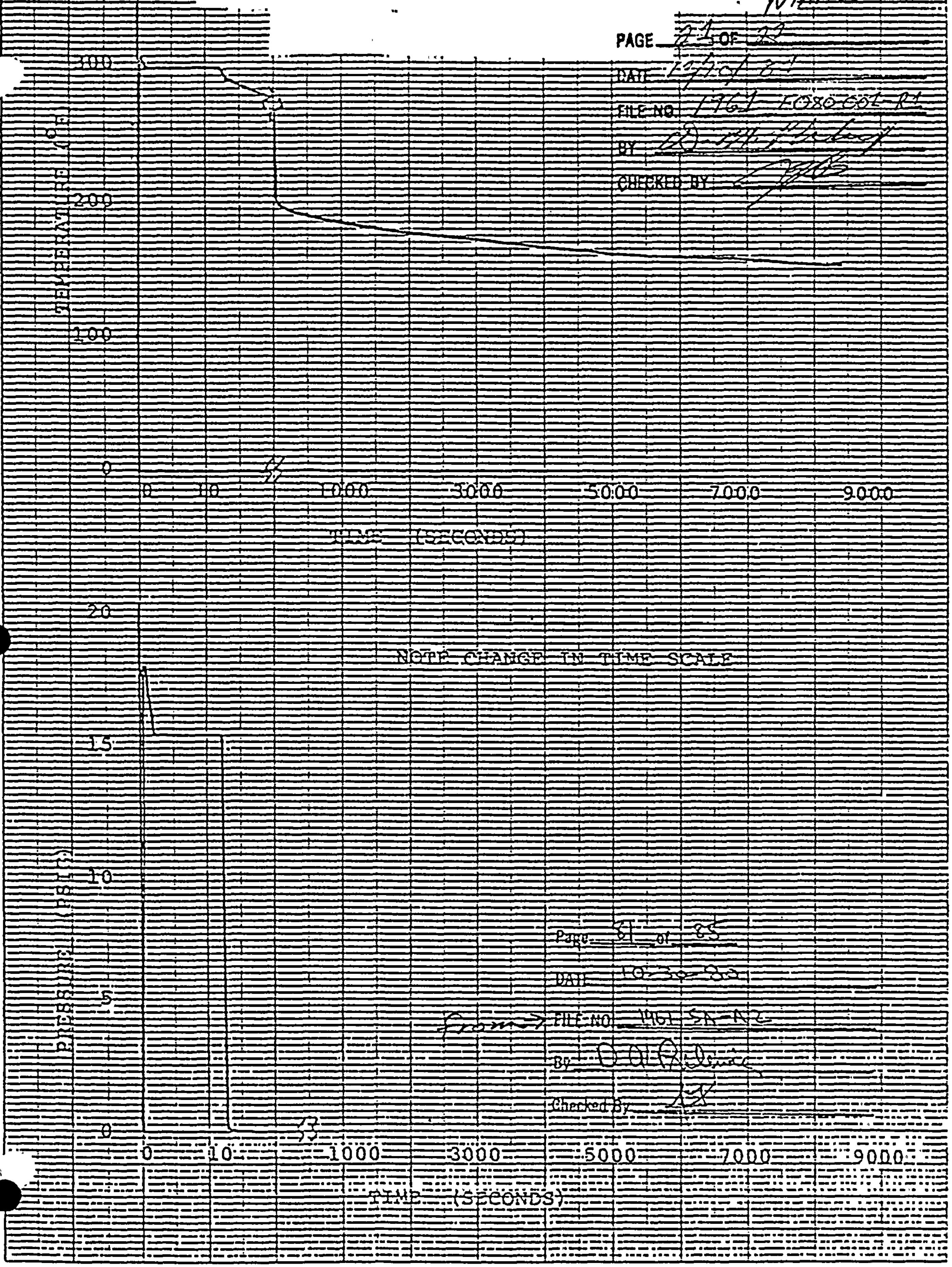

Table 1
Materials List and Qualification Data
for
Fenwal Model 17002-40 Temperature Switch

Component Material	Manufacturer Rating	Radiation Threshold: Material Analyzed	Radiation Threshold: Radiation Threshold (rad)	Radiation Threshold: Reference	Aging Parameters: Material Analyzed	Aging Parameters: Activation Energy (eV)	Aging Parameters: Intercept	Aging Parameters: Reference
Mica Insulation			N/A	Section 9.0		N/A	N/A	Section 9.0
TAGT leadwire Insulation (Mfr. Anaconda)	1x10^6 rad	TGAT (Anaconda)	1x10^6 rad	Ref 3	TFE teflon wire Insulation	1.720 eV	-27.9	Ref 4
Silicone Varnish Dow Corning 991		Dow Corning 997	3.1x10^7 rad	Ref 5	Dow Corning 991	1.172 eV	-19.448	Ref 5
Braided Fiberglass Sleeving			N/A	Section 9.0		N/A	N/A	Section 9.0
Graphite			N/A	Section 9.0		N/A	N/A	Section 9.0
Glass			N/A	Section 9.0		N/A	N/A	Section 9.0

PAGE 22 OF 22
DATE 12/10/81
FILE NO. 1961-F080-001-R1
BY D. [illegible]
CHECKED BY [illegible]
Taken from Ref-10

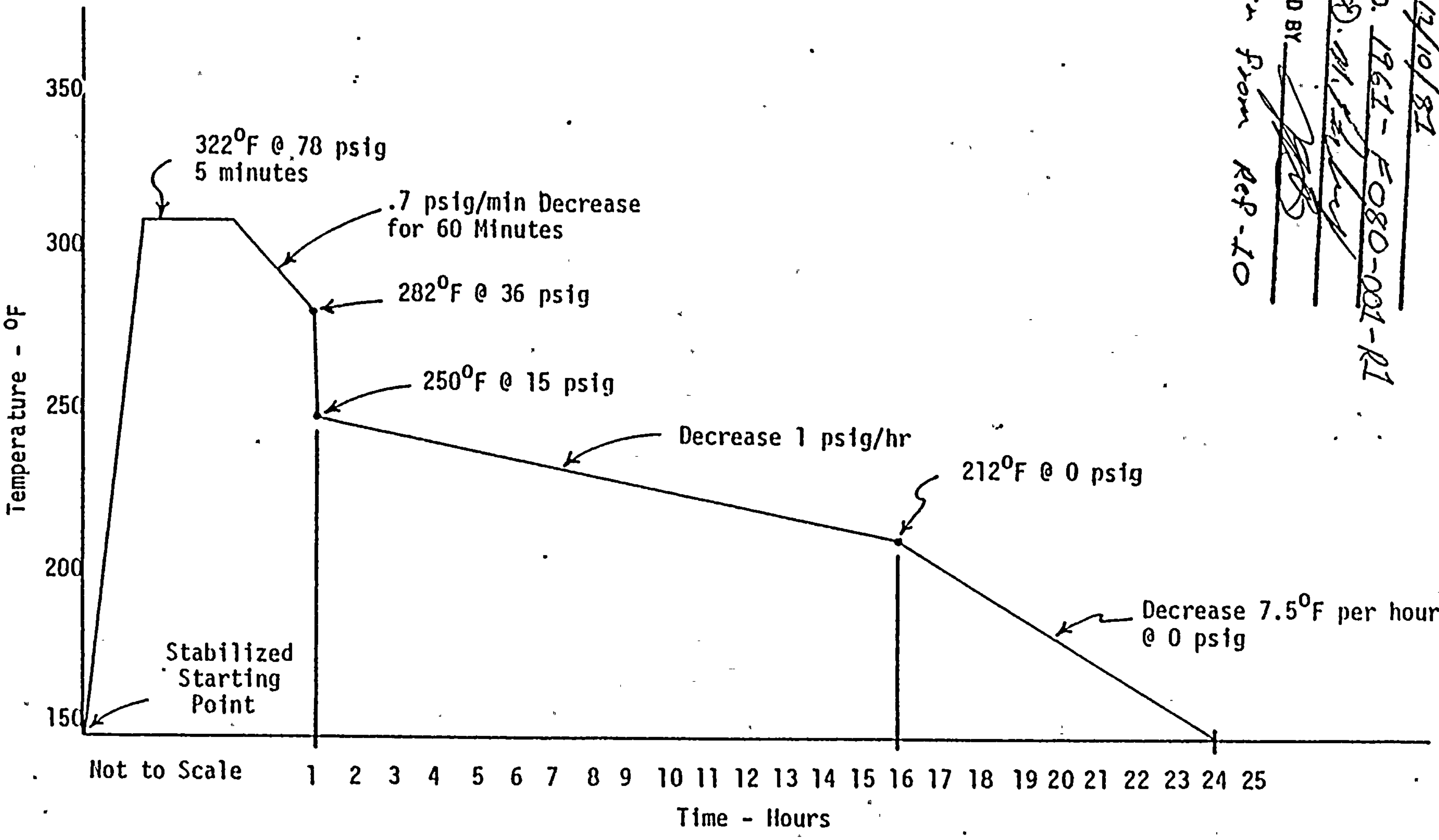

Figure 2 ~~FIGURE 1.~~ POSTULATED ACCIDENT Test ENVIRONMENT PROFILE

QUALITY ASSURANCE RECORD

NUS CORPORATION
CONSULTING DIVISION

RECORD OF SYSTEM/COMPONENT ANALYSES

FILE NO.:	NO. OF PAGES:	NUMBER OF VOLUMES OF COMPUTER OUTPUT:
1961-F135-001	20	NA

CLIENT: NMPC

PROJECT NO.: 1961

ANALYSIS TITLE: ENVIRONMENTAL QUALIFICATION ASSESMENT FOR FISHER TYPE 546 ELECTRO-PNEUMATIC TRANSDUCER

AUTHOR: ROGER STEINBERG

PURPOSE OF ANALYSIS: TO ASSESS THE ABILITY OF THE FISHER TYPE 546 ELECTRO-PNEUMATIC TRANSDUCER TO PERFORM ITS SAFETY RELATED FUNCTION IN NORMAL AND HARSH ENVIRONMENTS AT NMP-1

SUMMARY OF ANALYSIS PROCEDURE AND RESULTS:

TEST DATA AS WELL AS ANALYSIS OF MATERIALS USING THE ARRHENIUS THEORY WERE USED TO DETERMINE IF THE FISHER TYPE 546 ELECTROPNEUMATIC TRANSDUCER COULD PERFORM ITS SAFETY RELATED FUNCTION IN NORMAL AND HARSH ENVIRONMENTS AT NMP-1. IT WAS CONCLUDED THE TRANSDUCER COULD WITHSTAND 1.4×10^6 RADS TOTAL INTEGRATED RADIATION DOSE. IT WAS ALSO CONCLUDED THAT WITH A REGULAR REPLACEMENT PROGRAM TO REPLACE BUNA-N COMPONENTS, THE TRANSDUCER COULD WITHSTAND A HARSH ENVIRONMENT OF 200°F, 9PSIG FOR APPROXIMATELY 79 HOURS. BASED ON THE ARRHENIUS THEORY IT WAS CONCLUDED THAT THE LIFE OF BUNA-N COMPONENTS AT NORMAL SERVICE CONDITIONS WAS 12.5 YEARS NECESSITATING A REGULARLY SCHEDULED REPLACEMENT PROGRAM FOR THE BUNA-N COMPONENTS

DATE COMPLETED: 11/19/81

VERIFICATION REQUIRED: ☒ YES ☐ NO

ANALYSIS REVIEWED AND ACCEPTED: (DISCIPLINE MANAGER) [signature] **DATE:** 12-11-81

ANALYSIS:	BY: (FILE NO.)	DISCIPLINE MANAGER:	DATE:
☐ SUPERSEDED ☐ SUPPLEMENTED			

NUS 202 10 REVISED 0181
(Formerly CD-28 12/77)

NUS CORPORATION
CONSULTING DIVISION

RECORD OF ANALYSIS VERIFICATION

FILE NO.: 1961-F135-001

PAGE 1 **OF** 2

ANALYSIS TITLE:

Environmental Qualification Assessment for Fisher Type 546 Electro-Pneumatic Transducer

AUTHOR:	NO. OF PAGES:	NO. OF VOLUMES OF COMPUTER OUTPUT:
R. Steinberg	20	NA

VERIFICATION SCOPE (CHECK AS APPLICABLE):

- [x] METHOD OF ANALYSIS
- [x] ASSUMPTIONS
- [x] INPUT INFORMATION
- [ ] COMPUTER CODE APPLICATION
- [ ] CHECK OF SAMPLE CALCULATION
- [x] SPOT CHECK OF MATHEMATICS
- [ ] REASONABLENESS OF RESULTS
- [ ] COMPLETE CHECK OF MATHEMATICS
- [ ] PARTIAL INDEPENDENT ANALYSIS

BUDGET: (APPROXIMATE)	DESIRED COMPLETION DATE:
1/4 MANDAYS	12/11/81

DESCRIPTION OF VERIFICATION—ACTIVITIES, FINDINGS AND RESOLUTION:

6.4 SR Function page 5 need to be determined.

9.3 Magnet wire coating not addressed PD (probably much more able to withstand environment than

Buna-N TB's not addressed - same thing as above.

P. 12 t, 268.76 hrs also page 14

all pages — change file number to NUS-1961-F135-001

Resolution

(1) Stated safety related function. RS

(2) 9.3. Added assumption 9.7, page 11 to address this. RS

(3) PG. 12 & 14 moved decimal point to correct data. RS

RECORD OF ANALYSIS VERIFICATION

VERIFIER'S SIGNATURE: [signature]

DATE: Dec 10 1981

ACCEPTANCE BY: (DISCIPLINE MANAGER) [signature]

DATE: 12-11-81

FINAL ANALYSIS REVIEW CHECKLIST

Project #/Project Title 1961 Client NMPC

Date: Mar 24, 1987

Analysis File Title: ENVIRONMENTAL QUALIFICATION ASSESSMENT FOR FISHER TYPE 546 ELECTRO-PNEUMATIC TRANSDUCER

Analysis File Number: 1961-F135-001

Checklist Item	Yes	N/A
1. Unique Analysis File Number assigned to the file.	✓	
2. Analysis recorded on CD-60	✓	
a. pages numbered	✓	
b. total pages specified	✓	
c. all pages dated	✓	
d. client identified on each page	✓	
e. correct file number on each page	✓	
f. author(s) specified on each page	✓	
g. subject specified on each page	✓	
h. verifier initials on each page	✓	
3. Analysis File includes:		
a. client identification	✓	
b. analysis file number	✓	
c. analysis title	✓	
d. author(s) identification	✓	
e. description of the purpose of the analysis	✓	
f. discussion of the general method of analysis	✓	
g. identification of input information source	✓	
h. identification of input information status	✓	
i. major assumptions used in performing the analysis	✓	

Date: Mar 24, 1961

3.	(Continued)		
	j. important references, including material properties	✓	
	k. identification of specific versions of codes used		✓
	l. detailed calculation	✓	
	m. listing of computer input		✓
	n. microfiche of computer output		✓
	o. summary of results	✓	
4.	Record of analysis provided onn CD-28	✓	
5.	All applicable entries on CD-28 correct.	✓	
6.	All referenced NUS internal memos included in analysis file.	✓	
7.	All referenced telecons included in analysis file.	✓	
8.	Separate computer output labeled with analysis file number.	✓	
9.	Record of analysis file verification on CD-29.	✓	
10.	All entries on CD-29 completed and correct.	✓	
11.	Item (7) of CD-29 completed and comments numbered	✓	
12.	Verification checklist CD-30 included.	✓	
13.	Computer code used verified per QAI 3.5.		✓
14.	Corrected items crossed out clearly enough to show on Xerox copies.	✓	
15.	List of input information and major assumptions checked for commpleteness.	✓	
16.	Documents Complete (Page Count)	✓	
17.	Documents Legible and Reproducible	✓	
18.	All Documents Identified on Index Received	✓	
19.	Documents Properly Paginated	✓	
20.	Documents Identified to Project/Item	✓	
21.	All Unsatisfactory Conditions Resolved (List)	✓	

Date 24 Mar 1987

22. Remarks:

Reviewed by: [signature] 24 Mar 1987
Date

[initials] 12-11-87

NUS CORPORATION
CONSULTING DIVISION

ANALYSIS VERIFICATION CHECKLIST

ANALYSIS TITLE: ENVIRONMENTAL QUALIFICATION ASSESSMENT FOR FISHER TYPE 546 ELECTRO-PNEUMATIC TRANSDUCER

ANALYSIS FILE NUMBER: 1961 – F135 – 001

INDICATE "YES, NO, OR N/A (NOT APPLICABLE)," FOR EACH ITEM AND INCLUDE IN ANALYSIS PACKAGE WITH RECORD OF ANALYSIS VERIFICATION	YES	NO	N/A
METHOD OF ANALYSIS			
IS THE METHOD USED APPROPRIATE CONSIDERING THE PURPOSE AND TYPE OF ANALYSIS AND THE USE AND ACCEPTABILITY OF THE RESULTS (i.e., MARGIN TO LIMITS)?	☑	☐	☐
IS THE METHOD IN ACCORDANCE WITH CODES, STANDARDS, AND REGULATORY REQUIREMENTS?	☑	☐	☐
HAS THE METHOD BEEN EMPLOYED ELSEWHERE IN INDUSTRY OR IN LICENSE APPLICATIONS?	☑	☐	☐
ASSUMPTIONS			
ARE ASSUMPTIONS NECESSARY TO PERFORM THE ANALYSIS ADEQUATELY DESCRIBED AND REASONABLE?	☑	☐	☐
WHERE NECESSARY, ARE THE ASSUMPTIONS IDENTIFIED FOR SUBSEQUENT RE-VERIFICATIONS WHEN THE DETAILED DESIGN ACTIVITIES ARE COMPLETED?	☑	☐	☐
INPUT INFORMATION			
ARE THE INPUTS INTO THE ANALYSIS STATED AND THEIR SOURCE IDENTIFIED?	☑	☐	☐
IS THE INPUT INFORMATION FROM THE LATEST AVAILABLE REVISION TO THE DOCUMENT?	☑	☐	☐
IS THE STATUS (PRELIMINARY, CONCEPTUAL, ETC.) OF THE INPUT SOURCE IDENTIFIED FOR LATER CONFIRMATION OF THE VALIDITY OF THE INPUT?	☑	☐	☐
ARE THE INPUTS SUFFICIENT CONSIDERING THE PURPOSE OF THE ANALYSIS?	☑	☐	☐
COMPUTER CODE APPLICATION			
ARE ALL CODES USED IDENTIFIED ALONG WITH SOURCE, COMPUTER TYPE, INPUTS, AND OUTPUTS?	☐	☐	☑
HAS THE CODE BEING USED BEEN ADEQUATELY VERIFIED?	☐	☐	☑
IS THE CODE SUITABLE FOR THE PRESENT ANALYSIS?	☐	☐	☑
DOES THE COMPUTER MODEL (NODING, TIME STEPS, ETC.) ADEQUATELY REPRESENT THE PHYSICAL SYSTEMS?	☐	☐	☑
REASONABLENESS OF RESULTS			
IS THE MAGNITUDE OF THE RESULT REASONABLE?	☑	☐	☐
ARE THE DIRECTION OF TRENDS REASONABLE?	☑	☐	☐

PREPARED BY: [signature]

DATE: 24 Nov 1987

NUS 204 10 REVISED 0181
(Formerly CD-30 Rev. 1)

NUS CORPORATION

DATE November 17, 1981

CLIENT NMPC FILE NO. 1961-E135-001 BY R. Steinberg

SUBJECT Environmental Qualification for Fisher Type 546 Electropneumatic Transducer Checked By [signature]

ENVIRONMENTAL QUALIFICATION ASSESSMENT

FOR

FISHER TYPE 546 ELECTROPNEUMATIC TRANSDUCER

FOR USE IN

NIAGARA MOHAWK POWER CORPORATION'S

NINE MILE POINT-1

NUCLEAR POWER GENERATING STATION

NUS CORPORATION

2536 COUNTRYSIDE BOULEVARD

CLEARWATER, FL. 33528

NUS CORPORATION

DATE November 17, 1981

CLIENT NMPC FILE NO. 1961-F135-001 BY R. Steinberg

SUBJECT Environmental Qualification for Fisher Type 546 Electropneumatic Transducer Checked By [signature]

TABLE OF CONTENTS

CLIENT NMPC FILE NO. 1961-F135-001 BY R. Steinberg

SUBJECT Environmental Qualification for Fisher Type 546 Electropneumatic Transducer Checked By [signature]

TABLE OF CONTENTS CONTINUED

CLIENT NMPC FILE NO. 1961-F135-001 BY R. STEINBERG

SUBJECT ENVIRONMENTAL QUALIFICATION FOR FISHER TYPE 546 ELECTROPNEUMATIC TRANSDUCER Checked By [signature]

1.0 CLIENT IDENTIFICATION

NIAGARA MOHAWK POWER CORPORATION (NMPC)

2.0 ANALYSIS FILE NO.

1961 – F135-001

3.0 ANALYSIS TITLE

ENVIRONMENTAL QUALIFICATION ASSESSMENT OF FISHER TYPE 546 ELECTROPNEUMATIC TRANSDUCER FOR USE IN NMPC'S NINE MILE POINT - UNIT 1 NUCLEAR GENERATING STATION.

4.0 AUTHOR IDENTIFICATION

R.J. STEINBERG

5.0 PURPOSE OF ANALYSIS

THE PURPOSE OF THIS ANALYSIS IS TO DETERMINE IF THE DESIGN OF THE FISHER TYPE 546 ELECTROPNEUMATIC TRANSDUCER IS ADEQUATE TO ASSURE THAT THE TRANSDUCER WILL OPERATE ON DEMAND TO MEET THE SYSTEM PERFORMANCE REQUIREMENTS UNDER NORMAL ENVIRONMENTAL CONDITIONS AS WELL AS DURING DESIGN BASIS EVENTS AT NMP-1.

6.0 INPUT INFORMATION

6.1 Equipment Identification

THE EQUIPMENT CONSISTS OF FISHER CONTROLS TYPE 546 ELECTROPNEUMATIC TRANSDUCER USED IN THE FOLLOWING SYSTEMS (REF 1).

SYSTEM	ID NUMBER	MODEL NUMBER
RBCLC	70-137	4154882

6.2 MATERIALS

A LISTING OF NON METALLIC COMPONENTS OF THE TYPE 546 ELECTROPNEUMATIC TRANSDUCER WAS NOT OBTAINED FROM THE MANUFACTURER. HOWEVER

NUS CORPORATION

DATE November 17, 1981

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SUBJECT Environmental Qualification for Fisher Type 546 Electro Pneumatic Transducer Checked By [signature]

6.2 CONT. IT IS KNOWN FROM THE TEST REPORT ON THIS ITEM (Ref 2) THAT IT CONTAINS NITRILE RUBBER IN THE FORM OF DIAPHRAGMS AND O RINGS.

6.3. SAFETY RELATED FUNCTION

TYPE 546 ELECTROPNEUMATIC TRANSDUCER THROTTLES CONTROL VALVES FOR TEMPERATURE CONTROL, PROVIDES CONTROLLED COOLING FOR AUXILIARY EQUIPMENT IN REACTOR AND WASTE DISPOSAL BUILDINGS. COOLING WATER SUPPLIED TO SHUT DOWN COOLING HEAT EXCHANGER. (REF 7)

6.4 SERVICE CONDITIONS

THE NORMAL SERVICE CONDITIONS AS SPECIFIED BY NMPC (Ref 3) FOR THE TYPE 546 ELECTRO-PNEUMATIC TRANSDUCER ARE AS FOLLOWS.

- TEMPERATURE: 103°F OR 39.4°C
- PRESSURE: 0 PSIG
- RELATIVE HUMIDITY: 50 - 90% Assumed
- RADIATION: 1×10^4 Rads Assumed
- DURATION: 40 YEARS
- OPERATIONAL CYCLING: NONE SPECIFIED

THE HARSH ENVIRONMENT CONDITIONS TO WHICH THE SUBJECT TRANSDUCER MAY BE EXPOSED DURING A DESIGN BASIS EVENT (HELB OR LOCA) WERE OBTAINED FROM NUS ANALYSIS 1961-SA-A1 (Ref 4)

CLIENT NMPC FILE NO. 1961-F135-001 BY R. Steinmaag

SUBJECT Environmental Qualification for Fisher Type 546 Electropneumatic Transducer Checked By [signature]

6.5 CONT.

And 1961-R-1 (Ref 5). Temperature and pressure plots for a design basis event are presented in Figure I (Ref 8) the maximum conditions that the Type 546 Electropneumatic Transducer may be subject to are as follows.

- Temperature: (Ref 4) 300 °F - 151.7 °C
- Pressure: (Ref 4) .1 PSIG
- Relative Humidity: 100% Assumed
- Radiation: (Ref 5) 1×10^6 Rads
- Duration: (Ref 8) < 30 seconds at maximum conditions
- Cycling: None Specified

7.0 Method of Analysis

7.1 Materials

A list of non metalic materials was not obtained from the manufacturer of the subject transducer. However for those non-metalic components known to be included in the construction of the transducer (See paragraph 6.3 this analysis), a literature search was conducted to obtain radiation and temperature threshold levels, and time/temperature aging data, for those materials that may be subject to degradation from these factors.

CLIENT NMPC FILE NO. 1961-F135-001 BY R Steinberg

SUBJECT Environmental Qualification for Fisher Type 546 Electropneumatic Transducer Checked By [signature]

7.2 Radiation

A literature search was conducted to determine the radiation threshold level for the known organic materials used in the Fisher Type 546 transducer.

7.3 Time/Temperature Effects

The present state of the art allows acceleration of the aging effects of temperature by subjecting a material to increased temperatures for a relatively short duration. For many non metallic materials, it is known that the degradation process can be defined by a single temperature-dependent reaction that follows the Arrhenius equation:

$$K = A \exp -\left(E_a / K_b T\right) \qquad (1)$$

where,

K = Reaction Rate

A = Frequency Factor

EXP = Exponent to Base e

E_a = Activation Energy (eV)

K_b = Boltzman's Constant

T = Absolute Temperature

CLIENT NMPC FILE NO. 1961-F135-001 BY R STEINBERG

SUBJECT ENVIRONMENTAL QUALIFICATION FOR FISHER TYPE 546 ELECTRO PNEUMATIC TRANSDUCER Checked By [signature]

7.3 CONT.

EQUATION (1) CAN ALSO BE EXPRESSED IN A FORM WHICH YIELDS AN EXPECTED LIFETIME OF THE MATERIAL AT A SPECIFIC TEMPERATURE THIS FORM IS:

$$\ln \tau_i = E_a/k_b \left(1/T_i \right) + I \qquad (2)$$

WHERE:

LN = NATURAL LOGARITHM

τ_i = EXPECTED LIFE AT TEMPERATURE T_i (HOURS)

T_i = SERVICE TEMPERATURE FOR LIFE τ_i (°K)

I = CONSTANT (INTERCEPT)

EQUATION (2) CAN ALSO BE REPRESENTED IN A LINEAR REGRESSION LINE AS

$$Y_i = mX_i + I \qquad (3)$$

WHERE

$Y_i = \ln \tau_i$

$X_i = 1/T_i$

$m = E_a/k_b$

I = CONSTANT (INTERCEPT)

CLIENT NMPC FILE NO. 1961-F135-001 BY R. Steinberg

SUBJECT Environmental Qualification for Fisher Type 546 Electropneumatic Transducer Checked By [signature]

7.3 CONT.

For the purpose of this analysis the Arrhenius equation is used to calculate the expected life of the known non metallic material used in the type 546 Electropneumatic Transducer. Time/Temperature test data was collected from available literature on the temperature sensitive material and the activation energy and intercept calculated for the specified failure criteria. (Ref 6). The activation energy and intercept were then used to calculate the expected life of the material under the maximum harsh environment temperature conditions. If the life calculated for the material at harsh environment temperature conditions exceeds 40 years, no futher analysis was done because the harsh environment maximum temperature envelopes all other temperature conditions. If the material life as calculated above did not exceed 40 years, then the expected life at ambient conditions was also calculated and a determination of the expected life was made using the combination of 40 years at normal service conditions and the specified duration of a design basis event.

7.4 Harsh environment - Design Basis event.

A Fisher type 546 Electropneumatic Transducer was exposed to harsh environment conditions in a test conducted on both type 546 transducer and a type 67FR supply pressure regulator. (Ref 2)

CLIENT NMPC FILE NO. 1961-F135-001 BY R. STEINBERG

SUBJECT ENVIRONMENTAL QUALIFICATION FOR FISHER TYPE 546 ELECTROPNEUMATIC TRANSDUCER Checked By [signature]

7.5 CYCLING

A CYCLE TEST WAS DONE ON THE FISHER TYPE 546 ELECTROPNEUMATIC TRANSDUCER (REF 2)

8.0 COMPUTER CODES

COMPUTER CODES WERE NOT USED IN THIS ANALYSIS

9.0 MAJOR ASSUMPTIONS

9.1 IT IS ASSUMED THAT FOR THE PURPOSE OF THIS ANALYSIS THE DETERIORATION OF ANY METALLIC COMPONENTS DUE TO TIME/TEMPERATURE EFFECTS AND RADIATION EXPOSURE IS INSIGNIFICANT.

9.2 IT IS ASSUMED THAT THE KNOWN ORGANIC MATERIAL WILL BE THE LIMITING FACTOR FOR TIME/TEMPERATURE EFFECTS AND RADIATION EXPOSURE

9.3 IT IS ASSUMED THAT NITRILE RUBBER WILL BE THE LIMITING ORGANIC MATERIAL OF THE FISHER TYPE 546 TRANSDUCER.

9.4 IT IS ASSUMED THAT THE TYPICAL TEST DATA USED FOR BUNA-N IN REFERENCE 6 IS APPLICABLE TO THE O-RINGS AND DIAPHRAGM OF THE TYPE 546 ELECTROPNEUMATIC TRANSDUCER.

9.5 IT IS ASSUMED THAT THE RADIATION THRESHOLD LEVEL STATED IN REFERENCE 6 FOR BUNA-N IS APPLICABLE TO THE O-RINGS AND DIAPHRAGM OF THE TYPE 546 ELECTROPNEUMATIC TRANSDUCER

NUS CORPORATION

DATE November 17, 1981

CLIENT NMISC FILE NO. 1961-F135-001 BY R Steinberg

SUBJECT Environmental Qualification for Fisher Type 546 Electropneumatic Transducer Checked By [signature]

9.0 Continued

9.6 It is known that the Type 546 Transducer contains nitrile rubber as orings and diaphragms, however familiarity with the equipment suggests that there are also wires, terminal block, and a coil with magnet wire, used in the manufacture of the transducer. Experience dictates that these components generally have a much higher threshold level for radiation and time/temperature effects. For this reason then, it is assumed that they will not be a limiting factor in the qualification of the Type 546 transducer.

NUS CORPORATION

DATE November 17, 1981

CLIENT NMPC FILE NO. 1961-E135-001 BY R. STEINBERG

SUBJECT Environmental Qualification For Fisher Type 546 Electro Pneumatic Transducer Checked By [signature]

10.0 DETAILED CALCULATIONS

LIFE CALCULATION FOR NITRILE (BUNA-N) O-RINGS AND DIAPHRAGM USED IN TYPE 546 ELECTRO PNEUMATIC TRANSDUCER AT 300°F. (HARSH ENVIRONMENT MAXIMUM TEMPERATURE)

$300°F = 421.8°K$

$$Ln\tau_i = \frac{E_a}{K_b}\left(\frac{1}{T_1}\right) + I \qquad (2)$$

$Ln\tau_i$ = LIFE IN HOURS

E_a = 0.75065 eV (REF 6)

K_b = 8.617×10^{-5} eV/°K

T_i = 421.8°K

I = −16.2810 (REF 6)

$$Ln\tau_i = \frac{0.75065}{8.617 \times 10^{-5}\ eV/°K}\left(\frac{1}{421.8K}\right) - 16.2810$$

$Ln\tau_i$ = 4.371

τ_i = 79.17 HOURS

CLIENT NMPC FILE NO. 1961-F135-001 BY R. STEINBERG

SUBJECT ENVIRONMENTAL QUALIFICATION FOR FISHER TYPE 546 ELECTROPNEUMATIC TRANSDUCER Checked By [signature]

10.0 CONTINUED

LIFE CALCULATION FOR NITRILE (BUNA-N) ORINGS AND DIAPHRAGM USED IN TYPE 546 ELECTROPNEUMATIC TRANSDUCER AT 103°F (AMBIENT CONDITIONS)

$103°F = 312.4°K$

$$LN\tau_i = E_a/K_b \left(1/T_i \right) + I \qquad (2)$$

$LN\tau_i$ = LIFE IN HOURS

E_a = 0.75065 eV (REF 6)

$K_b = 8.617 \times 10^{-5}$ eV/°K

T_i = 312.4°K

I = −16.2810 (REF 6)

$$LN\tau_i = \frac{0.75065}{8.617 \times 10^{-5} \text{ eV/°K}} \cdot \left(\frac{1}{312.4°K}\right) - 16.2810$$

$LN\tau_i = 11.60$

$\tau_i = 1.09 \times 10^5$ HOURS = 12.5 YEARS

10.0 Continued

It has been determined by the previous calculation that Buna-N is the most age sensitive material used in the subject transducer. The following calculation determines the loss of life for Buna-N should it be exposed to maximum harsh temperature conditions during its normal service life of 12.5 years at normal service temperatures.

$$\tau_2 = \tau_1 \exp\left[\frac{E_a}{K_b}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)\right] \quad (4)$$

Where

τ_1 = Time at T_1

τ_2 = Equivalent time at T_2

E_a = Activation energy (eV)

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

T_1 = Harsh environment temperature (°K)

T_2 = Normal service temperature (°K)

Where

τ_1 = 30 seconds - (Ref 8) Table I

E_a = .75065 eV (Ref 6)

K_b = 8.617×10^{-5} eV/°K

T_1 = 300°F = 421.8°K

T_2 = 103°F = 312.4°K

$$\tau_2 = \frac{1}{120} \exp\left[\frac{.75065}{8.617 \times 10^{-5}}\left(\frac{1}{312.4} - \frac{1}{421.8}\right)\right]$$

τ_2 = 11.52 Hours = .48 days

CLIENT NMPC FILE NO. 1961-F135-001 BY R. STEINBERG

SUBJECT ENVIRONMENTAL QUALIFICATION FOR FISHER TYPE 546 ELECTROPNEUMATIC TRANSDUCER Checked By [signature]

11.0 RESULTS

11.1 RADIATION

AS INDICATED IN TABLE I NITRILE RUBBER (BUNA-N) IS THE ONLY MATERIAL CONSIDERED IN THIS ASSESSMENT. A LITERATURE SEARCH WAS CONDUCTED AND THE RADIATION THRESHOLD LEVEL FOR BUNA-N WAS DETERMINED TO BE 1.4×10^6 RADS (REF 6)

11.2 TIME/TEMPERATURE EFFECTS

AS INDICATED IN TABLE I NITRILE RUBBER (BUNA-N) IS THE ONLY MATERIAL CONSIDERED IN THIS ASSESSMENT. A LITERATURE SEARCH WAS CONDUCTED AND AUDITABLE TIME/TEMPERATURE DATA WAS OBTAINED. USING THE ARRHENIUS EQUATION IT WAS CALCULATED THAT BUNA-N HAS AN EXPECTED LIFE AT AMBIENT CONDITIONS (103°F) OF 12.5 YEARS. AT THE MAXIMUM HARSH ENVIRONMENT TEMPERATURE (300°F) THE EXPECTED LIFE WAS CALCULATED TO BE 79.17 HOURS.

11.3 HARSH ENVIRONMENT

A TYPE 546 ELECTROPNEUMATIC TRANSDUCER WITH A 67FR REGULATOR WAS TESTED FOR ONE HOUR IN A 320°F, 75.2 PSIG SATURATED STEAM ATMOSPHERE AND THEN FOR 12 MORE HOURS WITH THE STEAM TEMPERATURE LOWERED TO 288°F, 41.3 PSIG. THE TRANSDUCER WAS EXERCISED AFTER THE FIRST HOUR AND SEVERAL TIMES THEREAFTER DURING THE 13 HOUR TEST. THROUGHOUT THE TEST, THE 546 TRANSDUCER REMAINED FUNCTIONAL. THE TEST REPORT (REF 2) CONCLUDES THAT THE

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SUBJECT ENVIRONMENTAL QUALIFICATION OF FISHER TYPE 546 ELECTRO PNEUMATIC TRANSDUCER Checked By [signature]

11.3 CONT

546 TRANSDUCER WOULD FUNCTION BOTH DURING AND AFTER AN ENVIRONMENTAL ATMOSPHERE (AS DESCRIBED) FOR UP TO 13 HOURS.

11.4 CYCLING

THE TYPE 546 TRANSDUCER WAS SUBJECTED TO 27,000 OPERATIONAL CYCLES AT 200°F DURING A 25 DAY PERIOD. THERE WERE NO DETRIMENTAL EFFECTS AND THE TRANSDUCER WAS STILL FUNCTIONAL. (REF 2)

12.0. SUMMARY OF RESULTS AND CONCLUSIONS.

12.1 RADIATION

THE LITERATURE SEARCH CONDUCTED FOR NITRILE RUBBER (BUNA-N) FOUND THAT THE RADIATION SAFE LEVEL IS 1.4×10^6 RADS, THIS VALUE IS GREATER THAN THE 1×10^6 RAD EXPOSURE IT WILL RECIEVE DURING A DESIGN BASIS EVENT.

12.2 TIME/TEMPERATURE EFFECTS

BASED ON AN ANALYSIS OF BUNA-N THE ONLY KNOWN NON METALLIC MATERIAL USED IN THE TYPE 546 TRANSDUCER, USING THE ARRHENIUS THEORY IT IS EXPECTED THAT THE TRANSDUCER HAS ONLY A 12.5 YEAR EXPECTED LIFE AT AMBIENT CONDITIONS (103°F), AND 79.17 HOURS AT MAXIMUM HARSH ENVIRONMENT TEMPERATURE. IF A DESIGN BASIS EVENT SHOULD OCCUR DURING THE 12.5 YEAR NORMAL TEMPERATURE LIFE, THE RESULTANT LOSS

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SUBJECT ENVIRONMENTAL QUALIFICATION FOR FISHER TYPE 546 ELECTRO PNEUMATIC TRANSDUCER Checked By

12.2 CONT.

TO NORMAL NORMAL SERVICE LIFE WOULD BE ABOUT ONE HALF DAY. IN THE ABSONSE OF A REGULAR REPLACMENT OF BUNA-N COMPONENTS, THE TRANSDUCER CANNOT BE EXPECTED TO PERFORM ITS SAFETY RELATED FUNCTION DURING AN END OF LIFE HELB OR LOCA.

12.3 HARSH ENVIRONMENT

SUBJECT TO A REGULARLY SCHEDULED REPLACMENT PROGRAM FOR THE AGE SENSITIVE MATERIALS, IT CAN BE CONCLUDED THAT BASED ON THE HARSH ENVIRONMENT TEST, (REF 2) THE TRANSDUCER IS QUALIFIED FOR A HARSH ENVIRONMENT OF 320°F, 75.3 PSIG PRESSURE. THESE VALUES ARE IN EXCESS OF THE 300°F, 9 PSIG HARSH ENVIRONMENT CONDITIONS TO WHICH THE TRANSDUCER COULD BE EXPOSED TO AT NMP-1.

12.4 RECOMMENDATIONS

IT IS RECOMMENDED THAT BUNA-N COMPONENTS IN THE TYPE 546 ELECTROPNEUMATIC TRANSDUCER BE REPLACED ON A REGULARLY SCHEDULED BASIS. THE MAXIMUM LIFE OF BUNA-N AT NORMAL SERVICE TEMPERATURE IS CALCULATED TO BE APPROXMATLY 12.5 YEARS. THESE COMPONENTS SHOULD BE REPLACED APPROXMATLY EVERY FIVE YEARS TO BE SAFE AND CONSERVATIVE.

CLIENT NMPC FILE NO. 1961-F135-00 BY R. STEINBERG

SUBJECT ENVIRONMENTAL QUALIFICATION FOR FISHER TYPE 546 ELECTROPNEUMATIC TRANSDUCER Checked By [signature]

13.0 References

1. NIAGARA MOHAWK POWER CORPORATION, NMP-1 ON GOING ASSESSMENT SUMMARY DATED 11/5/81.

2. FISHER CONTROLS REPORT NA-23 REVISION A DATED 2/16/81

3. NIAGARA MOHAWK POWER CORPORATION SUPPLIED NORMAL SERVICE CONDITIONS - MEMO FROM DAVE GREEN NMPC TO DEEPAK BAHTIA NUS DATED 3/11/81

4 NIAGARA MOHAWK POWER CORPORATION, NMP-1 PRESSURE AND TEMPERATURE MODEL FOR REACTOR BUILDING. NUS ANALYSIS NUMBER 1961-SA-A1 DATED 12/9/80

5 NIAGARA MOHAWK POWER CORPORATION RADIATION ENVIRONMENT SPECIFICATIONS FOR NMP-1 NUS ANALYSIS NUMBER 1961-R-1 DATED 10/25/81

6 NUS REPORT NUMBER NUS-LA-A-001 MATERIAL ANALYSIS OF ACRYLONITRILE RUBBER DATED 11/23/81

7 INTERNAL CORRESPONDENCE S. GAZDA (NUS) TO A. CANEPA (NUS) CD-ENG-9.26 DATED 11/23/81 NMPC SER RESPONSE PROJECT 1961 QUALIFIED COMPONENTS - SAFETY RELATED FUNCTION

8 NMPC RESPONSE TO NRC SAFETY EVALUATION REPORT OF 6/8/81 FOR NMP-1 DATED 9/8/81

DATE November 17, 1981

E135-001 By R. STEINBERG

ISHER DUCER Checked By [signature]

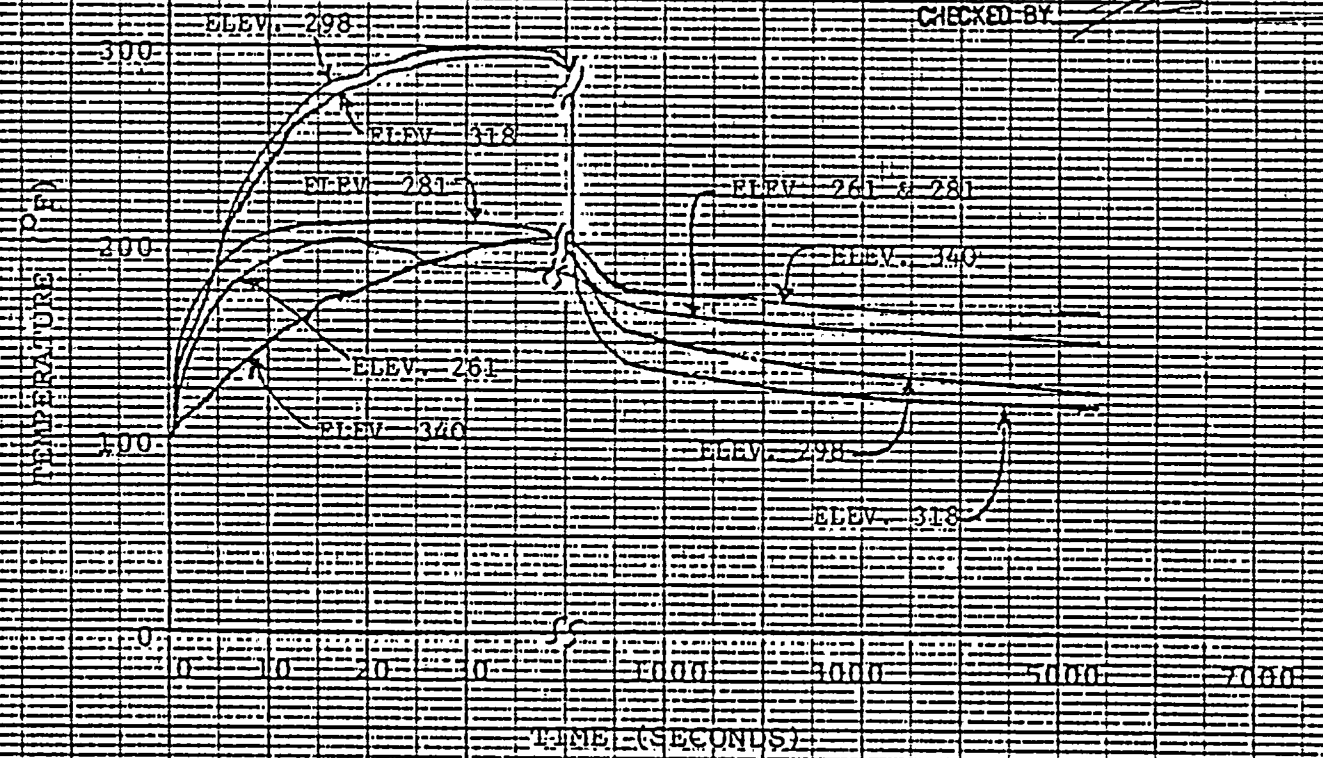
COMPONENT MATERIAL	MANUFACTURE RATING PT	REFERENCE
NITRILE RUBBER (BUNA-N)	NOT AVAILABLE	REF 6

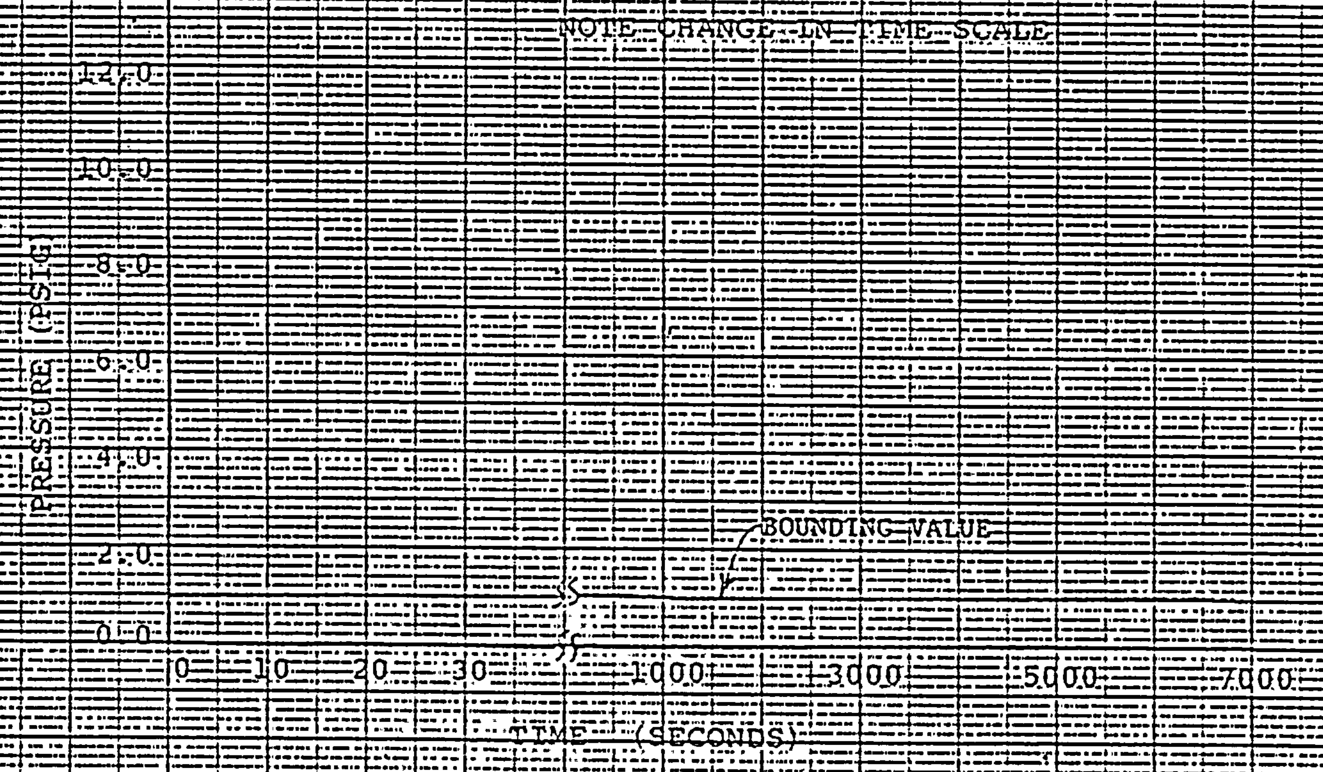
DATE November 17, 1981
FILE NO. [illegible]
BY R. [illegible]
CHECKED BY [illegible]

FIGURE I
(REF 8)

Fig. 4-9

LIMITING TEMPERATURE AND PRESSURE IN OPEN FLOOR AREAS NOT NEAR BREAK LOCATIONS





BWR EQUIPMENT QUALIFICATION SUMMARY

OK VJB

SUMMARY REPORT NO. QSR-044-E-01	COMPILED BY: E. L. Glass / E. L. GLASS DATE 9-11-80
	VERIFIED BY: R A GORDON RA Gordon DATE: 9-11-80

JAK 10/8/80

I. EQUIPMENT DESCRIPTION

ITEM Pressure Transmitter MFG. Bailey Meter MODEL(S) 551

FUNCTION measure and transmit the pressure at core spray header SIZE(IN.) ______ WT./(LBS) ______

II. EQUIPMENT LOCATION

BOSTON EDISON	GEORGIA POWER	MISS. P & L	PHILADELPHIA ELEC.
PILGRIM 1 ☐	HATCH 1 ☐	GRAND GULF 1 ☐	LIMERICK 1 ☐
CAROLINA P & L	HATCH 2 ☐	GRAND GULF 2 ☐	LIMERICK 2 ☐
BRUNSWICK 1 ☐	GULF STATES	NEBRASKA PUB POWER	PEACH BOTTOM 2 ☐
BRUNSWICK 2 ☐	RIVER BEND 1 ☐	COOPER ☐	PEACH BOTTOM 3 ☐
COMMONWEALTH	RIVER BEND 2 ☐	NIAGARA MOHAWK	PUB. SERV E & G
DRESDEN 2 ☒	HOUSTON P & L	NINE MILE PT. 1 ☒	HOPE CREEK 1 ☐
DRESDEN 3 ☐	ALLENS CREEK ☐	NINE MILE PT. 2 ☐	HOPE CREEK 2 ☐
QUAD CITIES 1 ☒	ILLINOIS POWER	NO. INDIANA PSC	TVA
QUAD CITIES 2 ☒	CLINTON 1 ☐	BAILLY ☒	BROWNS FERRY 1 ☐
LA SALLE 1 ☐	CLINTON 2 ☐	NORTHEAST UTIL	BROWNS FERRY 2 ☐
LA SALLE 2 ☐	IOWA ELECTRIC	MILLSTONE 1 ☒	BROWNS FERRY 3 ☐
CINCINNATI G & E	DUANE ARNOLD ☐	NO. STATES POWER	HARTSVILLE 1 ☐
ZIMMER ☐	JERSEY CENTRAL	MONTICELLO ☐	HARTSVILLE 2 ☐
CLEVELAND ELEC. ILUM.	OYSTER CREEK ☒	PASNY	HARTSVILLE 3 ☐
PERRY 1 ☐	LILCO	FITZPATRICK ☐	HARTSVILLE 4 ☐
PERRY 2 ☐	SHOREHAM ☐	PENN P & L	WPPSS
DETROIT EDISON		SUSQUEHANNA 1 ☐	WNP-2 ☐
FERMI 2 ☐		SUSQUEHANNA 2 ☐	YANKEE ATOMIC
			VERMONT YANKEE ☐

III. QUALIFICATION REPORTS

CONTINUED ☐

1. TITLE Temperature Influence DATE Aug 31, 1970
TEST AGENCY G. E. REPORT NO. 383
PROPRIETARY RECORDS AT G.E. RECORDS ATTACHED ☐
FILE NO. DV 145C3006 CONTACT ______

2. TITLE Seismic Test Results DATE 12-26-69
TEST AGENCY General Electric REPORT NO. 225A6263
PROPRIETARY RECORDS AT General Electric RECORDS ATTACHED ☐
FILE NO. DV 145C3006 CONTACT ______

3. TITLE Test Reports 228/241 DATE June 5-69
TEST AGENCY G.E. REPORT NO. 228/241
PROPRIETARY RECORDS AT GE RECORDS ATTACHED ☐
FILE NO. DV145C3006 CONTACT ______

WH 1183 Rev. 2 8/4/80

IV. QUALIFICATION DESCRIPTION

QUALIFICATION METHOD

- NONE LOCATED ☐
- TEST ☒
- ANALYSIS ☐
- ON-GOING ☐
- COMBINATION OF ☐ ______ & ______
- OTHER ______

SEPARATE TESTS ☒
SEQUENTIAL TESTS ☐

TEST SEQUENCE

1. ______ 5. ______
2. ______ 6. ______
3. ______ 7. ______
4. ______ 8. ______

☒ SEE COMMENT (Nort) PAGE 4-1

CYCLE AGING

NONE LOCATED ☒

NUMBER OF CYCLES ______

EQUIP. ENERGIZED? YES ☐ NO ☐

CYCLE AGED PRIOR TO SEVERE ENVIRONMENT TEST YES ☐ NO ☐

☐ SEE COMMENT PAGE ______

RADIATION AGING

NONE LOCATED ☒

NO TEST-JUSTIFIED BY ANALYSIS TO ______ RAD

TYPE OF RADIATION ______

DOSE RATE ______ RAD/HR

TOTAL DOSE ______ RADS

RADIATED PRIOR TO SEVERE ENVIRONMENT TEST YES ☐ NO ☐

☐ SEE COMMENT PAGE ______

TIME-TEMPERATURE AGING

NONE LOCATED ☒ AGING METHODOLOGY ______

NO T-T AGING-JUSTIFIED BY ANALYSIS TO ______ YRS

BASED ON AMBIENT TEMPERATURE OF ______ °F

AGING TEMPERATURE ______ °F

DURATION ______ HRS

RELATIVE HUMIDITY ______ %

T-T AGING PRIOR TO SEVERE ENVIRONMENT TEST YES ☐ NO ☐

GENERAL

	YES	NO
TEST SPECIMEN SAME AS LISTED EQUIPMENT?	☒	☐
EQUIP. MOUNTING SPECIFIED?	☐	☒
ACCEPTANCE/FAILURE CRITERIA STATED?	☒	☐
EQUIPMENT INTERFACES SPECIFIED	☐	☒
SPECIMEN OPERATED DURING TEST?	☒	☐

SEE Comment 4-2 pg 4

☒ SEE COMMENT (Nort) PAGE 4-1

OTHER AGING

______

SUBMERGENCE TEST YES ☐ NO ☒

STANDARDS APPLIED TO TEST:

- IEEE 323-19__ IEEE 382-19__
- IEEE 317-19__ IEEE 383-19__
- IEEE 324-19__ IEEE 344-19__
- NONE STATED ☒

OTHER: ______

☐ SEE COMMENT PAGE ______

COMMENTS: See p. 4.

SEISMIC QUALIFICATION

LOW LEVEL SINE SWEEP ☒
RANGE 5 TO 33 Hz
RATE 1 OCT/MIN.
ACCEL. .02 pk. g's
SING. AXIS ☒
BI-AXIAL ☐
EQUIP OPER? YES ☒ NO ☐
☐ SEE COMMENT PAGE ____

SINE DWELL ☒
ACCEL. ____ : 1.5 g's
FREQ. ____ - 5 Hz
____ Hz 12 Hz
____ Hz ____ Hz
DURATION ____ SEC
SING. AXIS ☒
BI-AXIAL ☐
EQUIP OPER? YES ☒ NO ☐
☐ SEE COMMENT PAGE ____

SINE BEAT ☐ Not applicable
ACCEL. ____ g's
FREQ ____ Hz
____ Hz ____ Hz
____ Hz ____ HZ
OSC./BEAT ____
SING. AXIS ☐
BI-AXIAL ☐
EQUIP OPER? YES ☐ NO ☐
☐ SEE COMMENT PAGE ____

RANDOM MULTIFREQUENCY ☐
RANGE ____ TO ____ Hz
ZPA ____ g's
DURATION ~~Not~~ ~~Noted~~ SEC
DAMPING ~~Noted~~ %
NO. OBE'S None Located
NO. SSE'S ____
SING. AXIS ☐ BI-AXIAL ☐
EQUIP OPER? YES ☐ NO ☐
☐ SEE COMMENT PAGE ____

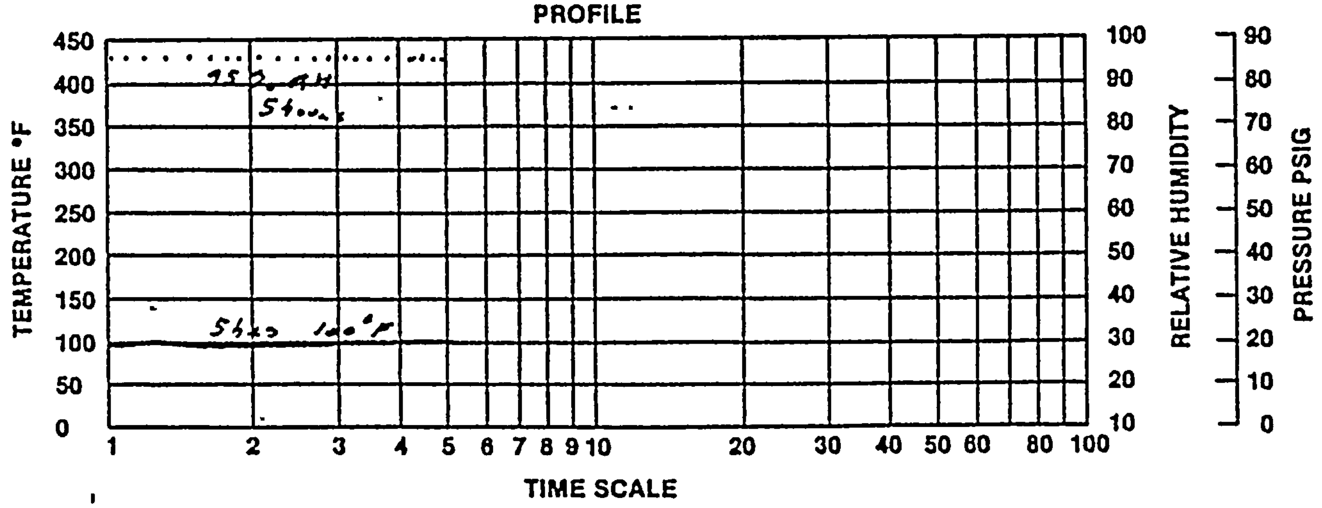
TIME HISTORY ☐ Not applicable
ACCEL. ____ g's
DURATION ____ SEC
NO. OBE'S ____
NO. SSE'S ____
SING. AXIS ☐
BI-AXIAL ☐
EQUIP OPER? YES ☐ NO ☐
☐ SEE COMMENT PAGE ____

COMPLEX WAVE ☐ Not applicable
ZPA ____ g's
INPUT DAMPING ____ %
OUTPUT DAMPING ____ %
NO. OBE'S ____
NO. SSE'S ____
SING AXIS ☐
BI-AXIAL ☐
EQUIP OPER? YES ☐ NO ☐
☐ SEE COMMENT PAGE ____

LOCA, MSLB, HELB, RECIRCULATION AREA

CONTINUED ☐

PROFILE



KEY TO PROFILE CHART
———— TEMP.
– – – – – PRESSURE
· · · · · · · · RELATIVE HUMIDITY
—◆—◆—◆— INDICATES EQUIP. CYCLING

CHEMICAL SPRAY
NONE ☒
CONTENT ____
pH ____
RATE ____ GPM/FT^2
DURATION ____ SEC
EQUIP. OPER? YES ☐ NO ☐

V. TRACABILITY

a. QUALIFICATION APPLIES TO AT LEAST THE FOLLOWING SERIAL NUMBERS:

None Located

b. QUALIFICATION APPLIES TO AT LEAST THE FOLLOWING MANUFACTURING DATES:

None Located

c. OTHER: None.

VI. REMARKS & COMMENTS

4-1) Test Report 383

Temp. Influence

Temp 180°F no %RH specified no pressure or time specified instrument was tested from 0 to 100% of full span. The output in milliamps was checked for error - Passed ok.

Test Report #228

Instrument was operated for 5 hrs at 100°F 95% RH and error limit checked (-0.35%) Checked at 175°F no RH no time given.

Test Report #241

No time, no RH, no PSI, was checked at 186°F error was ±1.04%

4-2) The pressure transmitter must provide a 10 to 50 ma. DC output within a ± 0.5% of span accuracy

WH 1183 Rev. 2 9/4/80

NUTECH COMMUNICATION RECORD

Persons Involved: MILT WOODHAM	Date/Time: 9-9-80 & 9-10-80
Company: BAILEY CONTROLS COMPANY	Recorded By: MILT WOODHAM
☒ Telecon/Ph. No.	Copy To: REH, VJB, FILE
☐ Meeting/Location	Route To:
File: 101.2401.0030	Page 1 of 3
SUBJECT:	COMMON ITEMS; 16, 17, 103, 104, 105, 145, 44, 45, 46, 94, 95

1. CALLED THE BAILEY HOME OFFICE IN WICKLIFFE OHIO, 216-943-5500. THEY REFERED ME TO ONE OF THE BAILEY SERVICE REPRESENTATIVES; ALICE SMITH, 216-944-9011.

2. CALLED ALICE SMITH. SHE TURNED OUT TO BE A COMPONENT (Piece part) buyer. she refered me to two other people
   - TED SNYDER, 216-943-5500.
   - SAN FRANCISCO AREA BAILEY REPRESENTATIVE, 415-569-1716

   MS. SMITH INDICATED THAT TED SNYDER WOULD PROBABLY BE THE ONE TO ANSWER QUESTIONS RELATING TO ANY OLD RECORDS ~~OF~~ PERTAINING TO NUCLEAR QUALIFICATION.

3. CALLED TED SNYDER.
   Supervisor, Renewal Parts technical
   Bailey Controls Co.
   mail stop 301
   29801 EUCLID AVE
   WICKLIFFE OHIO 44092

   - MR. SNYDER HAS NO KNOWLEDGE OF ANY QUALIFICATION TESTING (FOR NUCLEAR APPLICATIONS) DONE BY BAILEY. HE ALSO WAS OF THE OPINION THAT THE BAILEY ~~[illegible]~~ EQUIPMENT ITEMS HAD NOT BEEN APPLIED TO "SAFETY RELATED FUNCTIONS". (THIS DOES NOT AGREE WITH OUR EQUIPMENT ITEM MATRIX).

NUTECH COMMUNICATION RECORD

Persons Involved: MILT WOODHAM	Date/Time: 9-10-80
Company: BAILEY	Recorded By:
☐ Telecon/Ph. No.	Copy To:
☐ Meeting/Location	Route To:
File: 101,2401,0030	Page 2 of 3
SUBJECT:	

- IF WE WANT ~~to~~ BAILEY TO SEARCH THEIR FILES, WE MUST SEND THEM A FORMAL REQUEST IN WRITING. THE OLD GE-MAC ITEMS ARE PROBABLY BEYOND THE SCOPE OF THEIR FILES IN ANY CASE. MY TENTATIVE OPINION IS THAT SUCH A REQUEST IS A WASTE OF TIME.

4. CALLED THE SAN FRANCISCO REPRESENTATIVE OF BAILEY: MR. BILL RAWLING, 415-569-1716. HE HAPPENED TO BE REASONABLY KNOWLEDGABLE ABOUT THE BAILEY/GE MAC EQUIPMENT APPLICATION, AND WAS most helpful.

5. Following is what I CONSIDER TO BE A FAIRLY ACCURATE HISTORY OF THE GE-MAC /BAILEY HISTORY.

GE-MAC (General Electric measurement and control) manufactured a line of pressure transmitters which were ~~[illegible]~~ utilized in several of the nuclear power plants. THESE PRESSURE TRANSMITTERS were TYPE 551, 552, 553, 554, 555, and 556.

GE-MAC ALSO manufactured a line of electronic modules (summers, square root converters, alarms, etc.) which were utilized in the nuclear power plants.

several years ago BAILEY BOUGHT OUT PART OF THE GE-MAC product line, & GE-MAC AS SUCH DISAPPEARED. BAILEY simply fulfilled the outstanding orders for the GE-MAC equipment, then discontinued ~~[illegible]~~.

NUTECH COMMUNICATION RECORD

Persons Involved: MILT WOODHAM	Date/Time: 9-10-80
Company: BAILEY CONTROLS	Recorded By:
☒ Telecon/Ph. No.	Copy To:
☐ Meeting/Location	Route To:
File: 101.2401.0030	Page 3 of 3
SUBJECT:	

The line of pressure transmitters. They still manufacture the electronic modules (7000 series). Bailey also has 2 pressure transmitters (5000 series) which replace the old discontinued line. However, apparently neither the pressure transmitters nor the electronic modules have been qualified for nuclear application.

AT THIS POINT IN TIME, I HAVE NOT FIGURED OUT HOW TO TRY TO LOCATE ANY OF THE OLD GEMAC Records unless we submit a formal Request to Bailey to search their Records.

6. AS a minor side issue, the equipment matrix which we received from NUS HAS MANY INCOMPLETE AND/OR ERRONEOUS MODEL NUMBERS FOR THE BAILEY/GE-MAC ITEMS. WE are maintaining a separate list of these erroneous model numbers.

BWR EQUIPMENT QUALIFICATION SUMMARY

QUALITY ASSURANCE RECORD 20

SUMMARY REPORT NO. QSR 096-A-03

COMPILED BY: M. Blank DATE 10-15-80

VERIFIED BY: Milt Woodham DATE: 10-16-80

MILT WOODHAM

[signature] 10/17/80

I. EQUIPMENT DESCRIPTION

ITEM SOLENOID VALVE MFG. ASCO MODEL(S) 8300 SERIES

FUNCTION FLUID CONTROL SIZE(IN.) — WT./(LBS) —

II. EQUIPMENT LOCATION

BOSTON EDISON		GEORGIA POWER		MISS. P & L		PHILADELPHIA ELEC.	
PILGRIM 1	☐	HATCH 1	☐	GRAND GULF 1	☐	LIMERICK 1	☒
CAROLINA P & L		HATCH 2	☐	GRAND GULF 2	☐	LIMERICK 2	☒
BRUNSWICK 1	☐	GULF STATES		NEBRASKA PUB POWER		PEACH BOTTOM 2	☐
BRUNSWICK 2	☐	RIVER BEND 1	☐	COOPER	☒	PEACH BOTTOM 3	☐
COMMONWEALTH		RIVER BEND 2	☐	NIAGARA MOHAWK		PUB. SERV E & G	
DRESDEN 2	☐	HOUSTON P & L		NINE MILE PT. 1	☐	HOPE CREEK 1	
DRESDEN 3	☐	ALLENS CREEK	☐	NINE MILE PT. 2	☐	HOPE CREEK 2	
QUAD CITIES 1	☐	ILLINOIS POWER		NO. INDIANA PSC		TVA	
QUAD CITIES 2	☐	CLINTON 1	☐	BAILLY	☐	BROWNS FERRY 1	☐
LA SALLE 1	☐	CLINTON 2	☐	NORTHEAST UTIL		BROWNS FERRY 2	☐
LA SALLE 2	☐	IOWA ELECTRIC		MILLSTONE 1	☐	BROWNS FERRY 3	☐
CINCINNATI G & E		DUANE ARNOLD	☐	NO. STATES POWER		HARTSVILLE 1	☐
ZIMMER	☐	JERSEY CENTRAL		MONTICELLO	☒	HARTSVILLE 2	☐
CLEVELAND ELEC. ILUM.		OYSTER CREEK	☐	PASNY		HARTSVILLE 3	☐
PERRY 1	☐	LILCO		FITZPATRICK	☐	HARTSVILLE 4	☐
PERRY 2	☐	SHOREHAM	☐	PENN P & L		WPPSS	
DETROIT EDISON				SUSQUEHANNA 1	☐	WNP-2	
FERMI 2	☐			SUSQUEHANNA 2	☐	YANKEE ATOMIC	
						VERMONT YANKEE	

III. QUALIFICATION REPORTS

CONTINUED ☐

1. TITLE SIMULATED LOCA TEST DATE APRIL 19 1973
   TEST AGENCY NORWOOD ENGINEERING DEPT. REPORT NO. 8856-TG5-B-25-1
   PROPRIETARY RECORDS AT ______ RECORDS ATTACHED ☒
   FILE NO. PARTIAL of 101.2401.0389A CONTACT — PORTIONS ATTACHED

2. TITLE NONE IDENTIFIED DATE ______
   TEST AGENCY ______ REPORT NO. ______
   PROPRIETARY RECORDS AT ______ RECORDS ATTACHED
   FILE NO. ______ CONTACT ______

3. TITLE NONE IDENTIFIED DATE ______
   TEST AGENCY ______ REPORT NO. ______
   PROPRIETARY RECORDS AT ______ RECORDS ATTACHED
   FILE NO. ______ CONTACT ______

WH 1183 Rev. 2 9/4/80

IV. QUALIFICATION DESCRIPTION

QUALIFICATION METHOD

- NONE LOCATED ☐
- TEST ☒
- ANALYSIS ☐
- ON-GOING ☐
- COMBINATION OF ☐ ______ & ______
- OTHER ______

SEPARATE TESTS ☐
SEQUENTIAL TESTS ☒

TEST SEQUENCE

1. LOCA
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______
8. ______

☐ SEE COMMENT PAGE ____

CYCLE AGING

NONE LOCATED ☒

NUMBER OF CYCLES ______

EQUIP, ENERGIZED? YES ☐ NO ☐

CYCLE AGED PRIOR TO SEVERE ENVIRONMENT TEST YES ☐ NO ☐

☐ SEE COMMENT PAGE ____

RADIATION AGING

NONE LOCATED ☒

NO TEST-JUSTIFIED BY ANALYSIS TO ______ RAD

TYPE OF RADIATION ______

DOSE RATE ______ RAD/HR

TOTAL DOSE ______ RADS

RADIATED PRIOR TO SEVERE ENVIRONMENT TEST YES ☐ NO ☐

☐ SEE COMMENT PAGE ____

TIME-TEMPERATURE AGING

NONE LOCATED ☒ AGING METHODOLOGY ______

NO T-T AGING-JUSTIFIED BY ANALYSIS TO ______ YRS

BASED ON AMBIENT TEMPERATURE OF ______ °F

AGING TEMPERATURE ______ °F

DURATION ______ HRS

RELATIVE HUMIDITY ______ %

T-T AGING PRIOR TO SEVERE ENVIRONMENT TEST YES ☐ NO ☐

GENERAL

TEST SPECIMEN SAME AS LISTED EQUIPMENT? PG 4 (2) YES ☒ NO ☐

EQUIP. MOUNTING SPECIFIED? PG4 (1) YES ☒ NO ☐

ACCEPTANCE/FAILURE CRITERIA STATED? YES ☒ NO ☐

EQUIPMENT INTERFACES SPECIFIED YES ☒ NO ☐

SPECIMEN OPERATED DURING TEST? YES ☒ NO ☐

☐ SEE COMMENT PAGE ______

OTHER AGING NONE LOCATED

SUBMERGENCE TEST YES ☐ NO ☒

STANDARDS APPLIED TO TEST:

- IEEE 323-19__
- IEEE 317-19__
- IEEE 324-19__
- IEEE 382-19__
- IEEE 383-19__
- IEEE 344-19__
- NONE STATED ☒

OTHER: NONE STATED

☐ SEE COMMENT PAGE ____

COMMENTS:

(1) THIS TEST REPORT IS PART OF A LARGER REPORT PREPARED BY MASONEILAN INTERNATIONAL INC. NORWOOD MASS. REPORT NO 1003.

SEISMIC QUALIFICATION *NONE LOCATED*

W LEVEL SINE SWEEP ☐
RANGE ______ TO ______ Hz
RATE ______ OCT/MIN.
ACCEL. ______ g's
SING. AXIS ☐
BI-AXIAL ☐
EQUIP OPER? YES ☐ NO ☐
☒ SEE COMMENT PAGE ____

SINE DWELL ☐
ACCEL. ______ g's
FREQ. ______ Hz
______ Hz ______ Hz
______ Hz ______ Hz
DURATION ______ SEC
SING. AXIS ☐
BI-AXIAL ☐
EQUIP OPER? YES ☐ NO ☐
☐ SEE COMMENT PAGE ____

SINE BEAT ☐
ACCEL. ______ g's
FREQ ______ Hz
______ Hz ______ Hz
______ Hz ______ HZ
OSC./BEAT ______
SING. AXIS ☐
BI-AXIAL ☐
EQUIP OPER? YES ☐ NO ☐
☒ SEE COMMENT PAGE ____

RANDOM MULTIFREQUENCY ☐
RANGE ______ TO ______ Hz
ZPA ______ g's
DURATION ______ SEC
DAMPING ______ %
NO. OBE'S ______
NO. SSE'S ______
SING. AXIS ☐ BI-AXIAL ☐
UIP OPER? YES ☐ NO ☐
☒ SEE COMMENT PAGE ____

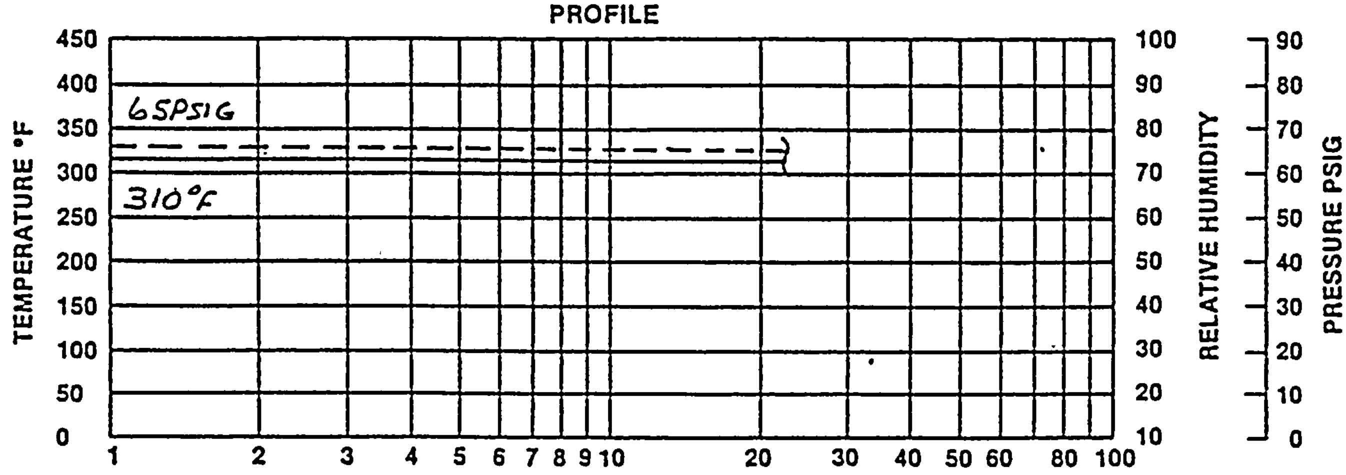
TIME HISTORY ☐
ACCEL. ______ g's
DURATION ______ SEC
NO. OBE'S ______
NO. SSE'S ______
SING. AXIS ☐
BI-AXIAL ☐
EQUIP OPER? YES ☐ NO ☐
☒ SEE COMMENT PAGE ____

COMPLEX WAVE ☐
ZPA ______ g's
INPUT DAMPING ______ %
OUTPUT DAMPING ______ %
NO. OBE'S ______
NO. SSE'S ______
SING AXIS ☐
BI-AXIAL ☐
EQUIP OPER? YES ☐ NO ☐
☒ SEE COMMENT PAGE ____

LOCA MSLB, HELB, RECIRCULATION AREA CONTINUED ☐

RELATIVE HUMIDITY NOT STATED

PROFILE



CHEMICAL SPRAY
NONE ☐
ONTENT *6% BORIC ACID*
pH *NOT STATED*
RATE *NOT STATED* GPM/FT^2
DURATION *NOT STATED* SEC
EQUIP. OPER? YES ☒ NO ☐

KEY TO PROFILE CHART
——— TEMP.
- - - - - PRESSURE
··········· RELATIVE HUMIDITY
—◆—◆— INDICATES EQUIP. CYCLING

V. TRACABILITY

a. QUALIFICATION APPLIES TO AT LEAST THE FOLLOWING SERIAL NUMBERS:

NONE IDENTIFIED

b. QUALIFICATION APPLIES TO AT LEAST THE FOLLOWING MANUFACTURING DATES:

NONE IDENTIFIED

c. OTHER: NONE IDENTIFIED

VI. REMARKS & COMMENTS

4-① THE SOLENOID VALVE WAS PLACED INSIDE AN 8 INCH 10,000 SERIES DOUBLE SEAT VALVE BODY FOR A PERIOD OF 23 HOURS AT A TEMP. OF 310°F, 65 PSIG. A 6% SOLUTION (BY WEIGHT) OF BORIC ACID WAS INJECTED INTO THE VALVE BODY SIMULATING THE CORROSIVE EFFECT OF BORIC ACID SPRAYERS.

4-② THE COMMON ITEM IS IDENTIFIED AS ASCO VALVE SERIES 8300. THE TEST SPECIMEN WAS MODEL WPHT8300B61YF THE BASIC 8300 NUMBER IN THE MODEL MEANS THAT THE VALVES HAVE THE SAME CONFIGURATION AND BASIC DESIGN. THE ADDITIONAL PREFIX AND SUFFIX ADDITIONS TO THE BASIC NUMBER IDENTIFIES THE VALVE SIZE, THE TYPE OF COIL, THE MATERIAL THE VALVE USES FOR GASKETS AND MANY OTHER DESIGN FEATURES. ADDITIONAL ASCO VALVE MODEL INFORMATION IS PROVIDED AS ATTACHMENTS TO COMMON ITEM NO. 096/QSR 096-A-02. DUE TO THE LACK OF A COMPLETE MODEL FOR THE COMMON ITEM, IT IS NOT KNOWN IF THIS TEST DATA IS APPLICABLE.

VI. REMARKS AND COMMENTS (Continued)

TEST RESULTS -

Asco Solenoid Valve No. WPHT8300B61YF, Serial No. 96577A

The time duration of testing on this valve was also 23 hr. and the valve was activated 50 times. The valve performed well throughout the entire test and did not leak steam out the electr. connection until after 12 hours of exposure. The amount of leak was small in comparison to the other leaks experienced on this (see Fig. 5).

APPLICABLE PAGES FROM TEST REPORT ATTACHED

CONCLUSIONS:

The above simulated LOCA tests exceeded the combined time, pressure and temperature exposure expected in the containment area. Based on the excess test conditions and the performance of the equipment during test it is safe to say the Asco Solenoids #WPHTX8320A21V, Serial No. 96578A, WPHT8300B61YF, Serial No. 96577A, Namco Limit Switch #EA-740-500-00 and Masoneilan Model #77-4 Airset will continue to perform during and after a Loss of Operating Coolant Accident.

Robert D. Cronin

8856-J65-B-75-1

3-29-78

VENDOR'S DRAWING REVIEW
1 ☒ Approved—Mfg. may proceed.
2 ☐ Approved—Submit final dwg.—Mfg. may proceed.
3 ☐ Approved except as noted.—Make changes and submit final dwg.—Mfg. may proceed as approved.
4 ☐ Not Approved—Correct and resubmit
5 ☐ Approval not required.—Mfg. may proceed
Approval of this drawing does not relieve supplier from full compliance with contract or purchase order requirements.
REVIEWED C E L M I A — JOB 885
BY [signature] BECHTEL DATE 3-30-7

SIMULATED LOCA TEST

OF

* SOLENOID VALVES & LIMIT SWITCHES

FIRST PAGE ONLY

DISTRIBUTION	NO.	DA
VENDOR	2	
CLIENT	ORIG	
FIELD	1	
Q.E.		
CIVIL		
ELECT.		
PLT. DES.		
MECH.		
CON. SYS.	1	
ARCH.		
PURCH.		
EXPED.		
INSPECT		
SCHED.		
START-UP	1F	
RECORD	1F	
BECHTEL SAN FRANCISCO		

By

Norwood Engineering Department

R. D. Cronin

MASONEILAN INTERNATIONAL, INC.
Norwood, Massachusetts
April 19, 1973

FF104950

* Note: Solenoid valves were purchased from Circle Seal, see M/R 8856-J69 and J69B for qualification.

8809-J65-8-75-1

SIMULATED LOCA TEST

OF

SOLENOID VALVES & LIMIT SWITCHES

ABSTRACT

This test was undertaken to verify performance of specific solenoid valves and limit switches during a loss of operating coolant accident. Testing was conducted by Masoneilan at the request of Baltimore Gas & Electric and Bechtel Power Corporation. The results of the test show equipment can withstand LOCA conditions which in some instances is well beyond the equipment's maximum design conditions Radioactive environment was not a part of this test.

EQUIPMENT TESTED:

Solenoid Valve ASCO Model No. WPHTX8320A21V, Serial No. 96578A

Solenoid Valve ASCO Model No. WPHT8300B61YF, Serial No. 96577A

Limit Switch NAMCO Model No. SL3

Limit Switch NAMCO Model EA-740 500 00

TEST SETUP:

The above pieces of equipment were mounted inside an eight inch 10,000 Series double seat valve body. (See Fig. 1). The equipment was mounted so as to simplify the wiring and pneumatic piping. Pressure gauges were mounted at different locations to closely observe the steam pressure. A thermometer was mounted on the valve inlet flange. Activation of the two limit switches was handled by a side mounted handwheel which stroked the 8" valve's stem.

TEST PROCEDURE:

The steam supply valve was opened as well as the vent and steam trap valve. As soon as steam flowed out the vent, the vent valve was closed and left closed except during restart-ups. Next the steam pressure was adjusted to 65 psig, after which the switches and solenoids were activated to confirm proper operation. At random time intervals the solenoids and switches were activated to check for proper operation. One of the limit switches was used to activate the coil of the #WPHT8300B61YF solenoid which in turn supplied air to stroke a Masoneilan #9 Actuator. During the test a 6% solution (by weight) of boric acid was injected into the valve body (test chamber) to simulate the corrosive effect of the boric acid sprayers.

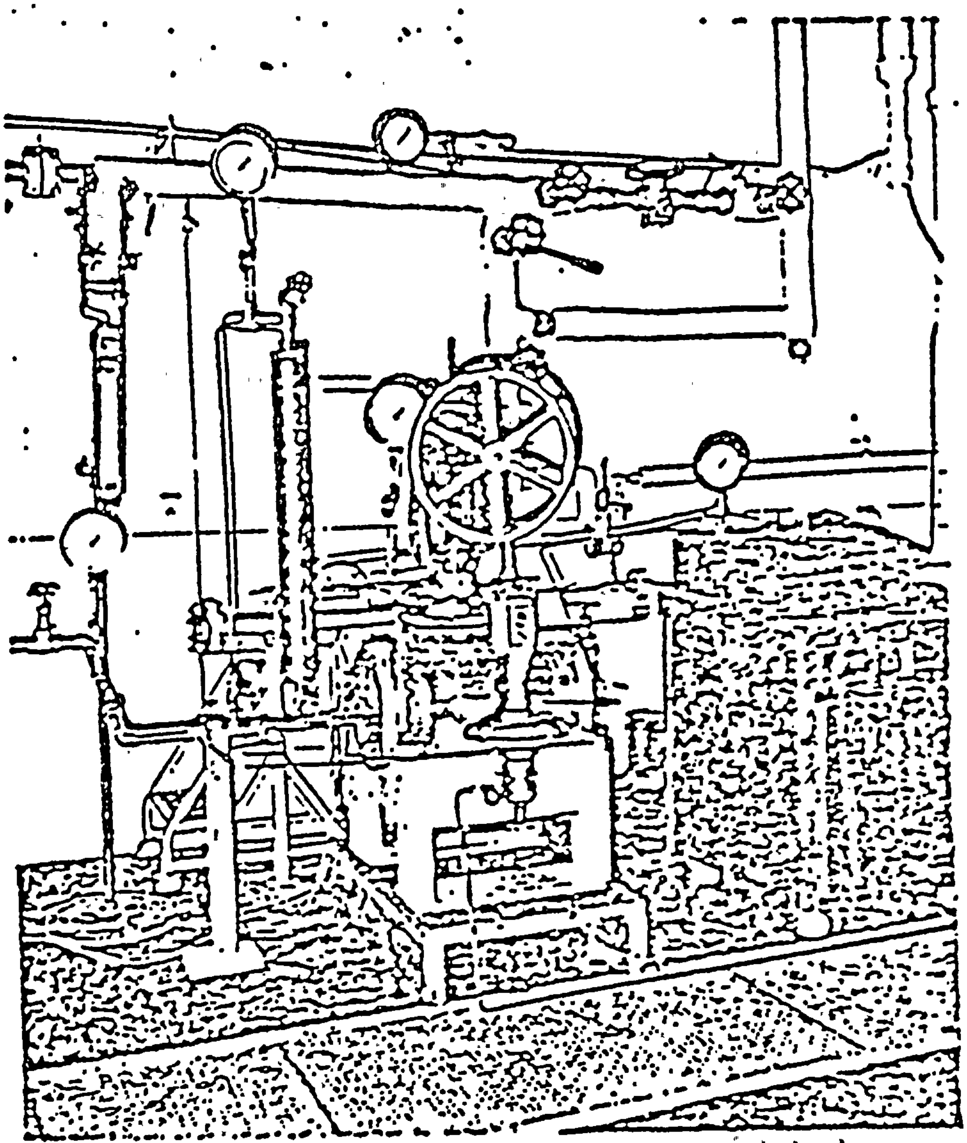
TEST RESULTS:

Namco Limit Switch No. SL3:

Five minutes of exposure at 310° F. and 65 psig was enough to cause steam to blow out the electrical connection. Before removing the switch, it was checked for operation, the switch still worked properly. Removal of the switch and subsequent disassembly showed a gasket failure; (see Fig. 2). This was to be expected, because the switch was not designed for 310° F. and 65 psig service.

Asco Solenoid Valve Model #WPHTX8320A21V, Serial No. 96578A.

When the test first started, steam leaked out the electrical connection, but at a very slow rate. During a 3-1/2 hour period that this solenoid was exposed to 310° F. and 65 psig steam it was activated 4 times and operated properly. At the end of 3-1/2 hours steam flow out the electrical connection became excessive. The valve was removed from the test chamber and disassembled. The housing gasket had failed in one spot (see Fig. 3). The valve was



TEST SETUP

The equipment was mounted inside the 8" valve body. A 3" pipe (to the left of the valve) was used as a 1 gallon tank to hold the boric acid solution.

reassembled and remounted in the test chamber with provisions to limit the flow of steam out the electrical connection. An additional test of 8 hours of 65 psig saturated steam (310° F) and boric acid was applied to the solenoid valve during which t the valve was activated 23 times and found to operate properly.

Namco Limit Switch No. EA-740-500-00.

This switch was tested for a total time of 23 hours during time the switch was activated 50 times and found to operat pro The housing did not leak steam out the electrical connection at during the entire test. The only weakness is the zinc cast lev arm which corroded so badly that the roller fell out during dis assembly (see Fig. 4). This can be resolved by using a steel a. with a steel roller, Namco Part No. DS1260.

Asco Solenoid Valve No. WPHT8300B61YF, Serial No. 965.7.

The time duration of testing on this valve was also 23 h. and the valve was activated 50 times. The valve performed w ll throughout the entire test and did not leak steam out the electr. connection until after 12 hours of exposure. The amount of lea was small in comparison to the other leaks experienced on this (see Fig. 5).

Masoneilan Airset Model #77-4

This piece of equipment was tested for an 8 hour period wi 65 psig saturated steam (310° F) and with an injection of a 6% solution of boric acid. During a portion of the test, air was through the airset to confirm correct operation. The airset pe well before, during and after the test. The paint on the die c. aluminum housing blistered, but still protected the aluminum. (S.

CONCLUSIONS:

The above simulated LOCA tests exceeded the combined time, pressure and temperature exposure expected in the containment area. Based on the excess test conditions and the performance of the equipment during test it is safe to say the Asco Solenoids #WPHTX8320A21V, Serial No. 96578A, WPHT8300B61YF, Serial No. 96577A, Namco Limit Switch #EA-740-500-00 and Masoneilan Model #77-4 Airset will continue to perform during and after a Loss of Operating Coolant Accident.

Robert D. Cronin

RDC:gn
4/19/73

Summary - Environmental Testing of MSS/RV Air Control Valves

QUALITY ASSURANCE
RECORD

Equipment: Main Steam Relief Valve Solenoid Valves

Mfg/Model: Target Rock - ASCO/8300B64F

Documents:

1. Plant Equipment Design Engineering Memorandum 126-62

Environmental Testing:

The following test profile was conducted at 100% RH;

- 340°F/65 psig - 2 min
- 340°F/45 psig - 3 hours
- 320°F/45 psig - 3 hours
- 250°F/25 psig - 90 hours

[redacted]

G.E. Conclusions

Solenoid valves are qualified for the installed environment based on the supporting data and G.E. philosophy detailed in G-HK-9-72 "Pilgrim Qualification Search" of 6-5-79 and G.E. Report G-HK-9-44 of 5-3-79.

BECo Conclusions:

Radiation test data does not envelope PNPS accident profiles. Parker Super-O-Lube should be used in place of Parker O-Lube which tends to bake at temperatures above 250°F and impede valve operation.

Prepared by: [signature]

Date: 6-28-79

/mam

101.2401.0359

PLANT EQUIPMENT DESIGN ENGINEERING MEMORANDUM

No. 126-62

To: B. P. Brooks
D. L. Murray

Subject: ENVIRONMENTAL TESTING OF MSS/RV AIR CONTROL VALVES

Record Copy Filed by: B. P. Brooks
Issued by: R. C. Green 1/15/75

Introduction

Four solenoid valve types like those used on Target Rock, Dresser, and Crosby safety/relief valves were tested under the accident environmental conditions anticipated after a design basis event. The temperature and pressure profiles used in these tests are similar to those required in IEEE Std. 323-1974.

Test Equipment and Procedure

Fig. 1 shows a schematic of the test apparatus. Two solenoid valves are shown however one, two or three valves were tested in any one of the seven tests that were performed. The test vessel used was 30 inches in diameter x 24 inches deep. Each inlet, cylinder and electrical connection to the valves was piped to the outside of the vessel. The exhaust port was left open to the vessel conditions. The following four types of valves were tested:

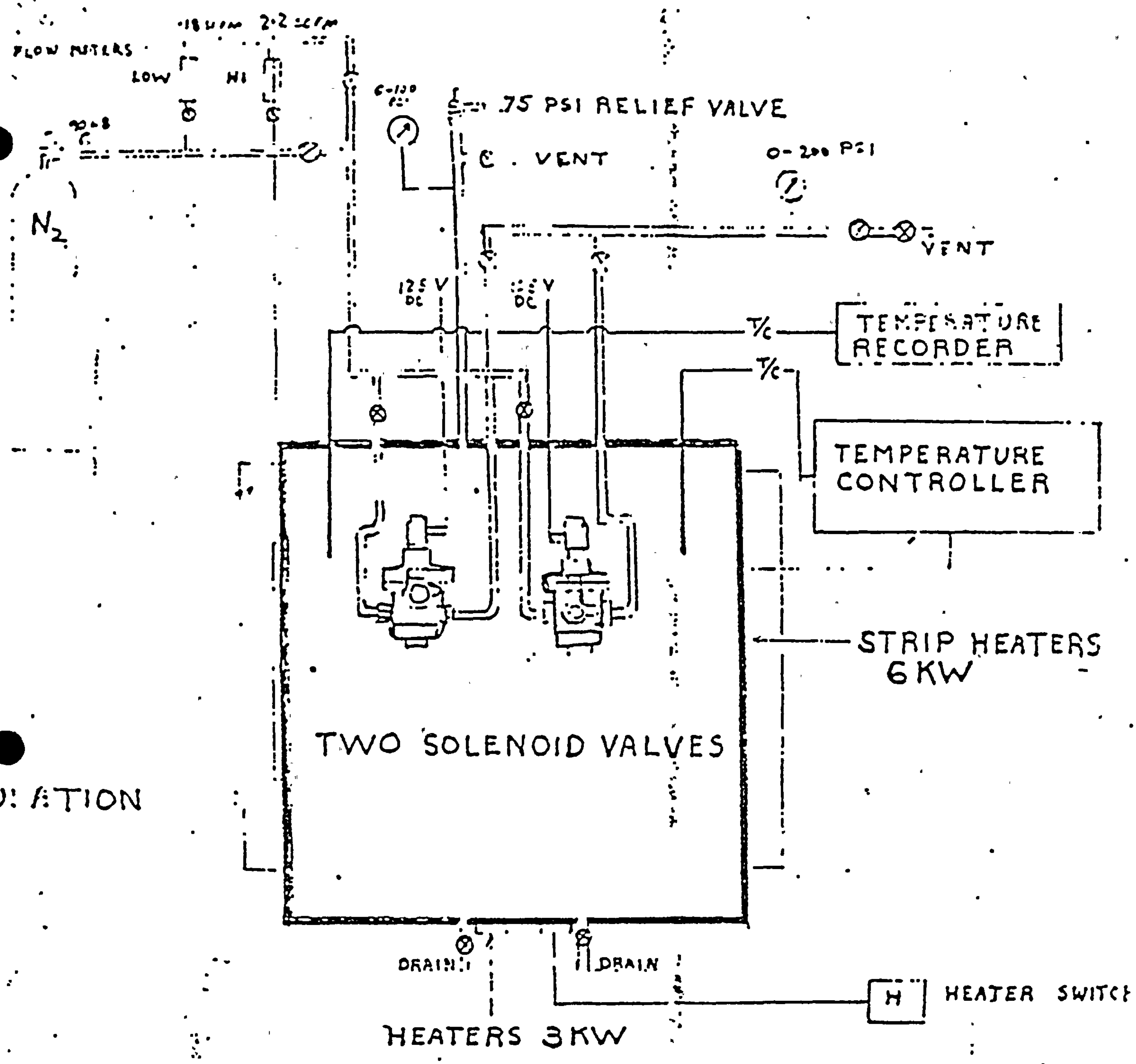
Designation	Manufacturer	Model No.	Characteristics
C	AVC	C-5246	1 1/4 inch, Viton seals
T	AVC	C-5450	1/2 inch, Viton seals
D	AVC	C-5450	1/2 inch, EP seals

[redacted]

The temperature controller automatically maintains a preset temperature in the vessel by turning the 6000 W strip heaters on the sides of the vessel on or off. The bottom heater is on a manual switch. Before testing the temperature controller, recorder, and probes and the cylinder and vessel pressure gauges were checked and calibrated.* During the test the two temperature probes agreed within 5°F. During assembly three inches of water was added to the bottom of the test vessel in order to maintain steam throughout the test. Before turning on the heaters, each valve was cycled 200 times to demonstrate operability and simulate a solenoid valve in service. The temperature controller was adjusted to maintain the following minimum test conditions:

Temperature	Pressure	Time
340°F	65 psig	2 min.
340°F	45 psig	3 hrs.
320°F	45 psig	3 hrs.
250°F	25 psig	90 hrs.

*Calibration records are maintained for traceability



SOLENOID VALVE TEST APPARATUS

FIGURE 1

The test procedure given in appendix 1 was used except for the following modifications:

Test	Modification
4&5	The valves were not operated during the test, only before and after.
6	For 5 consecutive days the valves were subjected to 340°F for 3 hrs, 320°F for 3 hrs. and 250°F overnight. Then an additional 2 days at 250°F. The T valve was operated after day 1, 2, 5 and 7. The D. valve was operated after day 1, 4, 5 and 7.
7	Day 1, 2, 3 and 6 saw 340°F for 3 hrs and 320°F for 3 hrs. Day 4, 5 and 7 and overnight saw 250°F. The valves were operated after day 6 and beginning of day 8.

The solenoid valves in test 1 and 2 were not irradiated. In test 3, 4 and 5 the valves were irradiated to a total integrated dose of 4×10^6 R. For test 7 and 8 they received a dose of 3×10^7 R. All irradiation was prior to assembling the test apparatus.

Results and Discussion

Table I shows a summary of test results. The following are more details by test number:

Test 1 Three of the four C type valves failed to operate properly. An AVC representative came to the test site to check the malfunctioning valves, however he could not explain the problem. He left two valves that did function properly. A shop inspection showed that some of the critical dimensions were not within drawing tolerance.

The C valve installed in the vessel operated erratically, however the inlet connection was made using a 1/2 inch pipe. Later it was determined that a 1/2 inch pipe does not supply enough air. Subsequent tests of C valves used a 1 1/2" pipe. This particular C valve continued to operate irradically even with a 1 1/2 inch inlet. A, D, and T valves had 1/2 inch piping on all tests.

The A valve operated satisfactorily with a slight leakage of .20 SCFM in the energized condition.

Test 2 Both valves operated satisfactorily with no leakage.

Test 3 Operated satisfactorily with no leakage, however when checking for the minimum shift ΔP it stuck twice, once at a ΔP of 20 psi and another time at ΔP of 45 psi. Increasing the pressure caused it to operate satisfactorily.

Test 4 The C valve operated satisfactorily with a leakage of 2.5 SCFM in the energized condition. Deenergized the leakage varied between 0 and .1 SCFM.

The T valve operated satisfactorily with no leakage, however after it cooled down it failed to shift on the first attempt. After that it operated satisfactorily every time. The teflon insulation on the electrical leads cracked and broke away due to the irradiation.

Test 5 Both valves operated satisfactorily. The A valve leaked 2.2 SCFM and the D valve leaked .13 SCFM in the energized condition. No leakage deenergized.

Test 6 Both valves operated satisfactorily. The T valve leaked 2.2 SCFM and the D leaked from 0 to .5 SCFM in the energized condition. No leakage deenergized.

Test 7 All valves showed erratic leakage when energized ranging from 0 to 2.2 SCFM. Deenergized leakage was very low ranging from 0 to .09 SCFM. All valves operated satisfactorily, however both C valves showed slow and sticky operation after the test in the cold condition. On disassembly it was found that the lubricant had turned to a sticky tar-like substance. Also, it was noted that on the last day of the test the vessel had gone dry so that the humidity was very low.

Subsequent testing of the lubricant used in these valves, Parker O Lube, showed that when baked in a dry oven for 24 hours, it turns black and gummy at about 250°F. At temperatures lower than 200°F it does not turn gummy. Another lubricant, Parker Super O Lube, continued to maintain its lubricant quality with no apparent bad effects at temperatures up to 350°F.

[redacted] This leakage has been primarily when the valve is in the energized condition. Deenergized leakage has been very minimal. [redacted] not Parker O Lube since the Parker O Lube has a tendency to bake at a temperature of 250°F or higher. Some of the valves had critical dimensions that are not within drawing tolerance, however, since those valves were manufactured AVC has initiated an improved quality control program.

A=> 8300B68F

Test	Test Sample	Test Parameters*	Results
1	C	2,3,4,6	failed to operate consistently (one of the 3 bad valves received)
[redacted]			
2	D	2,3,4,6	no malfunctions
	T	2,3,4,6	no malfunctions
3	T	1a,2,3,4,6,7	stuck twice, jogged into operability after subsequent attempts
4	C	1a,2,3,5,6,9,10	some leakage, no malfunction
	T	1a,2,3,5,6,9,10	stuck once when cold
5	[redacted]		
	D	1a,2,3,5,6,10	some leakage, no malfunction
6	T	1b,2,4,6,8,10	some leakage when energized, no malfunction
	D	1b,2,4,6,8,10	
7	C	1b,2,3,5,6,8,10	erratic leakage when energized, no malfunctions, sticky operation when co
	C	1b,2,3,5,6,8,10	erratic leakage when energized, no malfunction, sticky operation when col
[redacted]			

*Test Parameters:

1a. Radiation - 4 x 10^6 R
1b. Radiation - 3 x 10^7 R
2. 200 cycles - normal operation
3. emergency temperature/pressure conditions
4. valve operation after each step
5. valve operation only at end of test cycle
6. leakage check
7. additional temperature spike to 350°F
8. 4 test cycles of emergency test condition
9. cool down to 80° after high temp. portion
10. modified test sequence as shown on page 3

TABLE I

SOLENOID VALVE

TEST PROCEDURE

1.0 Assembly and Preliminary Testing

1.1 Assemble as shown in the schematic, adding 3 inches of water in the bottom of the test vessel.

1.2 Leak check the entire piping system using a soap solution and recheck using the flow meter. There shall be no leaks.

1.3 Close all of the valves on the cylinder side of the solenoid valves, and the vent valve.

1.4 Energize each solenoid valve 200 times with 106 VDC using the following procedure.

a. Open the valve on the cylinder side of the solenoid valve for the valve being tested only.

b. Each time after energizing the solenoid, check the pressure gage to see that the cylinder pressure increases to the inlet pressure showing satisfactory operation. Inlet pressure is set to 90 psig.

c. Before starting, and after every 50 times, check and record seat leakage of the solenoid valve in both the energized and de-energized condition. Leak check by noting the flow through either the high or low flow meter after equilibrium is reached. Check min. shift pressure.

1.5 If all solenoid valves continue to operate satisfactorily with less than .05 SCFH seat leakage, assemble and leak check the vessel including the lid and all vessel penetrations. There shall be no leakage.

2.0 Environmental Test

2.1 Adjust the over pressure trip to 75 psig and the over temperature trip to 375°F. Start the temperature recording chart and adjust it for the proper time on the scale.

2.2 Turn both heaters on (side and bottom) and adjust the temperature controller to 350°F. Open the vent if the vessel pressure exceeds 70 psig.

2.3 Turn on the N_2 supply and adjust to 90 psig. Check and record leakage in the de-energized condition while waiting for 340°F.

3.0 First Step

3.1 When the vessel temperature reaches 350°F ±10, turn the bottom heater off. Hold 65 $^{+5}_{-0}$ psig for 60 seconds, then reduce to 45 ± 5 psig by carefully cracking open the vent valve.

3.2 Energize the solenoid 4 times, checking to see that the cylinder pressure increases to inlet pressure (90 psig) each time. Hold the solenoid in the energized condition for 10 sec. each time.

3.3 Check and record seat leakage in the energized and de-energized condition. Check minimum shift pressure.

4.0 Second Step

4.1 Maintain 350°F ±10 and 45 ±5 psig for 3 hrs.

4.2 Repeat steps 3.2 and 3.3.

5.0 Third Step

5.1 Adjust the temperature controller to 330°F. Continue to maintain 45 ±5 psig.

5.2 Maintain 330 ±10°F and 45 ±5 psig for 3 hours.

5.3 Repeat steps 3.2 and 3.3

6.0 Fourth Step

6.1 Adjust the temperature controller to 260°F. Reduce the vessel pressure to 30 ±5 psig. Adjust the over pressure trip to 40 psig and the over temperature trip to 300°F.

6.2 Maintain 260 ±10°F and 30 ±5 psig for 24 hours.

6.3 Repeat 3.2 and 3.3

7.0 Fifth Step

7.1 Reduce the vessel pressure to 25 ±5 psig. Keep the temperature at 260 ±10°F.

7.2 Maintain these conditions until the total length of test time is 96 hours (an additional 66 hrs.).

7.3 Repeat 3.2 and 3.3 after a total test time of 48 hours and again at the end of test.

BWR EQUIPMENT QUALIFICATION SUMMARY

QUALITY ASSURANCE RECORD 5

SUMMARY REPORT NO.
QSR- 111-A-01

COMPILED BY: E.L. GLASS E Glass DATE 10-13-80

VERIFIED BY: A. HORSMAN A. Horsman DATE: 10/14/80

EJ[illegible] 10/14/80

I. EQUIPMENT DESCRIPTION

ITEM ECCS Motor MFG. General Electric MODEL(S) See Comment 6-1

FUNCTION Drive ECCS Pumps SIZE(IN.) — WT./(LBS) —

II. EQUIPMENT LOCATION

BOSTON EDISON	GEORGIA POWER	MISS. P & L	PHILADELPHIA ELEC.
PILGRIM 1 ☒	HATCH 1 ☒	GRAND GULF 1 ☒	LIMERICK 1 —
CAROLINA P & L	HATCH 2 ☒	GRAND GULF 2 ☒	LIMERICK 2 —
BRUNSWICK 1 ☒	GULF STATES	NEBRASKA PUB POWER	PEACH BOTTOM 2 ☒
BRUNSWICK 2 ☒	RIVER BEND 1 ☐	COOPER ☒	PEACH BOTTOM 3 ☒
COMMONWEALTH	RIVER BEND 2 ☐	NIAGARA MOHAWK	PUB. SERV E & G
DRESDEN 2 ☐	HOUSTON P & L	NINE MILE PT. 1 ☒	HOPE CREEK 1 ☐
DRESDEN 3 ☐	ALLENS CREEK ☐	NINE MILE PT. 2 ☐	HOPE CREEK 2 ☐
QUAD CITIES 1 ☒	ILLINOIS POWER	NO. INDIANA PSC	TVA
QUAD CITIES 2 ☒	CLINTON 1 ☐	BAILLY ☐	BROWNS FERRY 1 ☐
LA SALLE 1 ☐	CLINTON 2 ☐	NORTHEAST UTIL	BROWNS FERRY 2 ☐
LA SALLE 2 ☐	IOWA ELECTRIC	MILLSTONE 1 ☐	BROWNS FERRY 3 ☐
CINCINNATI G & E	DUANE ARNOLD ☐	NO. STATES POWER	HARTSVILLE 1 ☐
ZIMMER ☐	JERSEY CENTRAL	MONTICELLO ☒	HARTSVILLE 2 ☐
CLEVELAND ELEC. ILUM.	OYSTER CREEK ☐	PASNY	HARTSVILLE 3 ☐
PERRY 1 ☐	LILCO	FITZPATRICK ☐	HARTSVILLE 4 ☐
PERRY 2 ☐	SHOREHAM ☐	PENN P & L	WPPSS
DETROIT EDISON		SUSQUEHANNA 1 ☒	WNP-2 ☒
FERMI 2 ☐		SUSQUEHANNA 2 ☒	YANKEE ATOMIC
			VERMONT YANKEE ☐

III. QUALIFICATION REPORTS

CONTINUED ☐

1. TITLE Seismic & Environmental Testing of Formette serial #2 DATE 6 May, 1980
TEST AGENCY Wyle Laboratories REPORT NO. 58455
PROPRIETARY RECORDS AT General Electric Co., San Jose CA. RECORDS ATTACHED ☐
FILE NO. 491HA988 CONTACT Steve Gay, Mgr. Technical Services

2. TITLE Topical Report on Qualification Test on Class 1E ECCS Motors DATE 18 July, 1980
TEST AGENCY General Electric Co. REPORT NO. 491H988
PROPRIETARY RECORDS AT General Electric Co., San Jose, CA. RECORDS ATTACHED ☐
FILE NO. 491HA988 CONTACT Steve Gay, Mgr. Technical Services

3. TITLE None Located DATE
TEST AGENCY REPORT NO.
PROPRIETARY RECORDS AT RECORDS ATTACHED ☐
FILE NO. CONTACT

IV. QUALIFICATION DESCRIPTION

QUALIFICATION METHOD

- NONE LOCATED ☐
- TEST ☒
- ANALYSIS ☐
- ON-GOING ☐
- COMBINATION OF ☐ ____ & ____
- OTHER ____

SEPARATE TESTS ☐
SEQUENTIAL TESTS ☒

TEST SEQUENCE

1. Aging
2. Radiation
3. Seismic
4. LOCA
5. submergence
6. ____
7. ____
8. ____

☐ SEE COMMENT PAGE ____

CYCLE AGING

NONE LOCATED ☒

NUMBER OF CYCLES ____

EQUIP, ENERGIZED? YES ☐ NO ☐

CYCLE AGED PRIOR TO SEVERE ENVIRONMENT TEST YES ☐ NO ☐

☐ SEE COMMENT PAGE ____

RADIATION AGING

NONE LOCATED ☐

NO TEST-JUSTIFIED BY ANALYSIS TO ____ RAD

TYPE OF RADIATION Gamma

DOSE RATE 0.57 mega RAD/HR

TOTAL DOSE 5.5×10^6 RADS

RADIATED PRIOR TO SEVERE ENVIRONMENT TEST YES ☒ NO ☐

☐ SEE COMMENT PAGE 5-1

TIME-TEMPERATURE AGING Comment 5-2

NONE LOCATED ☐ AGING METHODOLOGY Arrhenius

NO T-T AGING-JUSTIFIED BY ANALYSIS TO ____ YRS

BASED ON AMBIENT TEMPERATURE OF Not Located °F

AGING TEMPERATURE 392 °F

DURATION 1362 HRS

RELATIVE HUMIDITY Not Located %

T-T AGING PRIOR TO SEVERE ENVIRONMENT TEST YES ☒ NO ☐

GENERAL Comment 6-1

TEST SPECIMEN SAME AS LISTED EQUIPMENT?	YES ☐	NO ☐
EQUIP. MOUNTING SPECIFIED?	YES ☐	NO ☒
ACCEPTANCE/FAILURE CRITERIA STATED?	YES ☐	NO ☒
EQUIPMENT INTERFACES SPECIFIED	YES ☐	NO ☒
SPECIMEN OPERATED DURING TEST?	YES ☒	NO ☐

☐ SEE COMMENT PAGE 4-1

OTHER AGING

SUBMERGENCE TEST YES ☒ NO ☐ Comment 5-3

STANDARDS APPLIED TO TEST:

- IEEE 323-1974
- IEEE 317-19__
- IEEE 324-19__
- IEEE 382-19__
- IEEE 383-19__
- IEEE 344-1975
- NONE STATED ☐

OTHER: IEEE 334-74, IEEE 275-66, IEEE 429

☐ SEE COMMENT PAGE ____

COMMENTS:

SEISMIC QUALIFICATION

LOW LEVEL SINE SWEEP ☒
RANGE 1 TO 80 Hz
RATE 10 Hz per min Sweep ~~OCT/MIN.~~ RATE
ACCEL. 0.3 g's
SING. AXIS ☐
BI-AXIAL ☒
EQUIP OPER? YES ☐ NO ☒
☐ SEE COMMENT PAGE ____

SINE DWELL ☒
ACCEL. 3g horiz. / 4g vertical g's
FREQ. 18 Hz
____ Hz ____ Hz
____ Hz ____ Hz
DURATION 30 each SEC
SING. AXIS ☐
BI-AXIAL ☒
EQUIP OPER? YES ☐ NO ☒
☐ SEE COMMENT PAGE ____

SINE BEAT ☐
ACCEL. ____ g's
FREQ ____ Hz
____ Hz ____ Hz
____ Hz ____ HZ
OSC./BEAT ____
SING. AXIS ☐
BI-AXIAL ☐
EQUIP OPER? YES ☐ NO ☐
☒ SEE COMMENT PAGE ____

RANDOM MULTIFREQUENCY ☒
RANGE 1 TO 100 Hz
ZPA 1g SSE 0.68g OBE g's
DURATION 30 SEC
DAMPING 3% SSE 2% OBE %
NO. OBE'S 5
NO. SSE'S 1
SING. AXIS ☐ BI-AXIAL ☒
EQUIP OPER? YES ☐ NO ☒
☐ SEE COMMENT PAGE ____

TIME HISTORY ☐
ACCEL. ____ g's
DURATION ____ SEC
NO. OBE'S ____
NO. SSE'S ____
SING. AXIS ☐
BI-AXIAL ☐
EQUIP OPER? YES ☐ NO ☐
☒ SEE COMMENT PAGE ____

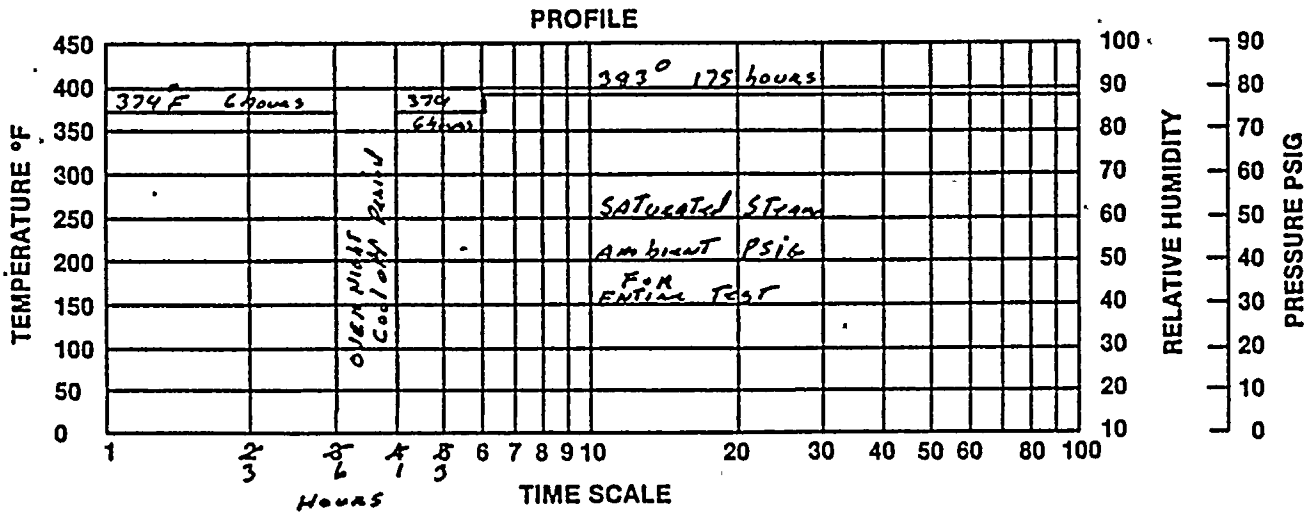
COMPLEX WAVE ☐
ZPA ____ g's
INPUT DAMPING ____ %
OUTPUT DAMPING ____ %
NO. OBE'S ____
NO. SSE'S ____
SING AXIS ☐
BI-AXIAL ☐
EQUIP OPER? YES ☐ NO ☐
☒ SEE COMMENT PAGE ____

LOCA, MSLB, HELB, RECIRCULATION AREA

Comment 4-1

CONTINUED ☐

PROFILE



KEY TO PROFILE CHART
———— TEMP.
– – – – – PRESSURE
· · · · · · · · RELATIVE HUMIDITY
—◆—◆—◆— INDICATES EQUIP. CYCLING

CHEMICAL SPRAY
NONE ☒
CONTENT ____
pH ____
RATE ____ GPM/FT^2
DURATION ____ SEC
EQUIP. OPER? YES ☐ NO ☐

V. TRACABILITY

a. QUALIFICATION APPLIES TO AT LEAST THE FOLLOWING SERIAL NUMBERS:

None Located

b. QUALIFICATION APPLIES TO AT LEAST THE FOLLOWING MANUFACTURING DATES:

None Located

c. OTHER: None Located

VI. REMARKS & COMMENTS

4-1) D.B.E. Test Wyle Report # 58455

The D.B.E. Test consisted of first heating the coils via resistance heating elements imbedded in an aluminum block. The block was in intimate contact with the underside of the formette frame. Then the formette was energized and saturated steam was blown into the chamber, thus impinging on the specimen. The steam was at ambient atmospheric pressure and its equivalent saturation temperature (212°F), and the coil temperature was controlled to 374°F as determined with thermocouples that were centrally located in the formette coil frame assembly.

The test consisted of two temperature/steam dwells of six hours duration with an overnight cooldown in between.

Post D.B.E. Test

At the end of the second DBE temperature dwell (no cool off period) the post DBE dwell test duration of 125 hours was begun. The DBE test description parameters apply for the post DBE test as well, except that the coil temperature was raised to 383°F for the entire test.

Post-Test Electrical Function Test

At the completion of the temp./steam environmental tests, the 6600 Vrms specimen coils were subjected to 500 VDC megohmeter and one minute 9467 Vrms high potential tests. The 4000 Vrms coils were subjected to similiar tests except the A.C. voltage was 6000 Vrms.

VI. REMARKS AND COMMENTS (Continued)

5-1) Radiation (Letter to Mr. M. Sheets, General Electric Co. San Jose, CA. From Isomedix . Dated April 1, 1980)

The specimen was exposed for 10 hours at an average dose rate of 0.57 megarads per hour. The calculated dose based on dosimetry is 5.7 megarads. Incorporating the ± 3% accuracy of the dosimetry system, Therefore, the reported minimum dose is 5.5 megarads.

5-2) Aging

The formette and repair samples were aged at General Electric, San Jose, CA. for 1362 hours at 392°F, which is 12 hours longer than specified. After aging, the formette passed the following AC. high potential test. (A) 6600 volt coil — 9462 volts AC

(B) 4000 volt coil — 6000 volts AC

5-3) Test Results and Final Inspection

1) Inspection — Coils showed no damage except some change in color and some surface epoxy wear

2) Test Results — (a) 500 volt DC. test for 1 minute = Minimum reading in excess of 10,000 megohms.

(b) AC HiPot test for 1 minute = No failures.

(c) Underwater test per IEEE 429

(1) 10 minute underwater test with 500 volt D.C. on coils = minimum reading in excess of 10,000 megohms.

(2) 1 minute underwater test with A.C. volts applied to coils. No failures.

(3) 1 minute underwater test with 500VDC. on coils = minimum reading in excess of 10,000 megohms.

VI. REMARKS AND COMMENTS (Continued)

6-1) A formette was built with the following coils:

A. 4000 Volt, Class F - same as existing motor using Kapton-backed micamat.

B. 4000 Volt, Class F - same as existing motor except using the mylar backed micamat.

C. 6600 Volt, Class F, same as existing motors using the Kapton-backed micamat.

D. 6600 Volt, Class F, same as existing motors except using the mylar backed micamat.

The 6600 volt coils were inserted in the same 2 coil slots and the 4000 volt coils were in the other 2 slots.

The size of the formette was 24" x 24" x 6"

IEEE 323 QUALIFICATION REPORT

AC LOAD CENTER UNIT SUBSTATIONS

FOR THE

PUBLIC SERVICE ELECTRIC AND GAS CO.

UNITS NO. 1 & 2

HOPE CREEK GENERATING STATION

LOWER ALLOWAYS CREEK TOWNSHIP

HANCOCK BRIDGE, NEW JERSEY

G-321-D
DOC. CATEGORY
8.0

10855-E117 (Q)-42-1

OCT 02 1979

DISTRIBUTION	COPY	DATE
SUPPLIER		
CLIENT	2+R	
FIELD	1+R	
ARCH.		
CIVIL		
ELECTRICAL	1	
CON SYS		
MECHANICAL		
PLT DES		
RECORD	R	

NOV 28 1979

JOB NO. 10855
BECHTEL POWER CORPORATION
San Francisco

SPECIFICATIONS BY

BECHTEL POWER CORPORATION
SAN FRANCISCO, CALIFORNIA

SPEC. E-117(Q) & G013(Q)

BECHTEL COMMENT

REPORT PREPARED BY

GENERAL ELECTRIC COMPANY
DISTRIBUTION ASSEMBLIES DEPARTMENT
PLAINVILLE, CONNECTICUT

SUPPLIER DOCUMENT REVIEW

1 ☐ WORK MAY PROCEED PER PO/CONTRACT PROVISIONS.
2 ☐ WORK MAY PROCEED AND FINAL DRAWING BE SUBMITTED PER PO/CONTRACT PROVISIONS.
3 ☒ REVISE AND RESUBMIT. WORK MAY PROCEED PER PO/CONTRACT PROVISIONS, SUBJECT TO INCORPORATION OF CHANGES INDICATED.
4 ☐ REVISE AND RESUBMIT. WORK MAY NOT PROCEED.
5 ☐ REVIEW NOT REQUIRED. WORK MAY PROCEED PER PO/CONTRACT PROVISIONS.

PERMISSION TO PROCEED DOES NOT CONSTITUTE ACCEPTANCE OR APPROVAL OF DESIGN DETAILS, CALCULATIONS, ANALYSES, TEST METHODS, OR MATERIALS DEVELOPED OR SELECTED BY THE SUPPLIER AND DOES NOT RELIEVE SUPPLIER FROM FULL COMPLIANCE WITH CONTRACTUAL OBLIGATIONS.

REVIEWED	A	C	E	J	M	P	Q	JOB NO. 10855
			✓					

BY [signature] DATE 11/25/79
BECHTEL POWER CORPORATION

NO.	DATE	REVISIONS	BY	APPROVAL
0	9/21/79	—	[signature]	[signature]

THIS SUPERSEDES THE PREVIOUS SUBMITTAL OF 10855-E-117 (Q)-2-1

BECHTEL COMMENT

1

REV NO.
286A8790
CONT ON SHEET 15 SH NO. 14

TITLE Class 1E Qualification AKR-30, AKRU-30, and AKR-30H Low Voltage Power Circuit Breakers
FIRST MADE FOR

REVISIONS

RADIATION TESTS

The purpose of radiation tests is to determine the ability of the AKR type breaker to withstand gamma radiation that may be present in nuclear stations.

For the AKR-30/50 breakers, since the insulation components on the two frame size breakers are identical, tests were made on the AKR-50 breaker to cover both the 1600 ampere AKR-50 and the 800A AKR-30 and all the design extensions associated with the A.C. varieties of these breakers.

The tests were made in parts as follows:

A. Test on SST Overcurrent Trip Device

An SST programmer Dwg. 568B604G-18, Serial No. 00392 was mounted in the radiation facility of ISOMEDIX, Inc., Parsippany, New Jersey, May 17, 1977. During radiation, the characteristics of the device were monitored with an SST/ECS test set type TAK-TS1. The radiation dosage rate was 2×10^4 rads/hour until 1×10^5 rads was accumulated and then increased to 0.7×10^6 rads/hour. There was no evidence of damage when 1×10^5 rads was accumulated and the tripping time of the various characteristics changed less than 10% until 4.3×10^5 rads were accumulated.

BE CO...

B. Test on AKR-50 Less Overcurrent Trip Device

An AKR-50 breaker, Catalog No. AKD-5720, less overcurrent trips, was tested in ISOMEDIX, INC. radiation facility--Parsippany, New Jersey, on August 9-10, 1977. The front frame assembly and barriers and a sample of Vulkene wire GE type SI 53043 was exposed to $.33 \times 10^6$ rads/hour and the back frame assembly was exposed to $.29 \times 10^6$ rads per hour. The test time was 2.25 hours.

Following the radiation, the breaker was returned to the Plainville Plant where 1,750 mechanical endurance operations were performed. At the completion of this series of tests, the breaker

PRINTS T

MADE BY M. B. Fornwalt	APPROVALS MBF	CPD DIV OR DEPT.	286A8790
ISSUED DEC 9 1977	12/9/77	Plainville, CT LOCATION	CONT ON SHEET 15 SH NO. 14

CODE IDENT

REVISIONS

Radiation Tests, Continued

was inspected. No evidence of deteriorated existed that could be attributable to the radiation.

It was concluded the breaker can withstand .65 x 10^6 rads. In combination with the SST, the breaker can withstand radiation levels up to 0.1 x 10^6 rads.

Breaker data recorded in Book 28, Location A.

PRINTS T

Dennis... 4

BWR EQUIPMENT QUALIFICATION SUMMARY

QUALITY ASSURANCE RECORD

SUMMARY REPORT NO.
QSR- 010-A-01

COMPILED BY: E. L. GLASS DATE 9-23-80

VERIFIED BY: H. BROXSON DATE: 9/23/80

I. EQUIPMENT DESCRIPTION

ITEM Terminal Board MFG. General Electric MODEL(S) EB-25

FUNCTION GENERAL PURPOSE, TERMINATE WIRES SIZE(IN.) — WT./(LBS) —

II. EQUIPMENT LOCATION

BOSTON EDISON	GEORGIA POWER	MISS. P & L	PHILADELPHIA ELEC.
PILGRIM 1 ☐	HATCH 1 ☐	GRAND GULF 1 ☐	LIMERICK 1 ☐
CAROLINA P & L	HATCH 2 ☐	GRAND GULF 2 ☐	LIMERICK 2 ☐
BRUNSWICK 1 ☐	GULF STATES	NEBRASKA PUB POWER	PEACH BOTTOM 2 ☐
BRUNSWICK 2 ☐	RIVER BEND 1 ☐	COOPER ☒	PEACH BOTTOM 3 ☐
COMMONWEALTH	RIVER BEND 2 ☐	NIAGARA MOHAWK	PUB. SERV E & G
DRESDEN 2 ☐	HOUSTON P & L	NINE MILE PT. 1 ☒	HOPE CREEK 1 ☐
DRESDEN 3 ☐	ALLENS CREEK ☐	NINE MILE PT. 2 ☐	HOPE CREEK 2 ☐
QUAD CITIES 1 ☐	ILLINOIS POWER	NO. INDIANA PSC	TVA
QUAD CITIES 2 ☐	CLINTON 1 ☐	BAILLY ☐	BROWNS FERRY 1 ☒
LA SALLE 1 ☐	CLINTON 2 ☐	NORTHEAST UTIL	BROWNS FERRY 2 ☒
LA SALLE 2 ☐	IOWA ELECTRIC	MILLSTONE 1 ☒	BROWNS FERRY 3 ☒
CINCINNATI G & E	DUANE ARNOLD ☐	NO. STATES POWER	HARTSVILLE 1 ☐
ZIMMER ☐	JERSEY CENTRAL	MONTICELLO ☐	HARTSVILLE 2 ☐
CLEVELAND ELEC. ILUM.	OYSTER CREEK ☐	PASNY	HARTSVILLE 3 ☐
PERRY 1 ☐	LILCO	FITZPATRICK ☐	HARTSVILLE 4 ☐
PERRY 2 ☐	SHOREHAM ☐	PENN P & L	WPPSS
DETROIT EDISON		SUSQUEHANNA 1 ☐	WNP-2 ☐
FERMI 2 ☐		SUSQUEHANNA 2 ☐	YANKEE ATOMIC
			VERMONT YANKEE ☐

III. QUALIFICATION REPORTS

CONTINUED ☐

1. TITLE Environmental Qualification of Terminal Blocks/Boxes DATE March 23, 1978
TEST AGENCY Franklin Institute REPORT NO. ~~None~~ DOCKET 50-213
PROPRIETARY RECORDS AT NOT APPLICABLE RECORDS ATTACHED ☒
FILE NO. 101.2401.0383B CONTACT

2. TITLE DATE
TEST AGENCY REPORT NO.
PROPRIETARY RECORDS AT RECORDS ATTACHED ☐
FILE NO. CONTACT

3. TITLE DATE
TEST AGENCY REPORT NO.
PROPRIETARY RECORDS AT RECORDS ATTACHED ☐
FILE NO. CONTACT

WH 1183 Rev. 2 9/4/80

IV. QUALIFICATION DESCRIPTION

QUALIFICATION METHOD

- NONE LOCATED ☐
- TEST ☒
- ANALYSIS ☐
- ON-GOING ☐
- COMBINATION OF ☐ ____ & ____
- OTHER ____

SEPARATE TESTS ☐
SEQUENTIAL TESTS ☒

TEST SEQUENCE
1. Thermal aging
2. irradiation
3. Environmental
4. ____
5. ____
6. ____
7. ____
8. ____

☐ SEE COMMENT PAGE ____

CYCLE AGING

NONE LOCATED ☒
NUMBER OF CYCLES ____
EQUIP, ENERGIZED? YES ☐ NO ☐
CYCLE AGED PRIOR TO SEVERE ENVIRONMENT TEST YES ☐ NO ☐
☐ SEE COMMENT PAGE ____

RADIATION AGING

NONE LOCATED ☐
NO TEST-JUSTIFIED BY ANALYSIS TO ____ RAD
TYPE OF RADIATION Gamma
DOSE RATE Not Located RAD/HR
TOTAL DOSE 5×10^6 RADS.
RADIATED PRIOR TO SEVERE ENVIRONMENT TEST YES ☒ NO ☐
☐ SEE COMMENT PAGE ____

TIME-TEMPERATURE AGING

NONE LOCATED ☐ AGING METHODOLOGY Arrhenius Plot
NO T-T AGING-JUSTIFIED BY ANALYSIS TO ____ YRS
BASED ON AMBIENT TEMPERATURE OF 158 °F
AGING TEMPERATURE 302 °F
DURATION 171 HRS
RELATIVE HUMIDITY Not Located %
T-T AGING PRIOR TO SEVERE ENVIRONMENT TEST YES ☒ NO ☐

GENERAL

TEST SPECIMEN SAME AS LISTED EQUIPMENT?	YES ☒	NO ☐
EQUIP. MOUNTING SPECIFIED?	YES ☒	NO ☐
ACCEPTANCE/ FAILURE CRITERIA STATED?	YES ☒	NO ☐
EQUIPMENT INTERFACES SPECIFIED	YES ☒	NO ☐
SPECIMEN OPERATED DURING TEST?	YES ☒	NO ☐

☒ SEE COMMENT PAGE 4-1

OTHER AGING

____

SUBMERGENCE TEST YES ☐ NO ☒

STANDARDS APPLIED TO TEST:

IEEE 323-19__ IEEE 382-19__
IEEE 317-19__ IEEE 383-19__
IEEE 324-19__ IEEE 344-19__
NONE STATED ☒
OTHER: ____

☐ SEE COMMENT PAGE ____

COMMENTS:

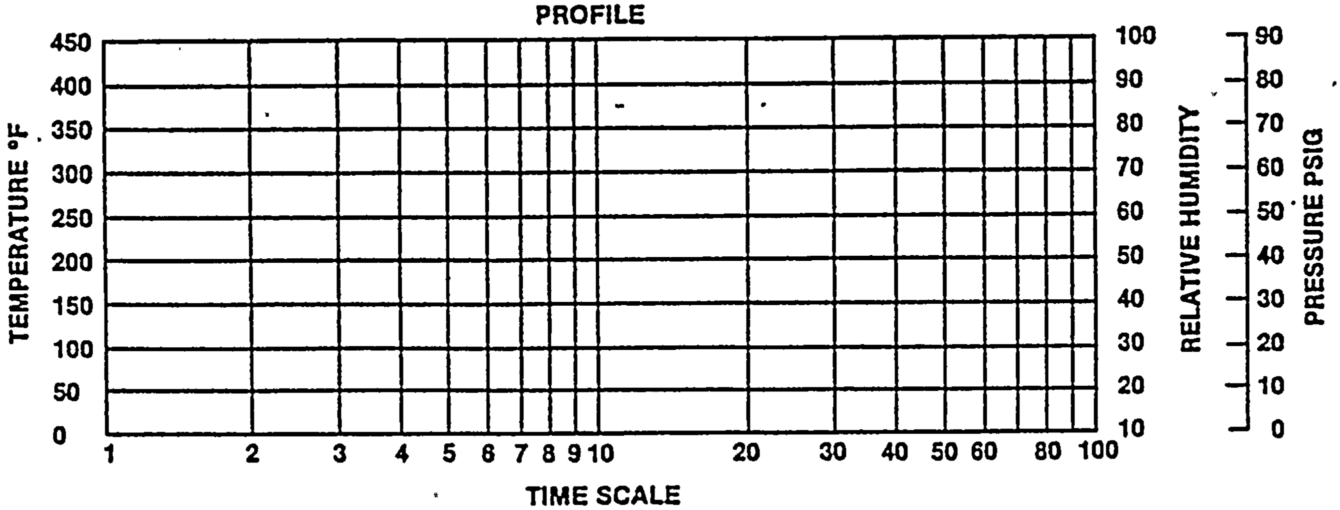
SEISMIC QUALIFICATION *NONE Located*

LOW LEVEL SINE SWEEP ☐	SINE DWELL ☐	SINE BEAT ☐
RANGE ____ TO ____ Hz	ACCEL. ____ g's	ACCEL. ____ g's
RATE ____ OCT/MIN.	FREQ. ____ Hz	FREQ ____ Hz
ACCEL. ____ g's	____ Hz ____ Hz	____ Hz ____ Hz
SING. AXIS ☐	____ Hz ____ Hz	____ Hz ____ HZ
BI-AXIAL ☐	DURATION ____ SEC	OSC./BEAT ____
EQUIP OPER? YES ☐ NO ☐	SING. AXIS ☐	SING. AXIS ☐
	BI-AXIAL ☐	BI-AXIAL ☐
	EQUIP OPER? YES ☐ NO ☐	EQUIP OPER? YES ☐ NO ☐
☐ SEE COMMENT PAGE ____	☐ SEE COMMENT PAGE ____	☐ SEE COMMENT PAGE ____

RANDOM MULTIFREQUENCY ☐	TIME HISTORY ☐	COMPLEX WAVE ☐
RANGE ____ TO ____ Hz	ACCEL. ____ g's	ZPA ____ g's
ZPA ____ g's	DURATION ____ SEC	INPUT DAMPING ____ %
DURATION ____ SEC	NO. OBE'S ____	OUTPUT DAMPING ____ %
DAMPING ____ %	NO. SSE'S ____	NO. OBE'S ____
NO. OBE'S ____	SING. AXIS ☐	NO. SSE'S ____
NO. SSE'S ____	BI-AXIAL ☐	SING AXIS ☐
SING. AXIS ☐ BI-AXIAL ☐	EQUIP OPER? YES ☐ NO ☐	BI-AXIAL ☐
EQUIP OPER? YES ☐ NO ☐		EQUIP OPER? YES ☐ NO ☐
☐ SEE COMMENT PAGE ____	☐ SEE COMMENT PAGE ____	☐ SEE COMMENT PAGE ____

LOCA, MSLB, HELB, RECIRCULATION AREA ** See attached profile* CONTINUED ☐

PROFILE



CHEMICAL SPRAY

NONE ☐

CONTENT *2640 ppm boric acid*

pH *Not Located*

RATE *Not Located* GPM/FT²

DURATION *24.0 hours* ~~SEC~~

EQUIP. OPER? YES ☒ NO ☐

KEY TO PROFILE CHART

- ——— TEMP.
- - - - - PRESSURE
- ········ RELATIVE HUMIDITY
- ←→←→ INDICATES EQUIP. CYCLING

V. TRACABILITY

a. QUALIFICATION APPLIES TO AT LEAST THE FOLLOWING SERIAL NUMBERS:

None Located

b. QUALIFICATION APPLIES TO AT LEAST THE FOLLOWING MANUFACTURING DATES:

None Located

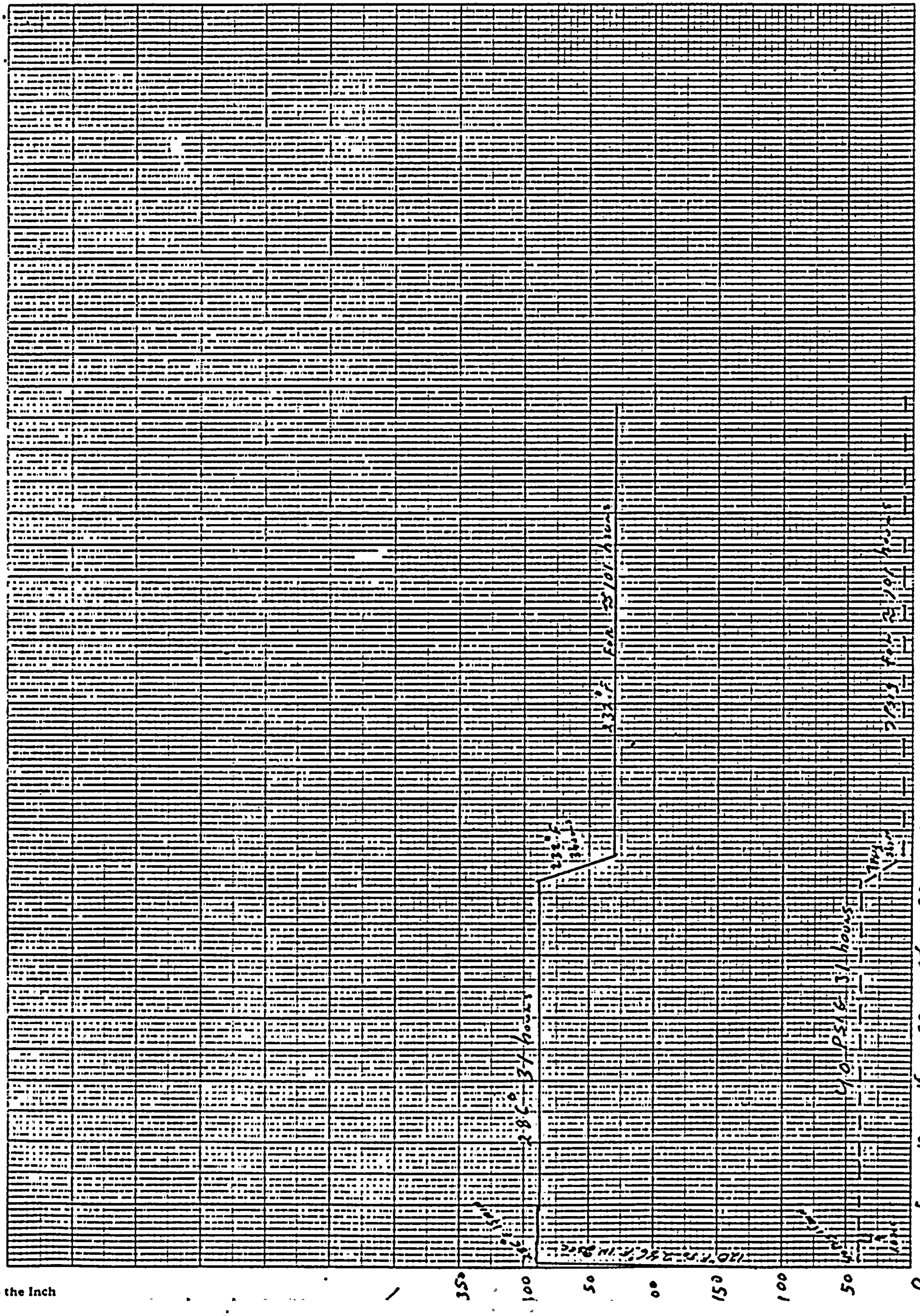
c. OTHER: None Located

VI. REMARKS & COMMENTS

4-1) A failure of the terminal point under test was defined as the inability of that point to continuously support the applied test voltage or current. Any other indications associated with test connections, autoclave penetrations, power supplies, etc. would not be defined as a failure of a test specimen. See conclusion on page 6

For equipment interfaces see the attached report

12,282



20 Squares to the Inch

[illegible handwritten number at top]

CONNECTICUT YANKEE ATOMIC POWER COMPANY

BERLIN, CONNECTICUT
P. O. BOX 270 HARTFORD, CONNECTICUT 06101

TELEPHONE
203-666-6911

March 29, 1978

Docket No. 50-213

Director of Nuclear Reactor Regulation
Attn: Mr. D. L. Ziemann, Chief
Operating Reactors Branch #2
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

References: (1) D. C. Switzer letters to B. H. Grier (NRC - I&E Region I), dated December 8, 1977 and January 13, 1978.
(2) W. T. Russell (NRC) Summary of Meeting Held on January 29, 1978, dated January 30, 1978.
(3) R. H. Graves (CYAPCO) letter to B. Grier dated March 23, 1978.

Gentlemen:

Haddam Neck Plant
Environmental Qualification of Terminal Blocks/Boxes

In Reference (1), Connecticut Yankee Atomic Power Company (CYAPCO) described its actions with respect to the replacement of four electrical connectors inside containment of the Haddam Neck Plant with terminal blocks mounted inside junction boxes ("terminal block/box combination"). This replacement was deemed prudent by CYAPCO solely in light of the fact that the original electrical connectors at the Haddam Neck Plant did not have specific documentation available regarding environmental qualifications. As described in Reference (1), the terminal block/box combination was judged to be environmentally qualified by material analyses; CYAPCO also stated therein that testing would be initiated to document the environmental qualification.

In response to that commitment, the following information is hereby provided.

Environmental qualification testing of the terminal block/box combination in use at the Haddam Neck Plant was initiated prior to January 30, 1978 with the successful completion of Phase I (screening) tests, performed under pressure, temperature, and humidity conditions which conservatively represented the postulated post-accident environment inside containment. The results of these tests were discussed in detail with the NRC Staff, as documented in Reference (2).

The Phase I tests were followed by Phase II tests during which two terminal block/box combinations* were subjected to temperature and radiation environ-

*General Electric (GE) terminal block inside a steel junction box and a GE terminal block inside an aluminum junction box prototypes.

ments simulating normal operation, prior to being subjected to the postulated post-accident environment. [redacted] sequence on March 22, 1978, [redacted]. It should be noted that the latter stages of the Phase II testing program were witnessed by a member of the NRC Staff. This terminal point failure was reported to the NRC Staff in Reference (3).

A description of the Phase II environmental qualification test program and pertinent preliminary test results, based on the report of a Northeast Utilities Service Company (NUSCO) representative, is provided in the Attachment.

Although CYAPCO and the NUSCO technical staff believe that the terminal block would have performed its intended function since the other terminal points on the block were operable throughout the duration of the test, it was nevertheless deemed prudent to replace the two aluminum boxes having one-inch vent holes housing the General Electric terminal blocks with steel boxes with 1/4-inch vent holes. This action was based upon test results which verified the fact that the same model General Electric terminal block enclosed in a similarly configured steel box performed acceptably during the same Phase II environmental qualification test program. These tests and their results, provided positive indications that the failure of the single terminal point on the GE block was due to the interface with the aluminum box. Further, the tests indicated that this situation was completely avoided using a steel box with improved block mounting and a 1/4-inch vent hole. This action and other pertinent considerations were discussed in detail with members of the NRC Staff at a meeting on March 23, 1978.

Review of this design change was performed, in accordance with Northeast Utilities Quality Assurance Procedures, by the Plant Operating Review Committee (PORC) and the NUSCO technical staff. Based on these reviews, the design of the block/steel box combination was determined to be technically acceptable in terms of performing its intended function in the core deluge valve circuits in the postulated post-accident environment. This determination was based, in part, on the results of the Phase II qualification tests, which were performed under temperature, pressure, radiation, humidity, and chemical conditions which conservatively simulated the post-accident containment environment at the Haddam Neck Plant; in addition, another evaluation concluded that the performance of the connections of the block box combination under seismic conditions would be acceptable. The pertinent environmental qualification data for the General Electric terminal block/steel box combination is summarized in the Attachment.

The Connecticut Yankee Nuclear Review Board (NRB) was also requested to review this design change. As a result of their review, the NRB concurred in the conclusions of the technical review discussed above and in the determination that the design of the block/box combination and the replacement and retest procedures did not

constitute an unreviewed safety question within the context of 10CFR 50.59; thus, the replacement was initiated on March 23, 1978 and completed on March 23, 1978.

Very truly yours,

CONNECTICUT YANKEE ATOMIC POWER COMPANY

D. C. Switzer
President

Attachment

DOCKET NO. 50-213

ATTACHMENT

HADDAM NECK PLANT

SUMMARY OF ENVIRONMENTAL QUALIFICATION TEST PROGRAM

TERMINAL BLOCK/BOX COMBINATIONS

MARCH, 1978

INTRODUCTION

In accordance with commitments made in a January 13, 1978 letter and at a meeting on January 29, 1978, CYAPCO engaged the Franklin Institute to perform full series environmental qualification testing of a General Electric terminal block type EB-25 enclosed in two different types of junction boxes (aluminum and steel) representative of those utilized in the core deluge valve motor operator circuits inside containment at the Haddam Neck Plant. Two block/aluminum box combinations are located in the reactor vessel head region while two block/steel box combinations are located on the charging floor inside containment. As discussed at the January 29, 1978 meeting, a block/box combination had already successfully undergone screening tests (Phase I tests), under pressure, temperature, and humidity conditions which conservatively simulated the post-accident environment inside containment.

The following information summarizes the full series test program (Phase II tests), including the test setup, procedures, and pertinent preliminary test results related to qualification of the block/box combinations.

DESCRIPTION OF TESTED COMPONENTS

As noted on the attached figure, for the purposes of simulating the installed equipment at the Haddam Neck Plant, [redacted] In addition, a number of other terminal blocks were installed in these two junction boxes and a third junction box for the purpose of gaining additional test data; in one of these combinations, a GE terminal block was mounted vertically in a steel box.

The GE terminal block tested was made of [redacted]

The steel box measured 12 x 10 x 4 inches (height, width, and depth) and was 1/16 of an inch in thickness. The aluminum box measured 12 x 12 x 6 inches and was 1/8 of an inch in thickness. Both boxes were somewhat larger than those originally installed in the core deluge circuits. The steel box utilized a terminal block mounting panel on standoffs from the back of its enclosure.

One of the two steel boxes, and the aluminum box, were mounted vertically in the autoclave. The terminal blocks within these enclosures were also vertically oriented. The second steel box was mounted horizontally, with the cover up, in the autoclave. The vertically oriented steel box had a 1/4-inch vent/drain hole in the center of the bottom of the box. The vertically oriented aluminum box had a 1/4 inch drain hole in the bottom of the box and a 1-inch diameter vent hole in the center of the cover of the box. The 1-inch vent hole was covered with 2 x 2 inch splash plate approximately 3/4 of an inch away from (outside) the surface of the cover. The horizontally oriented steel box had a 1-inch diameter vent/drain hole in the center of the bottom of the box behind the component mounting panel.

It should be noted that the aluminum box and the horizontal steel box were fabricated and oriented in a manner to duplicate the two boxes, with their General Electric type EB-25 terminal blocks, in each of the core deluge valve circuits at the Haddam Neck Plant. In fact, the horizontally oriented steel box which was tested, was identical to the two boxes which were installed in the core deluge circuits in November, 1977, in response to IE Bulletin 77-05. It was also identical to the EB-25 terminal block/junction box tested at Franklin Institute in January, 1978, as part of a screening test.

PRECONDITIONING OF TEST SPECIMENS

Prior to being put into the autoclave, the test specimens were thermally aged and irradiated. [redacted] Aging [redacted] 70°C figure was used as representative of the ambient temperature to simulate the terminal blocks located on the head of the reactor vessel. Since the terminal blocks on the charging floor operate in a cooler ambient temperature, they were effectively aged to an equivalent life much greater than 40 years.

The radiation exposure considered the cumulative dose due to both the normal operating and postulated post-Loss-of-Coolant Accident (LOCA) environments. [redacted]).

Both the thermal aging and irradiation were deemed to conservatively represent the normal operating and post-LOCA environment taking into account the actual location of the block/box combinations inside containment, and the actual expected years of service. Additional conservatisms exist when consideration is given to a more realistic assessment of postulated post-LOCA doses (see March 6, 1978 CYAPCO letter) and the actual environmental conditions during the required functional time of the core deluge valves.

ENVIRONMENTAL TEST SEQUENCE AND TEST PARAMETERS

The environmental qualification test sequence called for [redacted]. Again, this transient is felt to conservatively bound the limiting environmental condition inside containment following a postulated LOCA.

Five minutes into the test, a chemical spray of borated, demineralized water was introduced into the autoclave. One spray nozzle was directed toward each of the three boxes in the autoclave, with a nozzle spray angle of 120°. The spray nozzles were oriented such that they sprayed directly onto the covers of the two steel boxes and onto the back side of the aluminum box. The borated water was mixed to form a solution of 2640 ppm boric acid; which again conservatively represented expected concentrations of chemicals which could spray the block/box combinations, considering its actual location in containment and expected refueling water storage tank values. It is important to note that additional conservatism has been introduced into the qualification test sequence by virtue of the fact that the major source of spray, the containment spray system, is not expected to be utilized following the postulated LOCA.

Spray at the original boron concentration was continued for 17.1 hours. After 17.1 hours, the spray was taken from the sump of the autoclave in a recirculation mode; thereby, dilution of the boric acid concentration occurred. The spray was terminated after 24 hours.

[redacted] the test conditions of [redacted] At that time, [redacted] The [redacted] was [redacted]. This value was then held [redacted] after which the autoclav[redacted], respectively, [redacted] The [redacted] the [redacted]

After about 31 hours at 286°F and 40 psig, the temperature and pressure were brought down to 232°F and 7 psig, respectively, in 6 uniform steps over a 3-hour

period. These new conditions were then held constant for approximately 101 hours. At that time, it was determined that conditions had stabilized to the point where no additional, meaningful data could be expected to be obtained. Because of this and because the test had run sufficiently long to qualify the terminal block/box combinations for the core deluge system, the test was terminated.

TEST ELECTRICAL PARAMETERS

The extreme terminal points on both ends of each of the terminal blocks under test were energized to 525 volts. The terminal points immediately adjacent to these energized point were grounded. All other terminal points on each block were wired in series into a low-voltage, 20-ampere current source. The two 525-volt terminal points on each terminal board were connected to their power supply by a double-pole knife switch, allowing for quick isolation of a given terminal block. Further isolation of a given terminal point was possible by open circuiting the wiring between one pole of the knife switch and the terminal point in question. The power supplies for the 525-volt energized terminal points were protected by one-ampere circuit breakers. To conservatively represent the 480 volt plant electrical system, 525 volts was used as the test voltage. The 20-ampere current circuits were designed to conservatively present the 17 ampere locked rotor current of the core deluge valves. The terminal blocks were energized with voltage and current continuously throughout the test period, except when certain terminal points were isolated, for short periods, while Insulation Resistance (IR) readings were taken.

It should be recognized that this test setup conservatively simulated the dielectric paths to ground, when compared to the normal three-phase electrical system at the plant. During normal plant operation, the dielectric paths to ground would only be stressed at approximately 277 volts, instead of 525 volts.

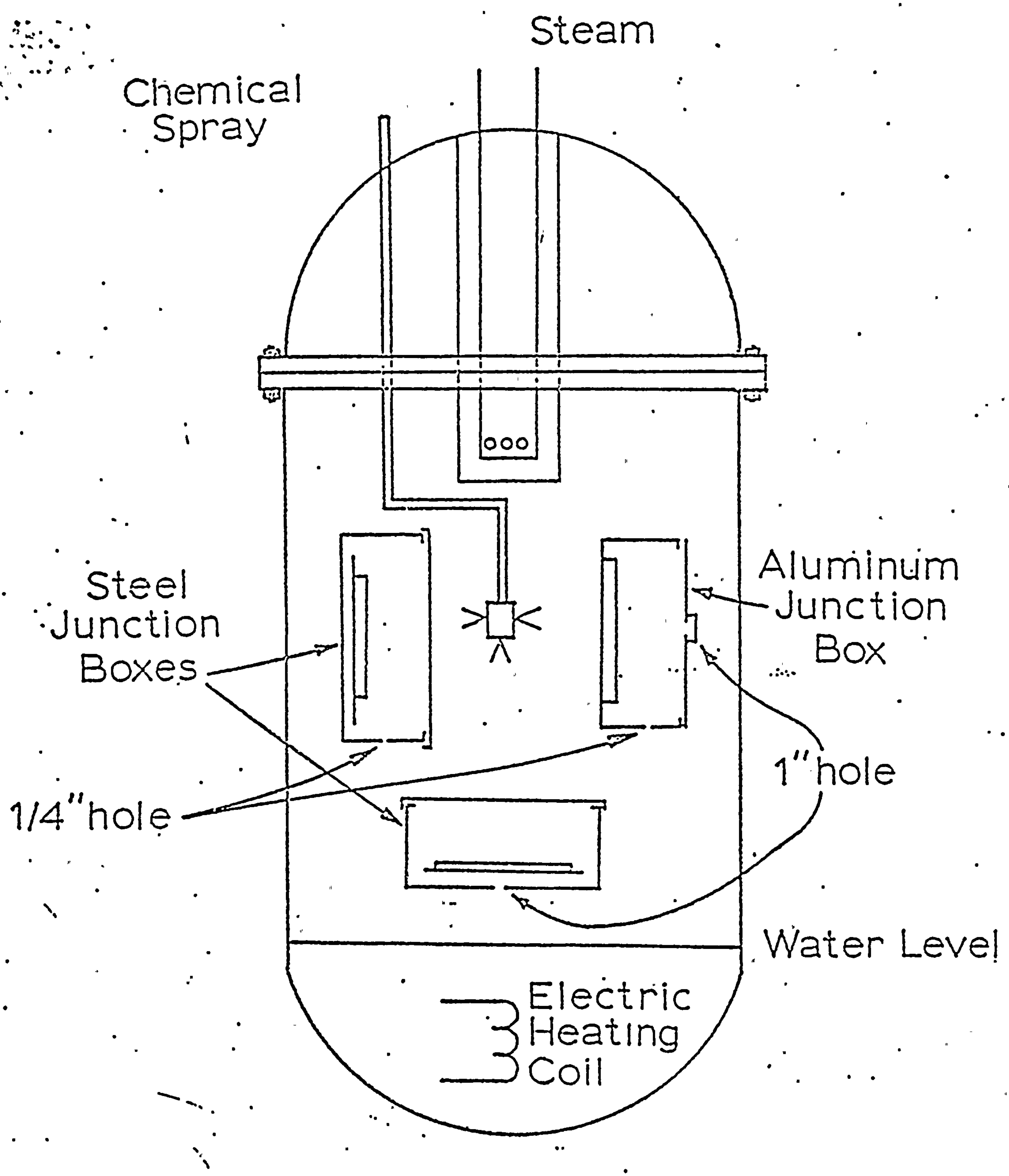
TEST PASS/FAIL CRITERIA

A failure of the terminal point under test was defined as the inability of that point to continuously support the applied test voltage or current. Any other indications associated with test connections, autoclave penetrations, power supplies, etc., would not be defined as a failure of a test specimen(s).

CONCLUSIONS

Insofar as a single point on the GE terminal block located in the aluminum box failed to its adjacent grounded terminal 30 minutes after initiation of the LOCA test sequence defined, its performance was not deemed acceptable under the acceptance criteria of the test, although it is still believed that the terminal block would have performed its intended function in actual service.

No failures occurred of the GE blocks mounted in steel boxes, and their performance was acceptable for the steel junction boxes oriented in both the horizontal or vertical positions. The IR data taken on the blocks in the steel boxes during the test confirmed that these block/box combinations would perform their intended function under the environmental conditions postulated for a LOCA and conservatively simulated in the test autoclave.. [redacted]



Environmental Qualification Test Setup Schematic

QA10

QUALITY ASSURANCE RECORD

Watch RVI

NES
NUCLEAR
ENERGY
SERVICES

nes NUCLEAR ENERGY SERVICES, INC.

DOCUMENT NO. 81A0636 REV. 0

SHIELDING DESIGN

REVIEW OF

NINE MILE POINT

NUCLEAR STATION UNIT 1

CONTROLLED COPY

Project Application	Prepared By	Date
5152	M. Jaworsky *M. Jaworsky*	7/15/80
APPROVALS		
TITLE/DEPT.	SIGNATURE	DATE
A. Gundersen, Director General Engineering	*A. Gundersen*	7/16/80
A. H. Yoli, Sr. Vice Pres. Engineering Operations	*A. H. Yoli*	7/15/80
Victor Potent, Quality Assurance Manager	*V. V. Potent*	7/14/80

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES Cont'd

1.0. SUMMARY

A Shielding Design Review was performed by NES for Niagara Mohawk Power Corporation's Nine Mile Point Nuclear Station Unit 1 in accordance with NUREG-0578 Section 2.1.6.b of the "TMI-2 Lessons Learned Task Force Status Report and Short Term Recommendations" (Reference 2). Plant systems were reviewed and identified for contamination due to an accident condition. Items requiring possible access or which could be damaged by radiation during or following such an event were identified. The list was subsequently reduced to areas or items located where the radiation fields will be high. These items and areas are:

1. Power Boards Nos. 161A, 161B, 167, 155, 16, and 17
2. Reactor Water Sampling Station
3. S.E. Stairway to Elev. 281' in the Reactor Building
4. Boron Tank
5. H_2-O_2 Monitoring Panel
6. Reactor Building Emergency Ventilation Filter Banks
7. Valve Nos. 80-40, 80-41, 80-43, 80-44, 80-45

Dose rates were calculated for areas or items located on a direct line from a source.

The NES analysis showed that airborne dose levels in the Reactor Building due to inleakage from the containment will preclude access. As a result of the airborne radionuclide concentrations, the Reactor Building Emergency Ventilation Filter Banks will become a radiation source in the Turbine Auxiliary Building. It may be necessary to install additional filter banks or sacrificial filters within the Reactor Building.

Class IE equipment located in the proximity of piping and components containing reactor water, containment air, or torus water could receive integrated doses which exceed the damage threshold of the constituent materials. This equipment has been identified and appropriate action, such as shielding or relocation of equipment, is given in Table 4.1.

All reactor water and containment air sampling will have to be performed outside of the Reactor Building. Radiological sampling of drywell air can be performed utilizing one of the sample lines to the H_2-O_2 Monitoring Panels which is located in the Turbine Building. A Reactor Water Sampling Station will have to be installed in the Turbine Building. To facilitate general access in the Turbine Building in the area of the sampling stations, shielding around the stations is recommended.

Dose rates to the Main Control Room, health physics laboratories, and Technical Support Center will be 1.1 mR/hr, 0.02 mR/hr, and 0.4 mR/hr, respectively, due to attenuation of the radiation sources by a distance factor and the several concrete walls and floors in the Turbine Building and Diesel-Generator Building.

Plans have been made by Niagara Mohawk to operate valves 80-40, 80-41, 80-43, 80-44, 80-45 remotely for heat removal from the torus, since they have been identified as being in a high radiation area.

2.0 INTRODUCTION

The TMI-2 Lessons-Learned Task Force instructed utilities in Section 2.1.6.b, of NUREG-0578 to: "Perform a design review of the shielding of systems processing primary coolant outside of containment. Determine any areas or equipment that are vital for post-accident occupancy or operation and assure that access and performance will not be unduly impaired due to radiation from these systems."* In conformance with this recommendation, NES performed a Shielding Design Review for Niagara Mohawk's Nine Mile Point, Unit 1 Nuclear Station.

The Review for Nine Mile Point Nuclear Station Unit 1 (NMP-1) consisted of six activities, as described below:

1. Identification of systems which would become contaminated in case of an accident;
2. Identification of plant areas requiring post-accident entry;
3. Identification of Class 1E equipment located within line-of-sight of piping and components containing accident sources;
4. Calculation of accident source terms;
5. Calculation of accident dose rates in areas where entry is necessary or degradation of equipment is a possibility;
6. Preparation of radiation zone maps reflecting areas of potential contamination due to accident conditions.

This report summarizes the results of the activities and presents possible recommendations for plant improvement.

*Note: Appendix A of this document contains further explanation of the NRC's position as was presented in Appendix A of NUREG-0578.

3.0 METHODS OF APPROACH

3.1 IDENTIFICATION OF POTENTIALLY CONTAMINATED SYSTEMS

All systems were included in the initial evaluation. Each system was evaluated to determine if it would or would not be contaminated under the given conditions. This approach assured that all plant systems had been properly considered.

Table 3.1 lists those systems which would be contaminated by direct contact with contaminated liquids and gases or by leakage of these contaminated fluids. Those systems which were also found to be the main source systems for doses to access items or Class 1E equipment are denoted with an asterisk (*). These source systems were identified as contributing significant radiation exposures to Class 1E equipment and the areas found to be necessary for access during accident conditions or recovery operations.

3.2 IDENTIFICATION OF PLANT AREAS REQUIRING POST-ACCIDENT ENTRY

Access areas were identified by reviewing plant operating procedures, special operating procedures, plant layout drawings, piping drawings and isometrics, and piping and instrumentation diagrams. Operating experience was also utilized in the processes of identifying the need for access to certain items during an accident condition or for recovery operations.

A visual determination of sources and access areas was made at the plant site as well. This enabled NES to obtain feedback from the NMP-1 plant staff concerning their evaluations as to which items would be necessary to access. This examination also made it possible to ascertain whether the path to the access item presented a radiological danger. The main items established as "necessary for access" are listed in Table 3.2.

TABLE 3-1

CONTAMINATED SYSTEMS

Reactor Water Contact

*Sampling System
Reactor Cleanup System (up to isolation valve)
*Drywell and Torus
Waste Disposal System (up to isolation valves on sumps)
*Emergency Cooling System
*Shutdown Cooling
*Core Spray
*Containment Spray
Reactor Recirculation
Main Steam (up to isolation valves)

Contamination From Potential System Leakage

Waste disposal system (remainder)
Feedwater
Closed Cooling
Condenser Air Removal
Main Steam (downstream of isolation valves)
Reactor Cleanup System (downstream or outside isolation valves)

Filter Contamination by Airborne

Radiation Monitoring (e.g., CAM)
*Reactor Building Emergency Ventilation

Systems Contaminated by Containment Atmosphere

*CAD (to 1st isolation valve)
*CAM
*Reactor Building Emergency Ventilation
*H_2-O_2 Monitoring

* Systems preceeded by an asterisk are main source systems.

TABLE 3-2

AREAS OR ITEMS IDENTIFIED FOR ACCESS

	Area or Item and Dose Point Locations	Location	Reason for access
1.	Power Boards 161A, 161B	Reactor Bldg. Elev. 261'	Contains main buss feed to reactor recirculation pump blockvalves and other reactor water components,diesel generators, etc.
2.	Reactor Water Sampling Station	Reactor Bldg. Elev. 261'	To fulfill requirements of Section 2.1.8a of NUREG-0578. (Reference 1)
3.	Power Boards 155, 167	Reactor Bldg. Elev. 281'	Motor control center for Torus Vent and Purge Air Isolation Valve, Liquid Poison Heater, Emergency Exhaust Heater, etc.
4.	Stairwell SE	Reactor Bldg. Elev. 281'	Necessary for access to elevation 281' in Reactor Building
5.	Power Boards 16, 17	Reactor Bldg. Elev. 281'	Contains main buss feed for air compressors, Reactors Bldg. Closed Loop Cooling Pumps, Shutdown Cooling Pumps, etc.
6.	Boron Tank	Reactor Bldg. Elev. 298'	May be necessary to refill tank if poison is added to the core.
7.	Reactor Bldg. Emergency Ventilation Filter Banks	Turbine Auxiliary Bldg. Elev. 289' 8"	May be necessary to change filters.
8.	H_2-O_2 Monitoring Panels	Turbine Bldg. Elev. 291'	(1) Necessary for sampling hydrogen and oxygen in drywell. (2) Anticipated to be used for radiation sampling of drywell air.

3.3 IDENTIFICATION OF SAFETY EQUIPMENT IN HIGH RADIATION AREAS

NES identified all of the areas in the Reactor Building containing accident sources which are external to the containment. A listing of Class 1E equipment was provided to NES by Niagara Mohawk. This listing was used during a plant walk-through to determine which equipment was located in the direct line of piping and components containing accident radiation sources. NES found approximately seventy-five pieces of equipment for which calculations were necessary to determine whether the integrated doses from these sources would exceed the damage threshold* to the most sensitive material or component in the equipment

3.4 CALCULATION OF SOURCE TERMS

Source term calculations were based on a clarification letter, dated October 30, 1979 from Harold R. Denton concerning the NUREG-0578 Report (see Appendix B). Release to the liquid-containing systems consisted of 100% of the core inventory of noble gases, 50% of the core inventory of halogens and 1% of the remaining fission products. Release to the gaseous-containing systems consisted of 100% of the core inventory of noble gases and 25% of the core inventory of halogens.** The specific isotopic inventory was based on the fission product inventory for UO_2 fuel at t = 0, 30 minutes, and 24 hours after shutdown, as taken from the GE Document "Radiation Sources" (see Ref. 1). The GE data was adjusted for operation at 1850 megawatts thermal. The isotopic inventory was decayed for 2, 3, 7, 11, 30, and 100 days using the computer code LOR2, a Babcock and Wilcox version of ORIGEN (Reference 8).

* The damage threshold is the total integrated radiation dose which will produce the first sign of degradation.

** NOTE: The noble gas inventory is accounted for twice by the NRC. This is a conservative assumption.

To obtain the reactor water inventory, the released isotopes (100% noble gases, 50% halogens, 1% remaining fission products) were homogeneously distributed throughout the reactor water volume downstream of the feedwater isolation valves. The reactor steam inventory was obtained by distributing the released isotopes (25% halogens, 100% noble gases) throughout the reactor steam volume. For the containment air inventory, the isotopes released to reactor steam were assumed to have been subsequently released to the drywell as a result of an accident such as a steamline break. The drywell atmosphere and torus air were assumed to be mixed. The containment spray system activities were obtained by mixing reactor water homogeneously with torus water.

The gamma activity of each isotope was distributed into seven gamma energy groups. Subsequently, the individual activities were summed to obtain a total activity for the system under consideration.

3.5 CALCULATION OF DOSE RATES

3.5.1 Direct Dose Rate from Contaminated Systems

Dose rate calculations were performed using methods from the Rockwell Shielding Design Manual (Reference 4). The geometric configuration of the calculations were based on NMP-1 drawings and a visual inspection of the area under consideration. Table 3.3 and 3.4 list the resulting dose rates and Figures 3.1 through 3.9 show the plant layout and the location of the dose points. It should be noted that these dose rates do not include the possible airborne doses listed in Table 3.5. These airborne dose levels could exist if leakages from the containment reach the maximum design leakage rates.

3.5.2 Integrated Doses to Equipment

The Gibbs & Hill, Inc. computer code, "COSACS", which performs Rockwell-type calculations was utilized to determine the dose rates to equipment at various time intervals. The geometric configurations used as input into the calculations were based on NMP-1 drawings and a visual inspection of the areas under consideration. An integrated dose to equipment for 0 to 100 days was calculated using these dose rates.

TABLE 3.3

DOSE RATES TO AREAS OR ITEMS IDENTIFIED FOR ACCESS
(Excluding airborne doses)

	Dose Point Location	Location	Source	t = 30 (Rem/Hr)	t = 24 hrs (Rem/Hr)
1.	Power Boards 161-A & 161-B	Reactor Bldg. Elev. 261'	Shutdown HX, pumps, and associated piping	320+ 30.4*	139+ 12.4*
2.	Reactor Water Sampling Station	Reactor Bldg. Elev. 261'	Reactor Water	4.3+ 117mRem/hr*	13.4+ 50.6mRem/hr*
3.	Power Boards:	Reactor Bldg. Elev. 281'	Containment Spray Lines		
	a. 155			836	353
	b. 167			109	45
4.	Stairwell SE	Reactor Bldg. Elev. 281'	Containment Spray Lines	323	135
5.	Power Board 16	Reactor Bldg. Elev. 281'	Containment Spray Lines	667	280
6.	Boron Tank	Reactor Bldg. Elev. 298'	Drywell	13mRem/hr	<1mRem/hr
7.	H_2-O_2 Monitoring Panel	Turbine Bldg. Elev. 291'	Drywell Air	6	2

+ Without containment spray
* With containment spray

NOTES:

1. Dose rates for these access items were not calculated for times after 24 hours since their access will probably be precluded by airborne dose rates.

2. Dose rate calculations were performed at the worst case point about a foot away from the access item.

3. Dose rate calculations were performed only for those items which are located in the direct line of a source; other items not listed in this table are hampered from access by the airborne dose rates.

TABLE 3.4

DOSE RATES FROM REACTOR BUILDING EMERGENCY VENTILATION FILTERS

ELEVATION 289'

WITH CAD (Rem/Hr)

Dose Point Location	t = 30 min.	t = 24 hr.	t = 2 day	t = 3 day	t = 7 day	t = 11 day	t = 30 day	t = 100 day
18" from midplane of charcoal filters	157	42,300	87,500	123,000	168,000	152,000	38,100	230
Eye level below charcoal filters on El. 261'	6.19	753	1,560	2,190	2,980	2,710	678	4.10
0. Screenhouse-Turbine-Aux. Bldg. doorway	1.17	125	258	363	495	449	112	0.68
1. Waste Bldg. Control Room Door	0.27	61.6	127	179	244	222	55.4	0.34

WITHOUT CAD (Rem/Hr)

Dose Point Location	t = 30 min.	t = 24 hr.	t = 2 day	t = 3 day	t = 7 day	t = 11 day	t = 30 day	t = 100 day
18" from midplane of charcoal filters	157	40,100	68,800	86,100	87,100	68,200	12,100	72.2
Eye level below charcoal filters on El. 261'	6.19	1,580	2,710	1,570	3,430	1,210	214	1.32
0. Screenhouse-Turbine-Aux. Bldg. doorway	1.17	296	509	261	645	201	35.4	0.22
1. Waste Bldg. Control Room Door	0.27	67.9	117	129	148	99.1	17.4	0.11

STATION FLOOR PLAN AT ELEVATION 225' – 0"

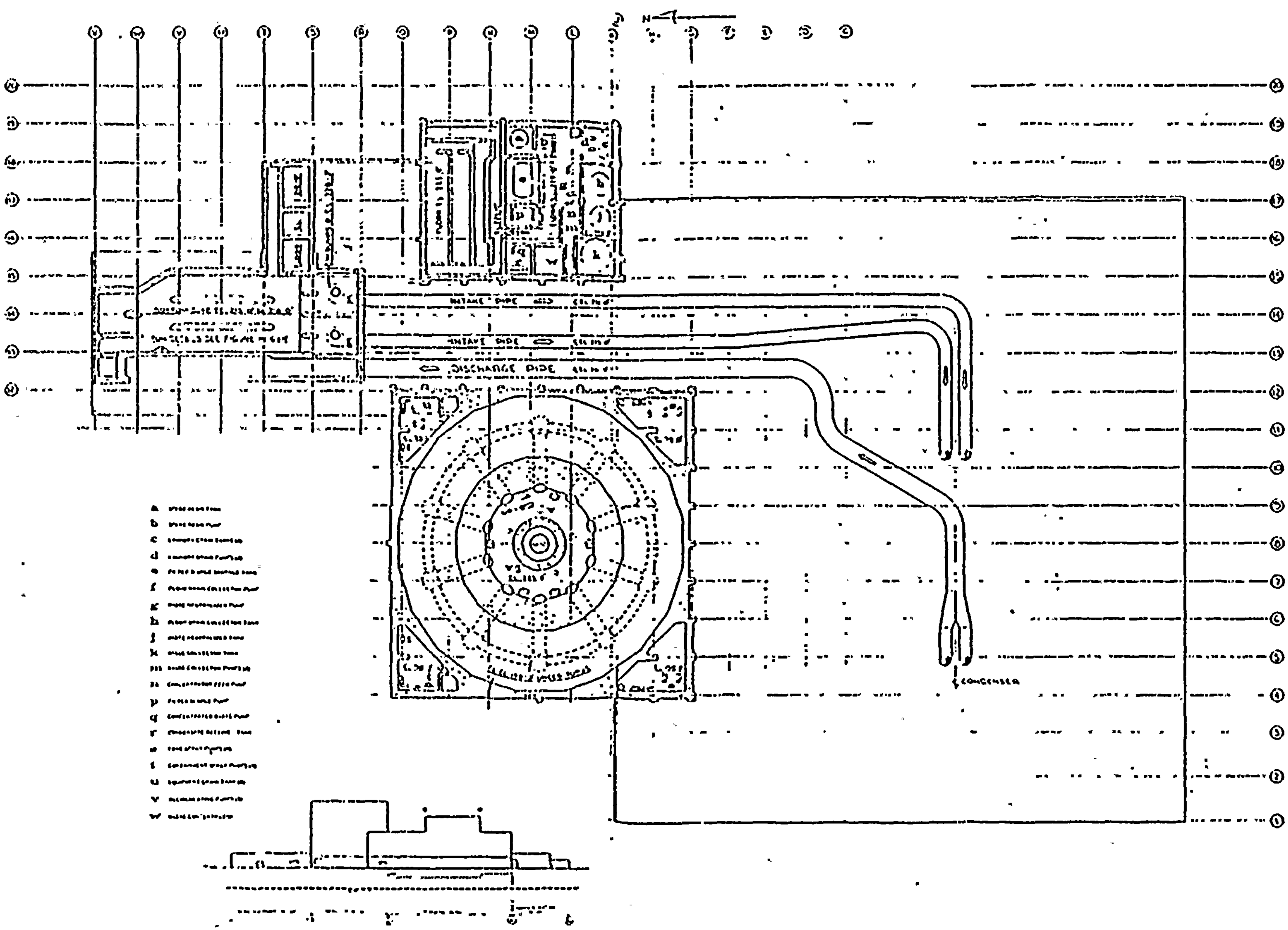


FIGURE 3.1

STATION FLOOR PLAN AT ELEVATION 250' – 0"

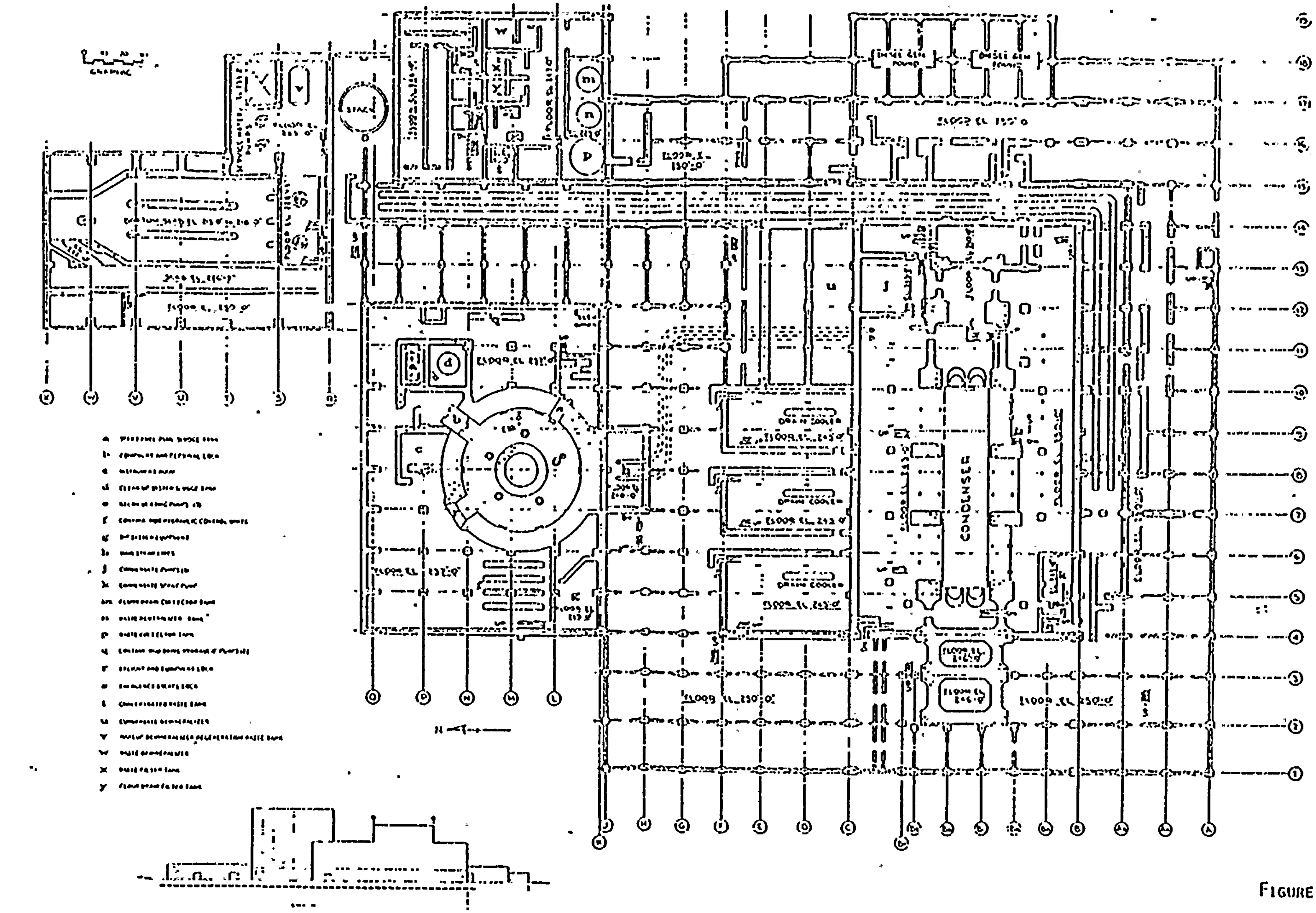


FIGURE 3.2

STATION FLOOR PLAN AT ELEVATION 261' - 0"

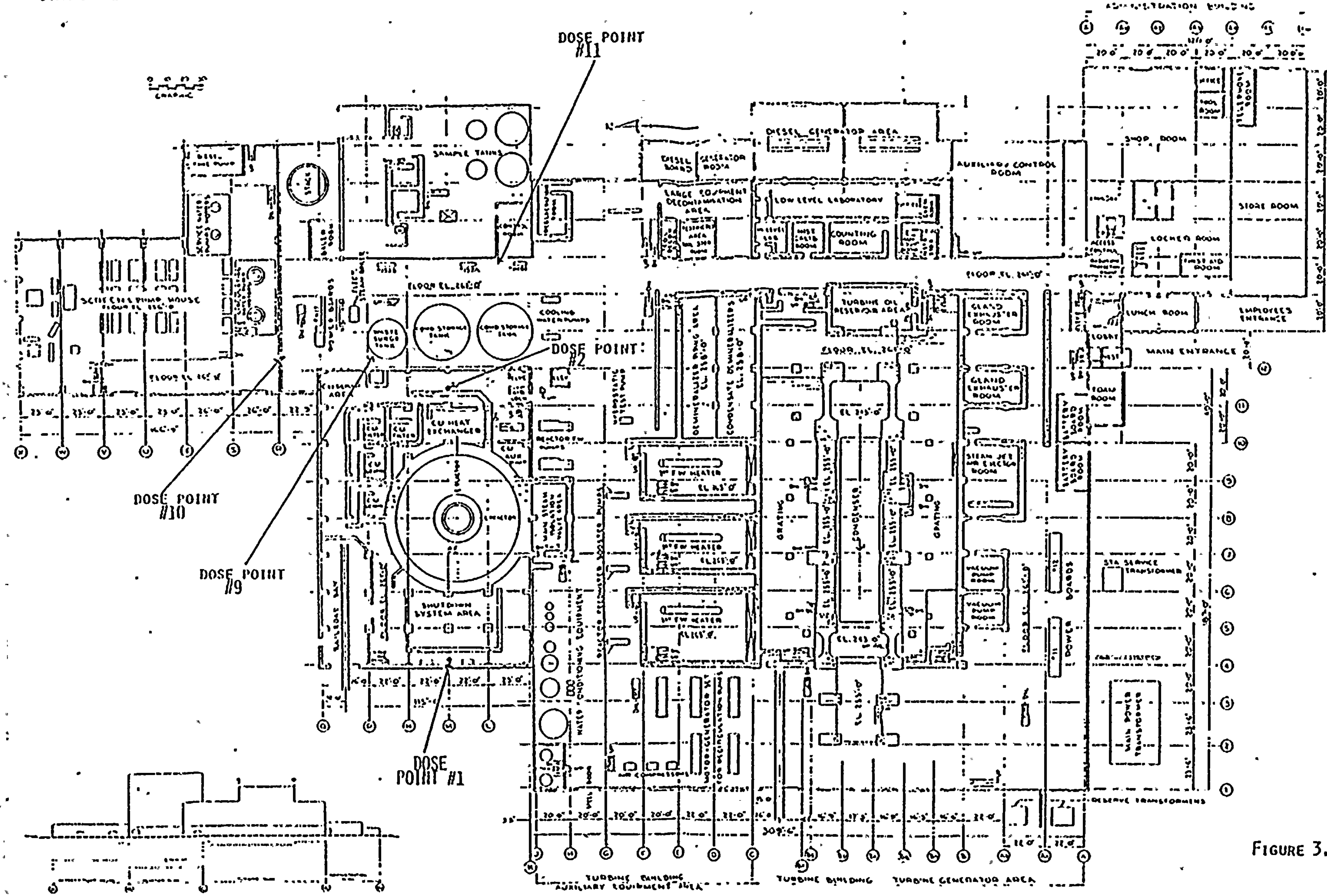


FIGURE 3.3

81A0636 18 of 56

STATION FL PLAN AT ELEVATION 277' - 0"

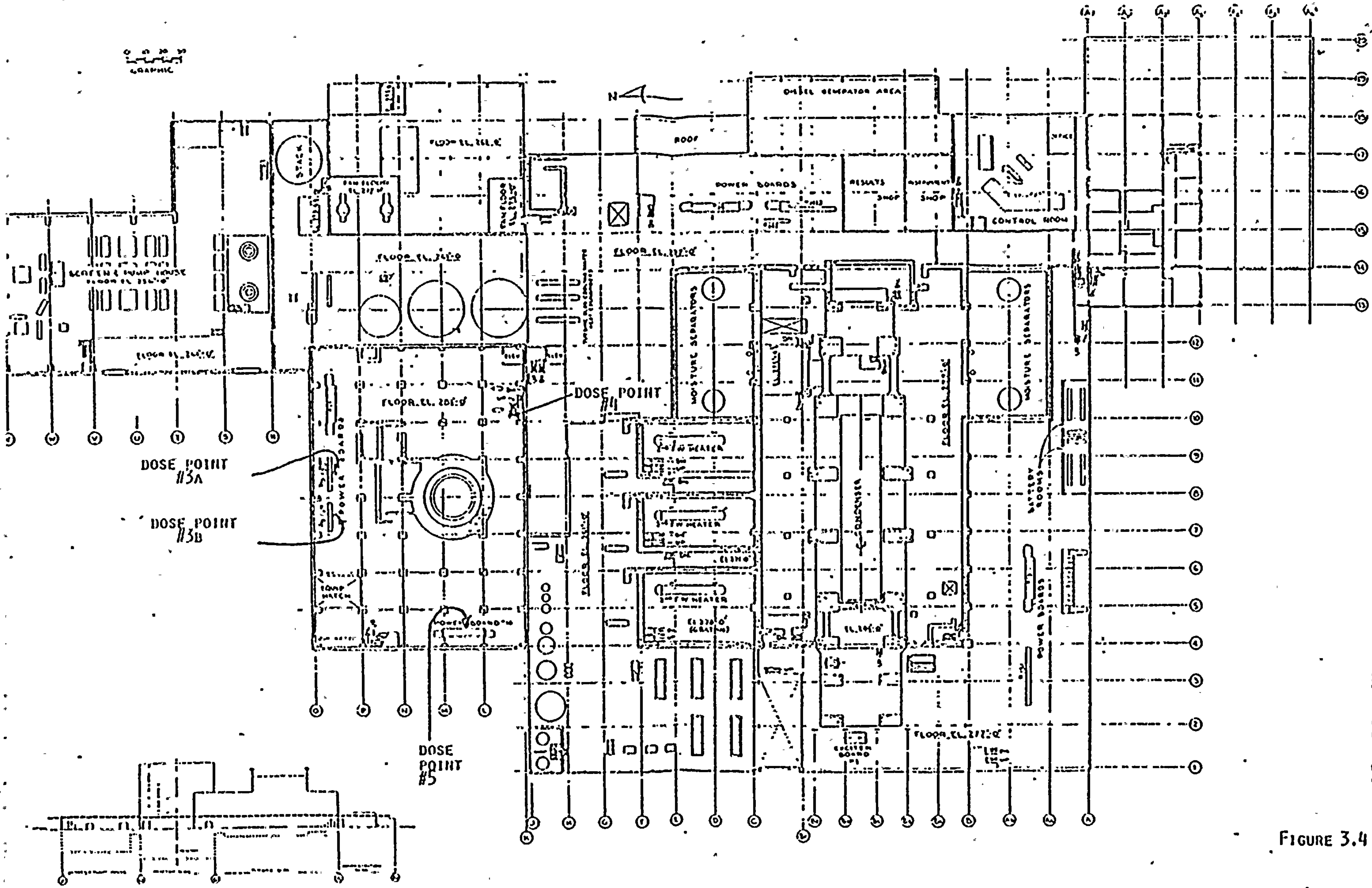
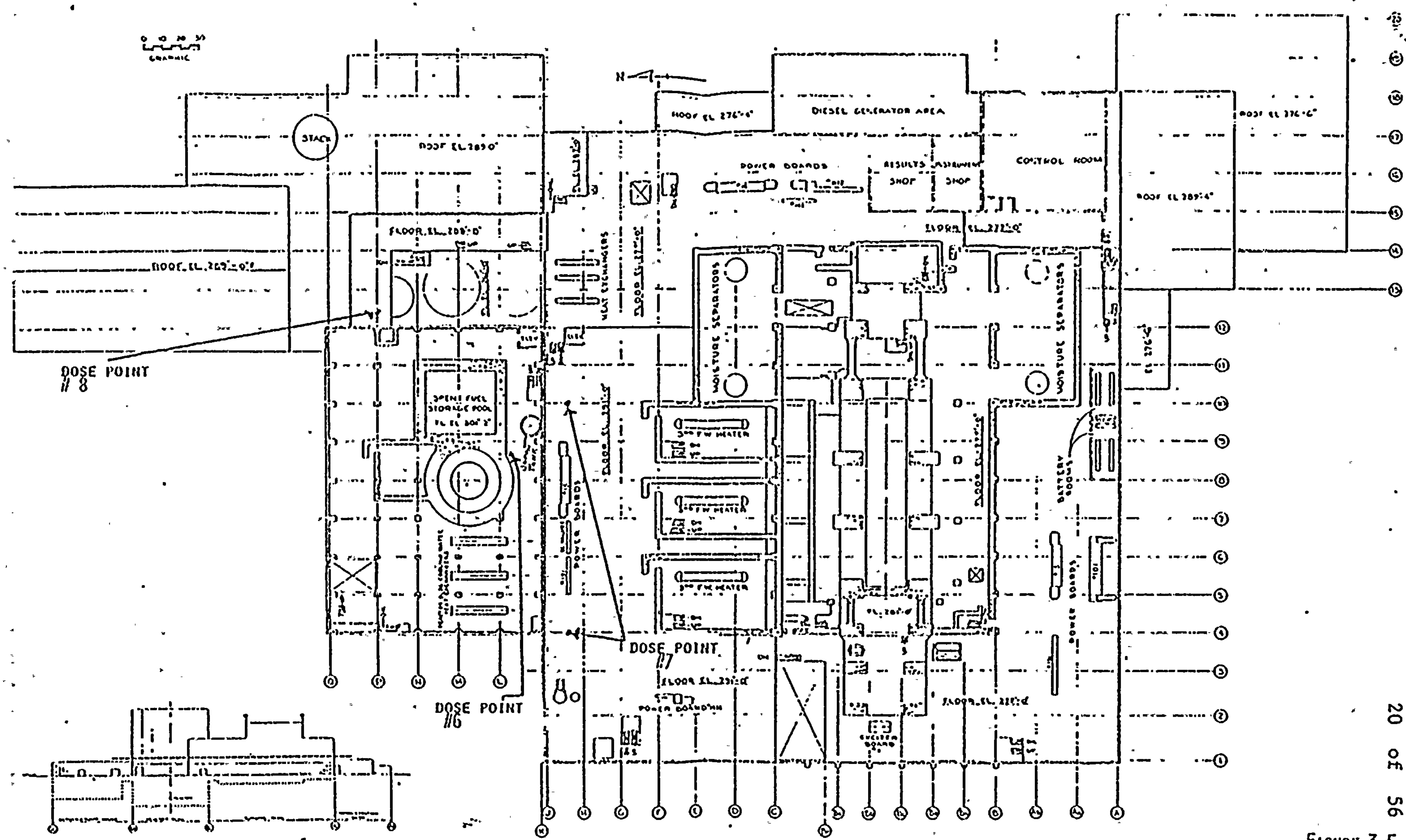


FIGURE 3.4

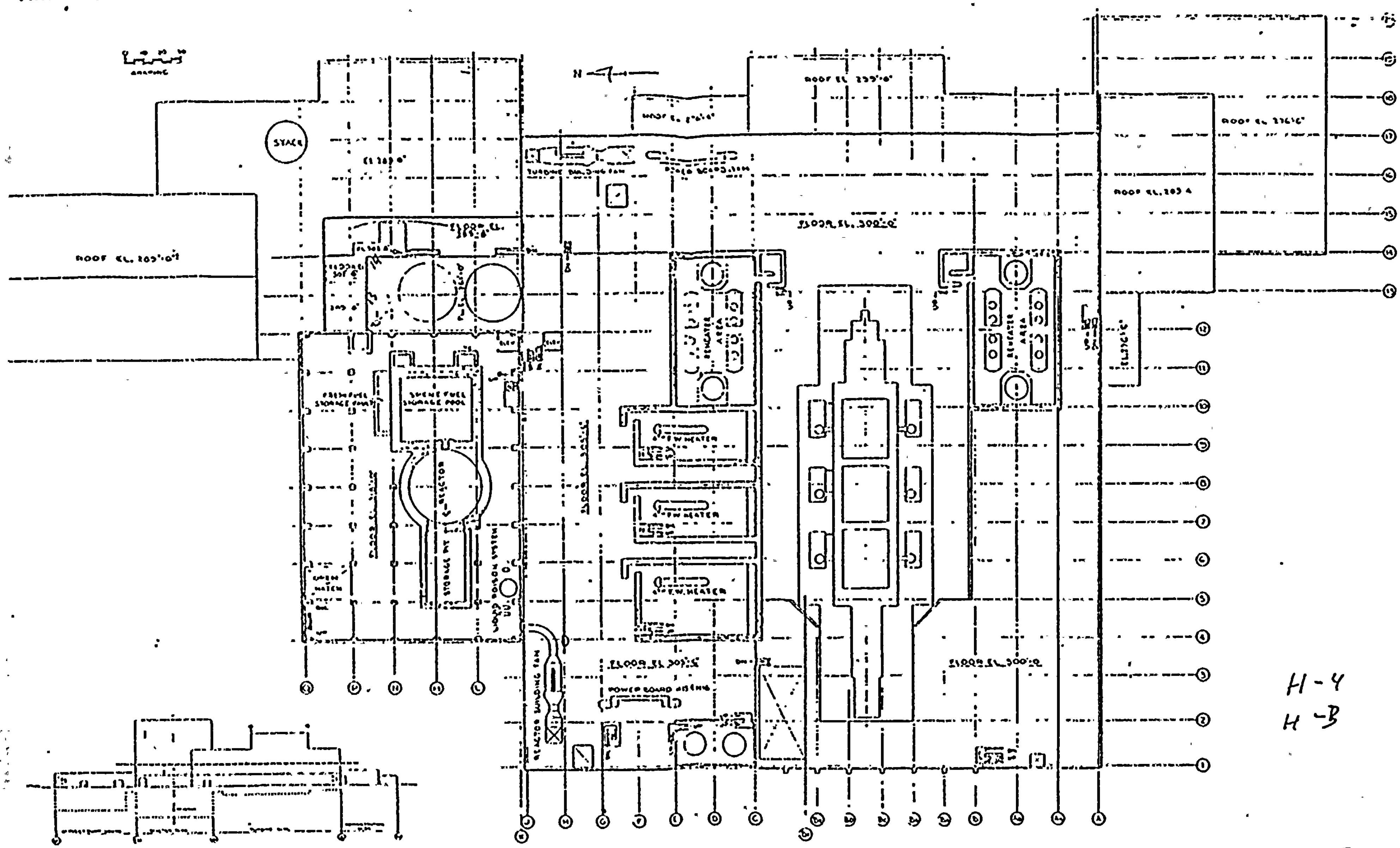
STATION FL... PLAN AT ELEVATI... -0"



81A0636
20 of 56

FIGURE 3.5

STATION FLOOR PLAN AT ELEVATION 305' - 0"



H-4
H-3

FIGURE 3.6

STATION FLOOR PLAN BETWEEN ELEVATIONS 317' – 0" AND 369' – 0"

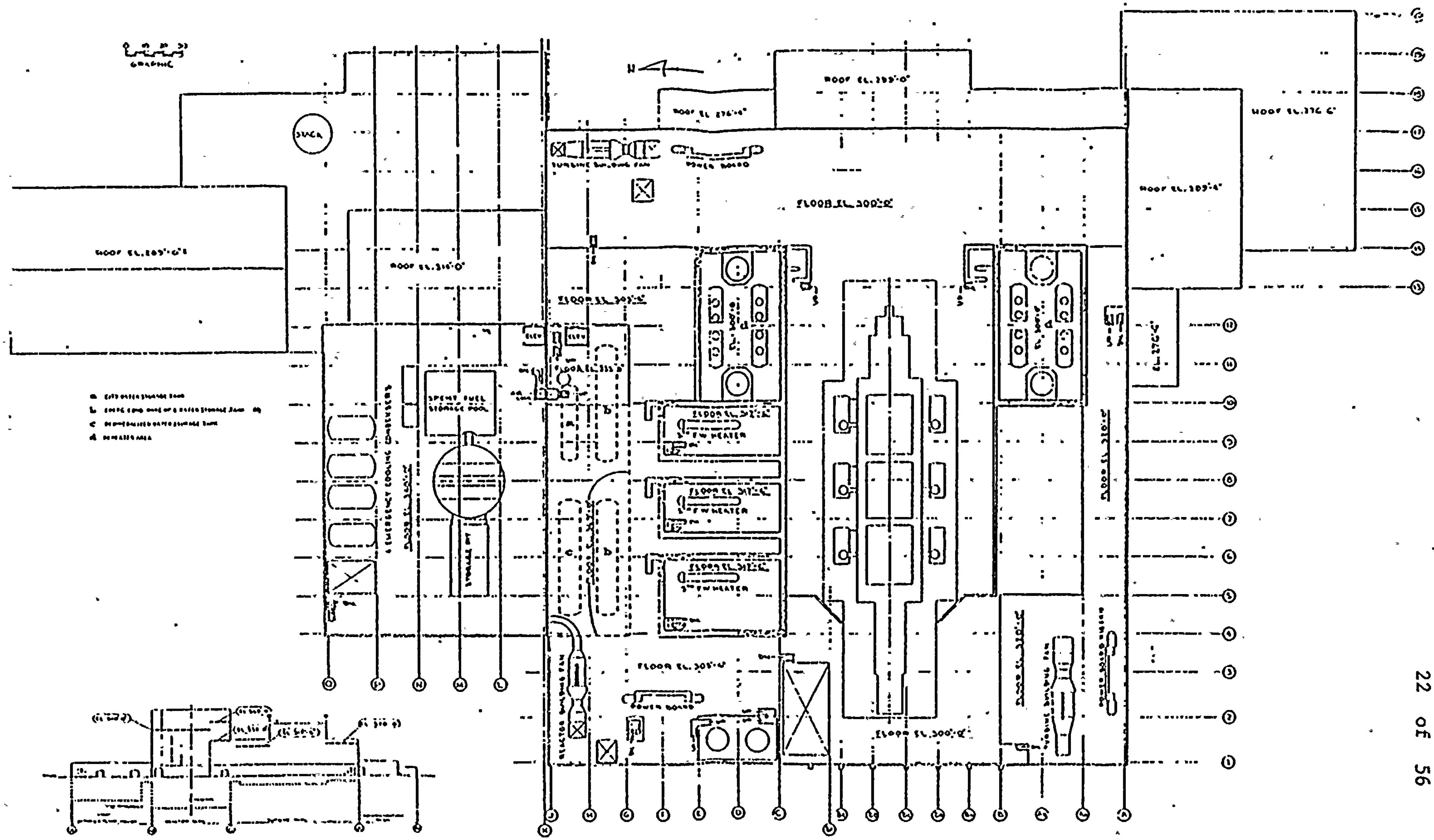


FIGURE 3.7

SECTION BET… COL… 7 AND 8

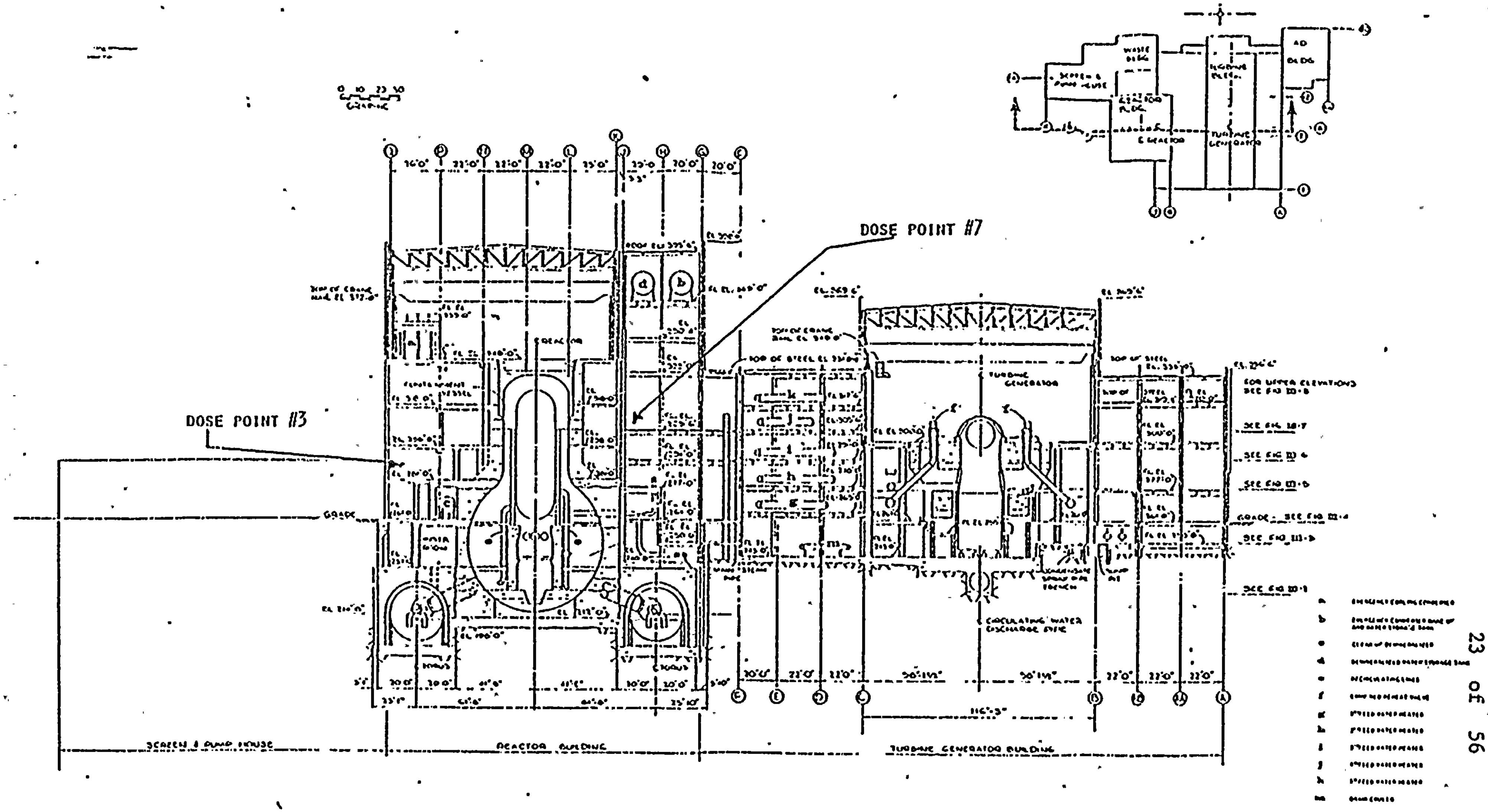


FIGURE 3.8

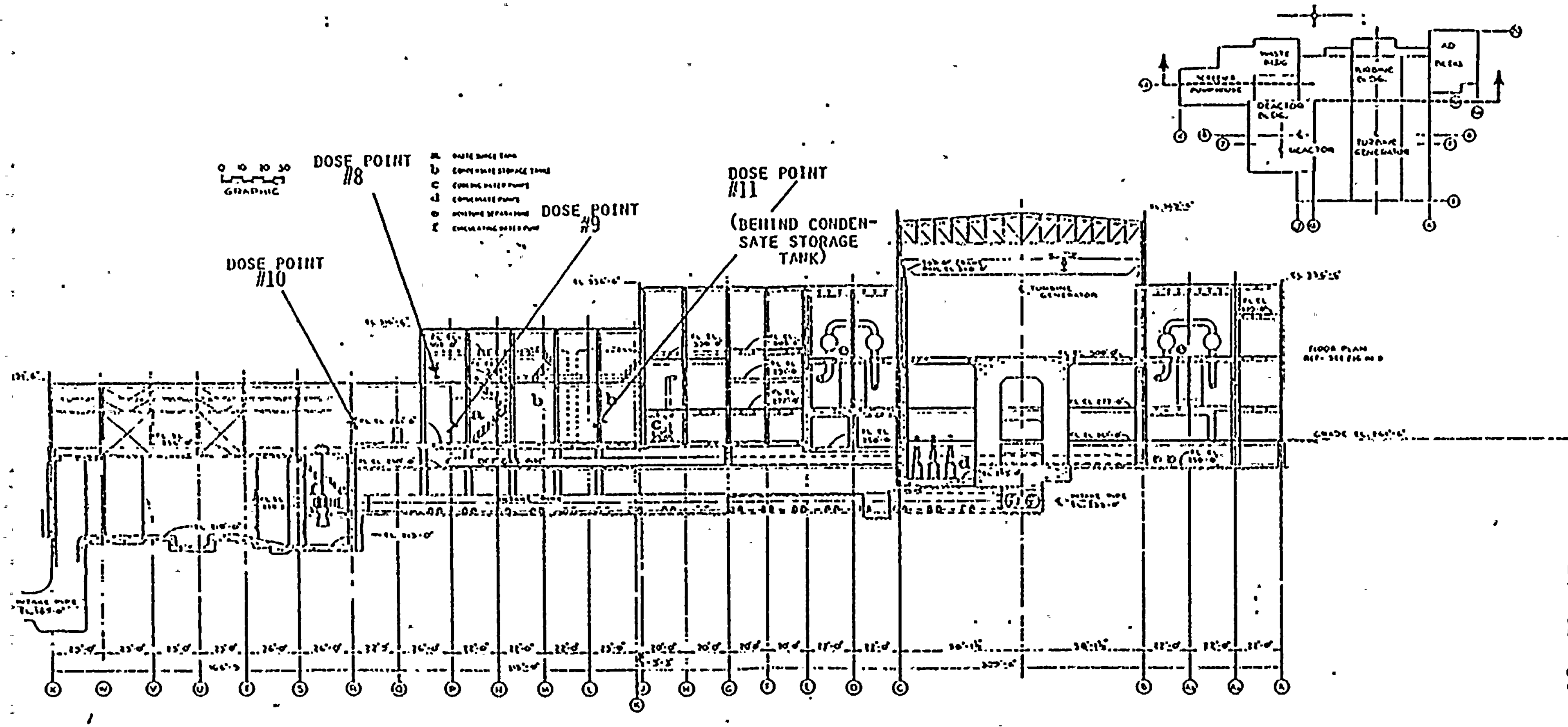

GRAPHIC
DOSE POINT #8
DOSE POINT #9
DOSE POINT #10
DOSE POINT #11
(BEHIND CONDENSATE STORAGE TANK)

FIGURE 3.9

The damage threshold for each piece of equipment was determined using the IE bulletin 79-01b (Reference 6) as a data base. This bulletin listed the common components and the respective damge thresholds of various categories of plant equipment. This list was generated by the Inspection and Enforcement Office of the NRC to serve as a basis for radiologically qualifying Class 1E equipment as required of all non-SEP plants by this bulletin. The items found to exceed the damage threshold are presented in Table 4.1. The remaining equipment was found to be below the damage threshold.

3.5.3 Airborne Dose Rates

Both the drywell and torus will experience an increase in pressure during and immediately following an accident. The drywell will experience a pressure spike of 35 psig during the first ten seconds. In the 60 seconds that follow, the torus and the drywell pressure will equalize at 22 psig, after which the pressure will decrease gradually to approximately 1.5 psig at $2X10^4$ seconds (about 5.5 hours). The drywell and torus will stablize at this pressure which is slightly greater than the pressure in the Reactor Building. Figures 3.10 and 3.11 graphically depict the aforementioned events.

Due to this positive pressure in the drywell and torus, the Reactor Building will experience an inleakage of contaminated containment atmosphere. (Note: the maximum allowable leakage rate from the containment for NMP-1 is 1.1%/day, when the containment is at a pressure of 22 psig.) Since leakage occurs as a result of the pressure difference between the Reactor Building and the containment structure, it can be assumed that the leakage will decrease with a decrease in the pressure difference between these plant areas. The airborne dose rate determinations were based on a the 10CFR relationship of $L=L_{22}(P/P_{22})^{1/2}$ where L equals the leakage rate at time (t), and pressure (P); L_{22} equals the leakage rate at 22 psig, which in this case is assumed to be the maximum allowable of 1.1%/day; and P_{22}= 22 psig.

When the CAD system is operated to eliminate the potential for detonation at hydrogen levels above 4% following an accident, the leakage rate will tend to increase with time, since the added nitrogen will increase containment pressure. This situation would continue until the containment is vented to the atmosphere via the Emergency Reactor Building Ventilation System. As a result of the leakage rate increase, the airborne dose rates increase. Table 3.5 lists airborne dose rates (with and without CAD operation) in the Reactor Building for various times following the accident.

A semi-infinite cloud model was used (as presented in U.S. NRC Regulatory Guide 1.109) to calculate the dose rates. The limiting factor in obtaining access to the Reactor Building is the airborne dose rate. High airborne activity also produces the high dose rates from the filter trains for the Emergency Reactor Building Ventilation System (see Table 3.4).

TABLE 3-5
AIRBORNE DOSE RATES IN REACTOR BUILDING

Time	Air (R/hr)* without CAD	Air (R/hr)* with CAD	Whole Body (R/hr)* without CAD	Whole Body (R/hr)* with CAD
30 min	590	590	560	560
24 hrs	2050	2210	1930	2080
48 hrs	1680	2070	1580	1950
3 days	1550	2150	1460	2020
7 days	590	1110	550	1040
11 days	290	649	271	606
30 days	14	50	12	46
100 days	.018	.054	.017	.052

* Semi-infinite cloud model

LOSS OF COOLANT ACCIDENT
DRYWELL PRESSURE
STRETCH POWER

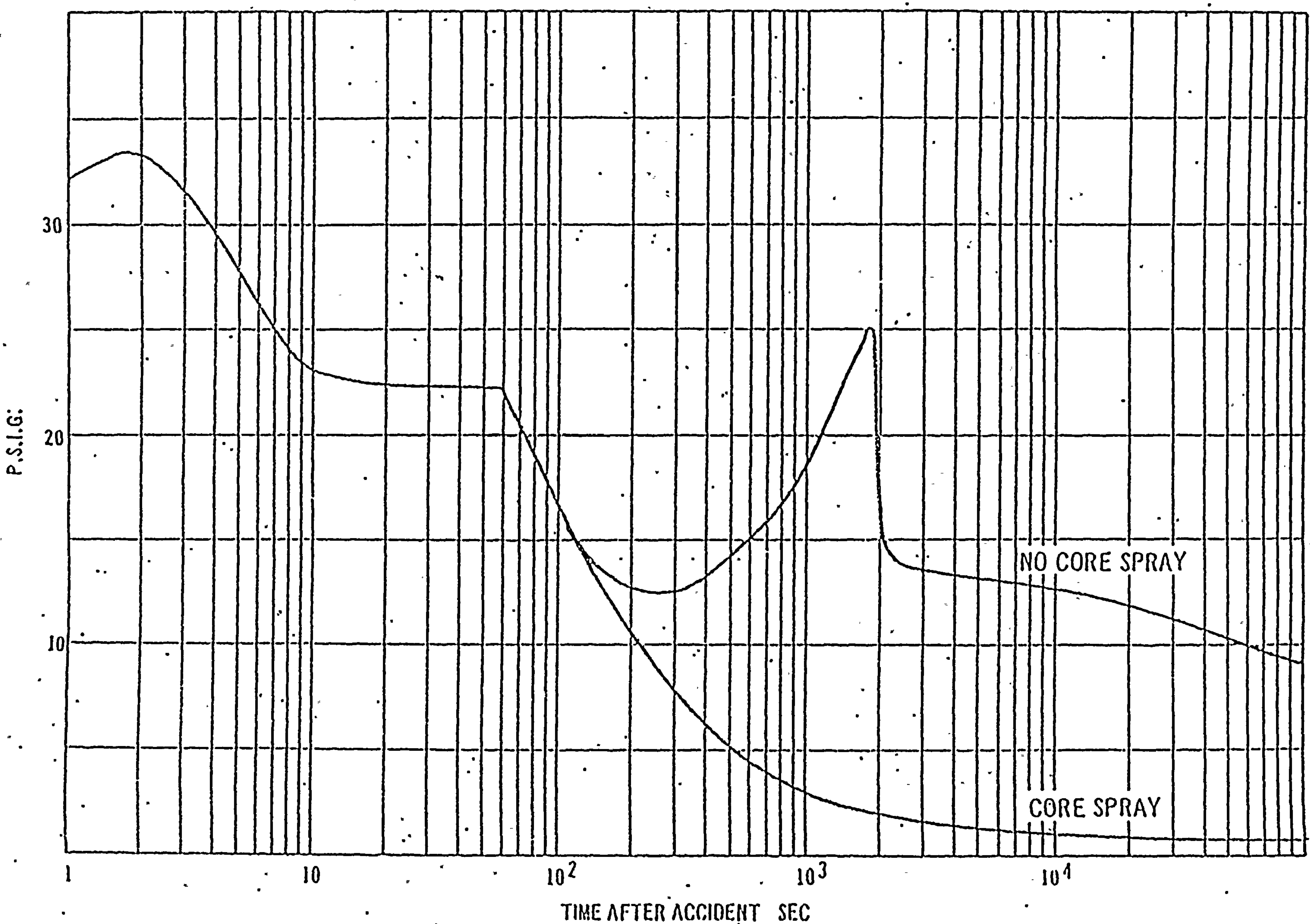


FIGURE 3.10

LOSS OF COOLANT ACCIDENT
SUPPRESSION CHAMBER PRESSURE
STRETCH POWER

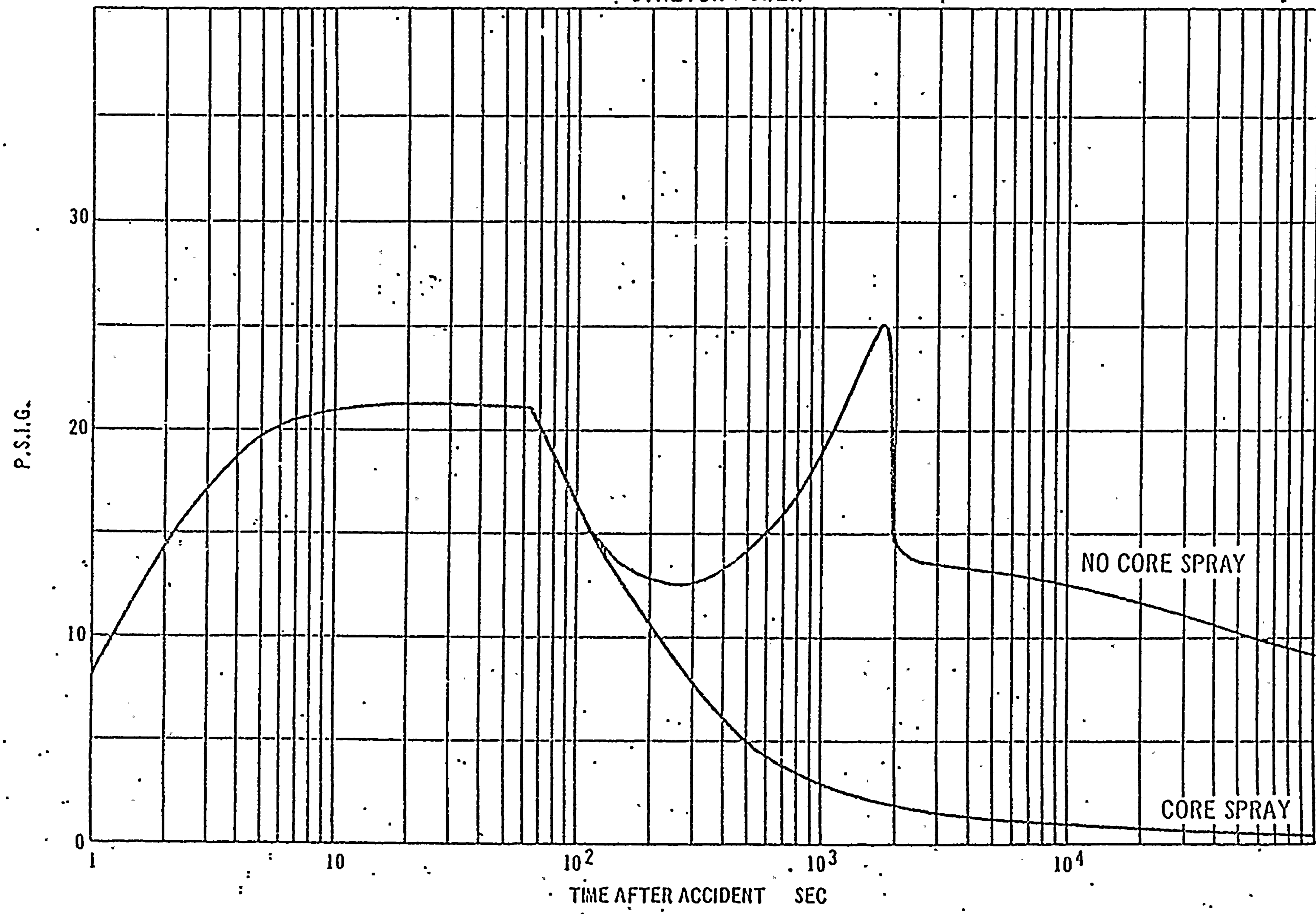


FIGURE 3.11

81A0636
28 of 56

3.5.4 Preparation of Radiation Zone Maps

The Radiation Zone Maps were constructed to show both known danger areas and areas which could become dangerous. Any area labeled as restricted access would not normally contain any large source of radiation. Such areas have the possibility of becoming inaccessible through additional equipment failure, e.g., leakage at the main steam or feedwater isolation valves). Restricted areas must be regarded as potentially dangerous until surveyed and proved otherwise.

The zone maps are plant elevations divided into three zones: prohibited access, restricted access, and unrestricted access. These areas are defined as follows:

Prohibited Access

Extensive Health Physics sampling and surveys are required prior to entry.

Restricted Access

Potential degradation of equipment requires periodic Health Physics surveys in post-LOCA conditions.

Unrestricted Access

Area dose rates are not anticipated to exceed 15 mr/hr. Periodic Health Physics surveys are recommended.

RADIATION ZONE MAPS FOR ELEVATION 225' - .0"

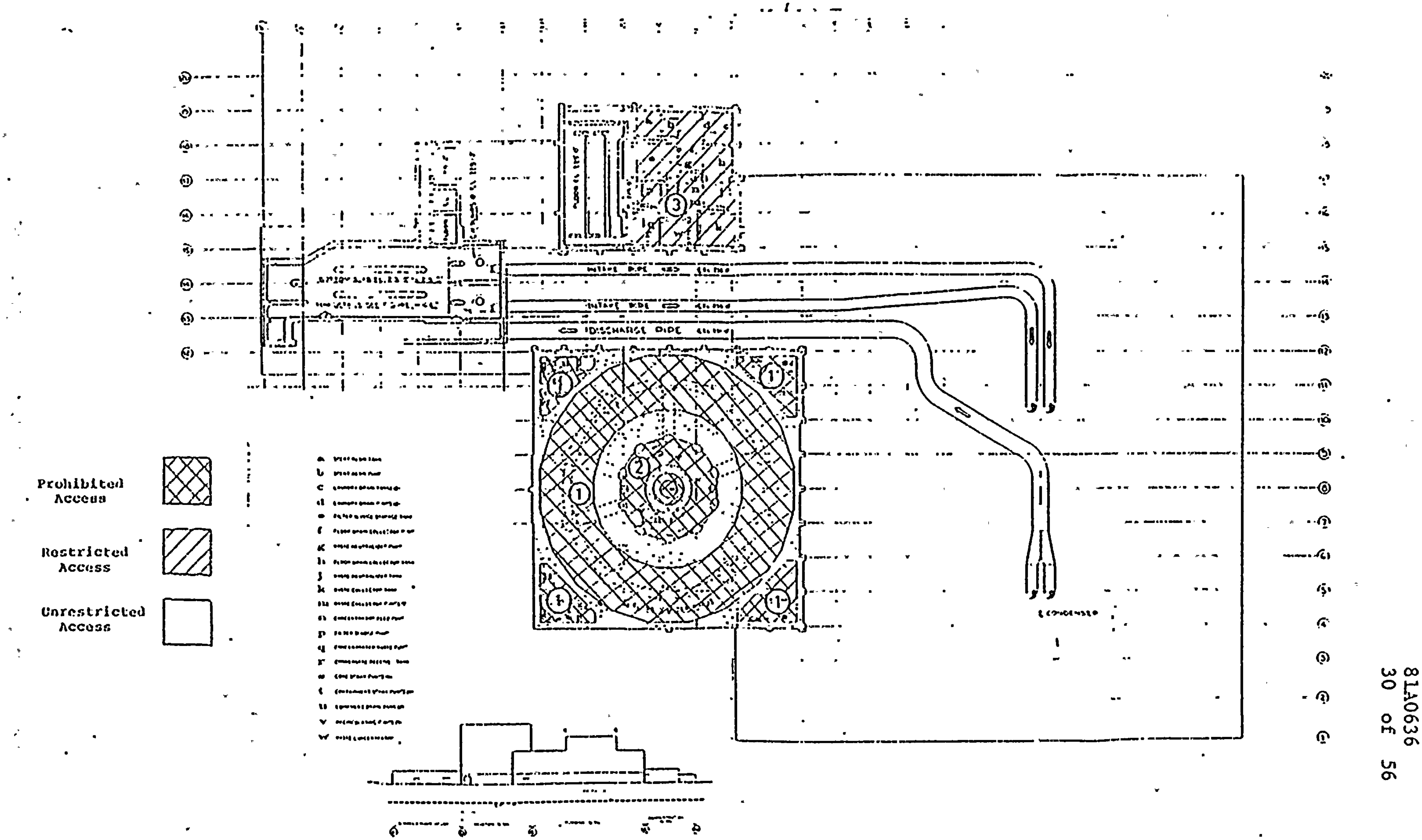


FIGURE 3.17

81A0636
30 of 56

RADIATION ZONE MAPS FOR ELEVATION 250' - 0"

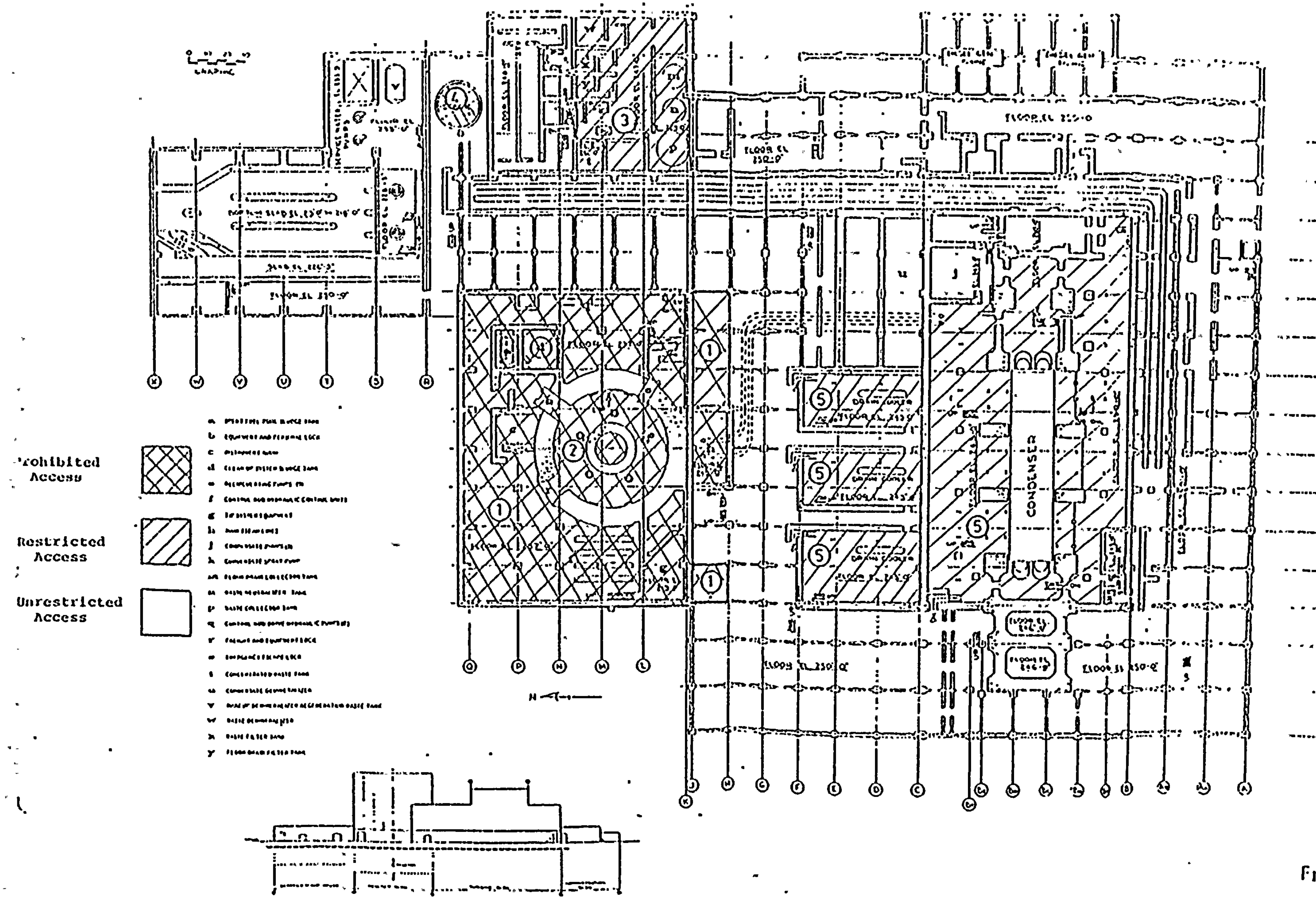


FIGURE 3.13

RADIATION ZONE MAPS FOR ELEVATION 261' - 0"

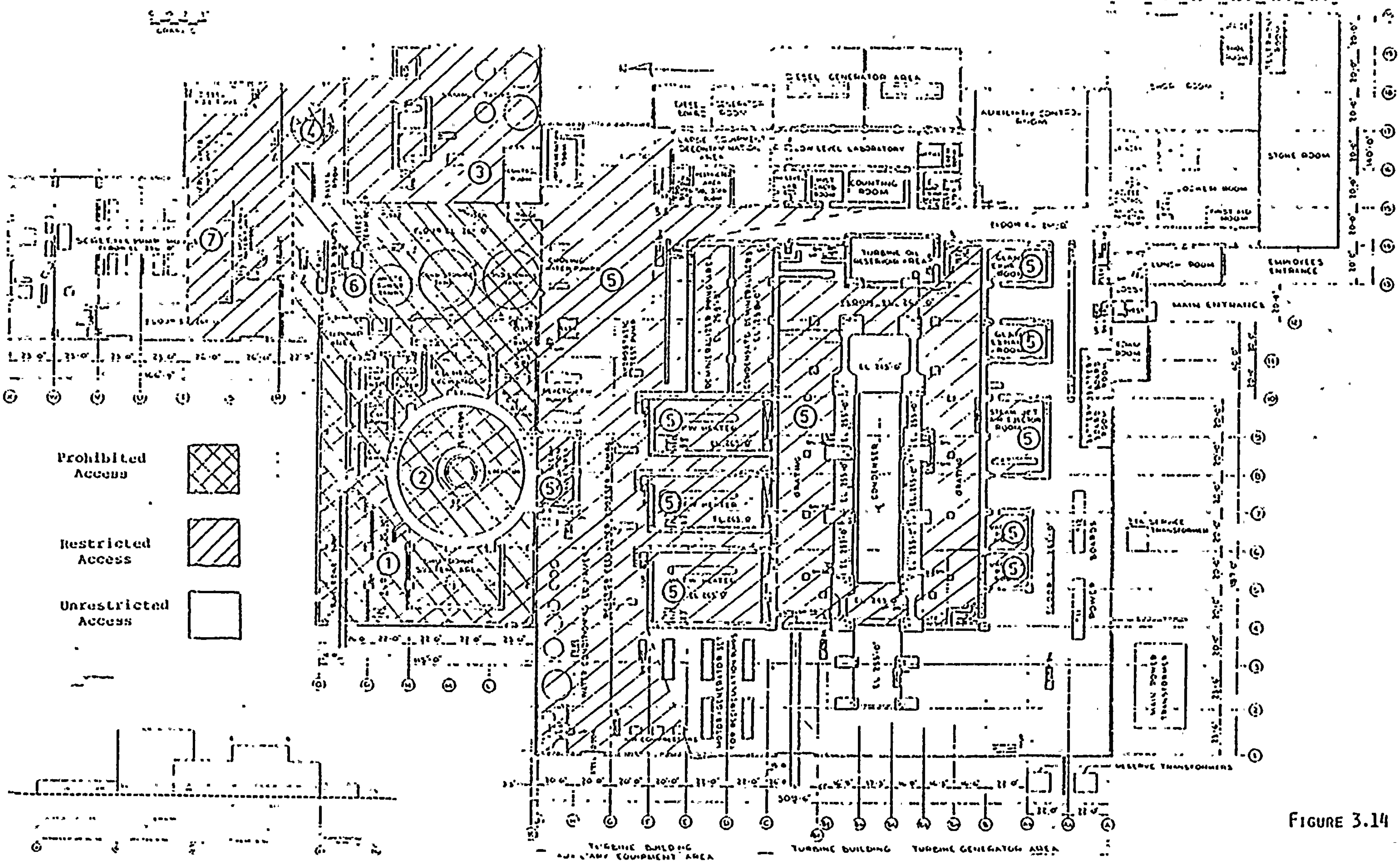


FIGURE 3.14

Radiation Zone Maps for Elevation 277' - 0"

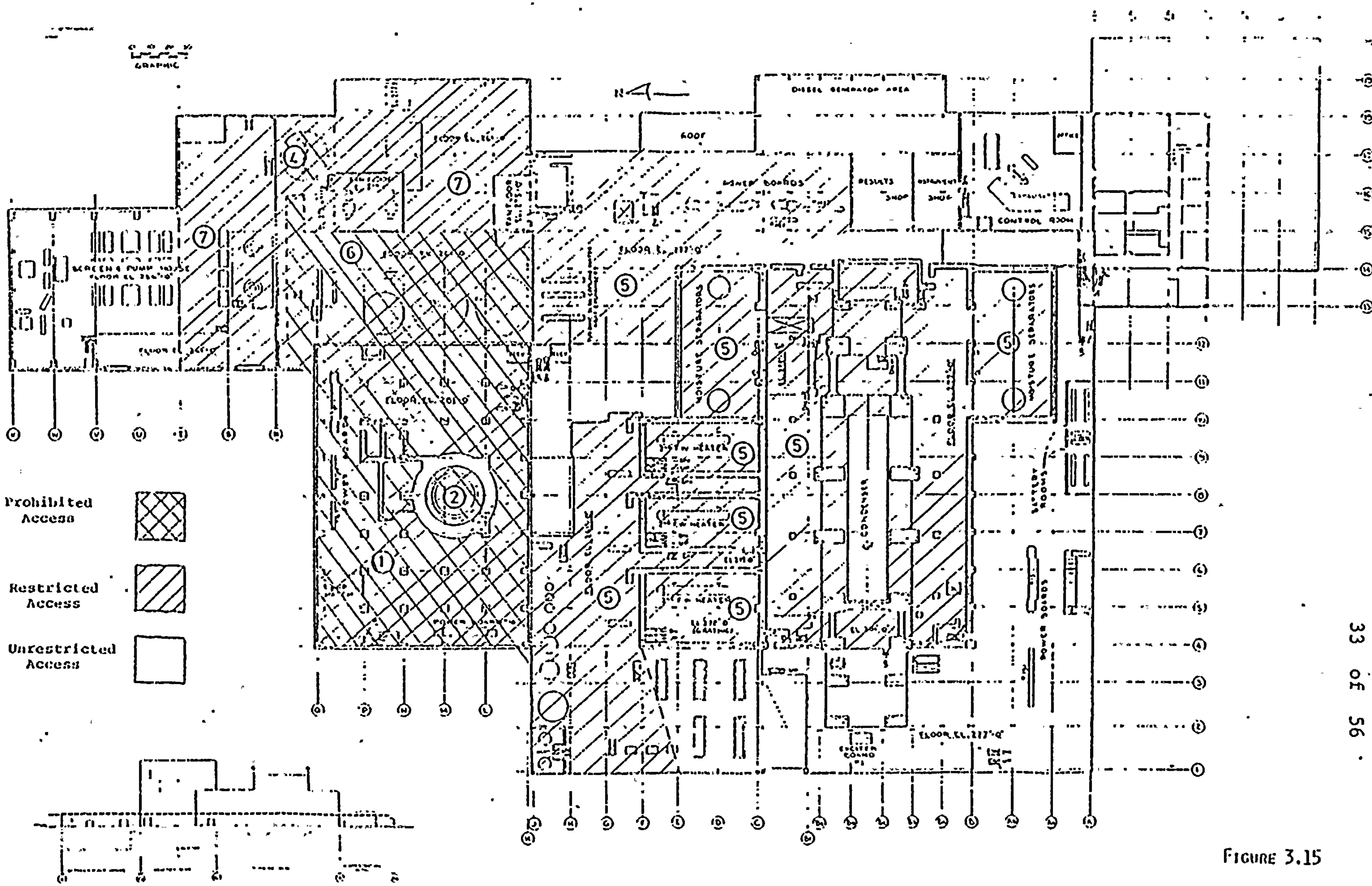


Figure 3.15

RADIATION ZONE MAPS FOR ELEVATION 291' - 0"

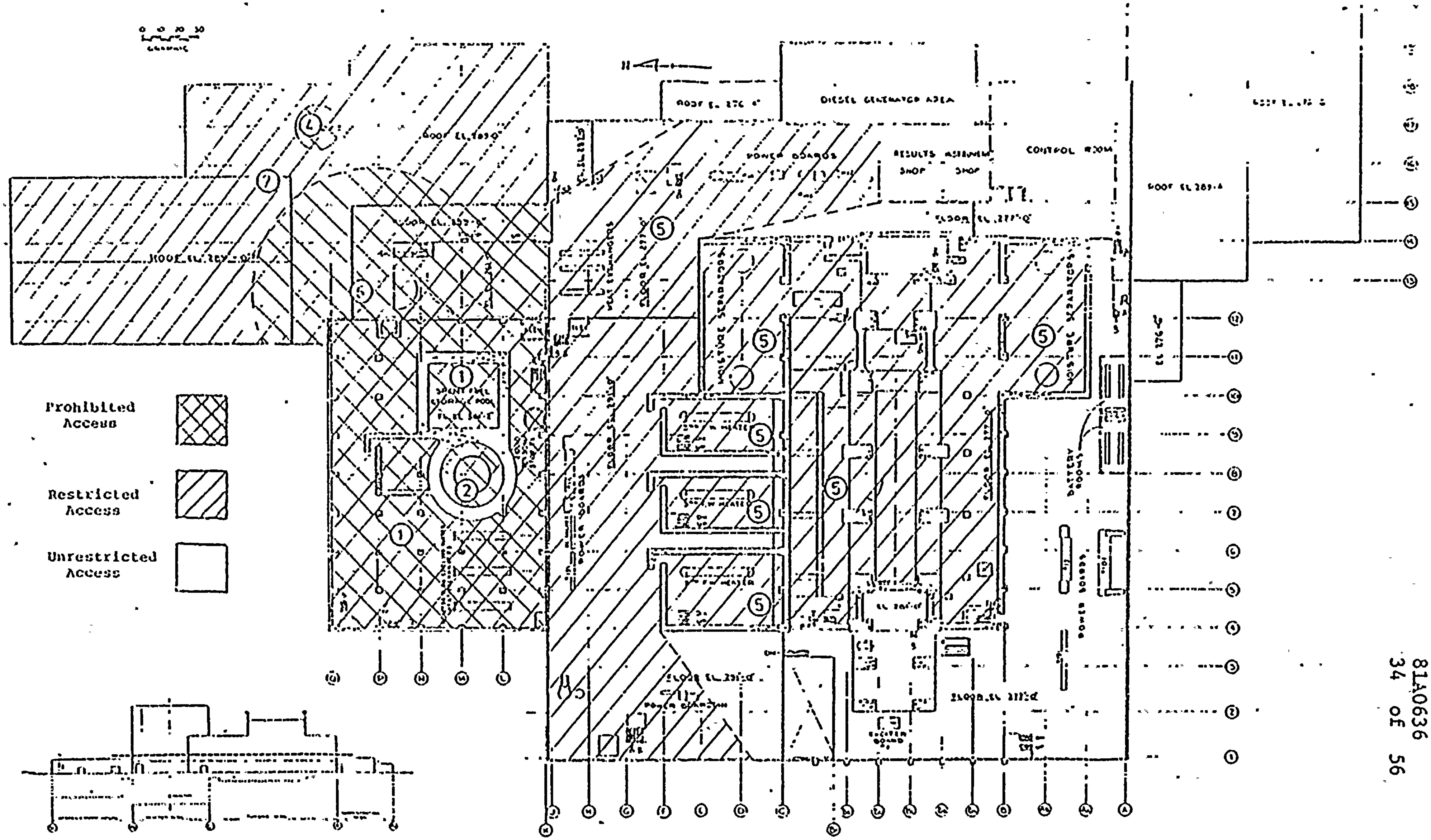


FIGURE 3.16

8110636
34 of 56

Radiation Zone Maps for Elevation 305' - 0"

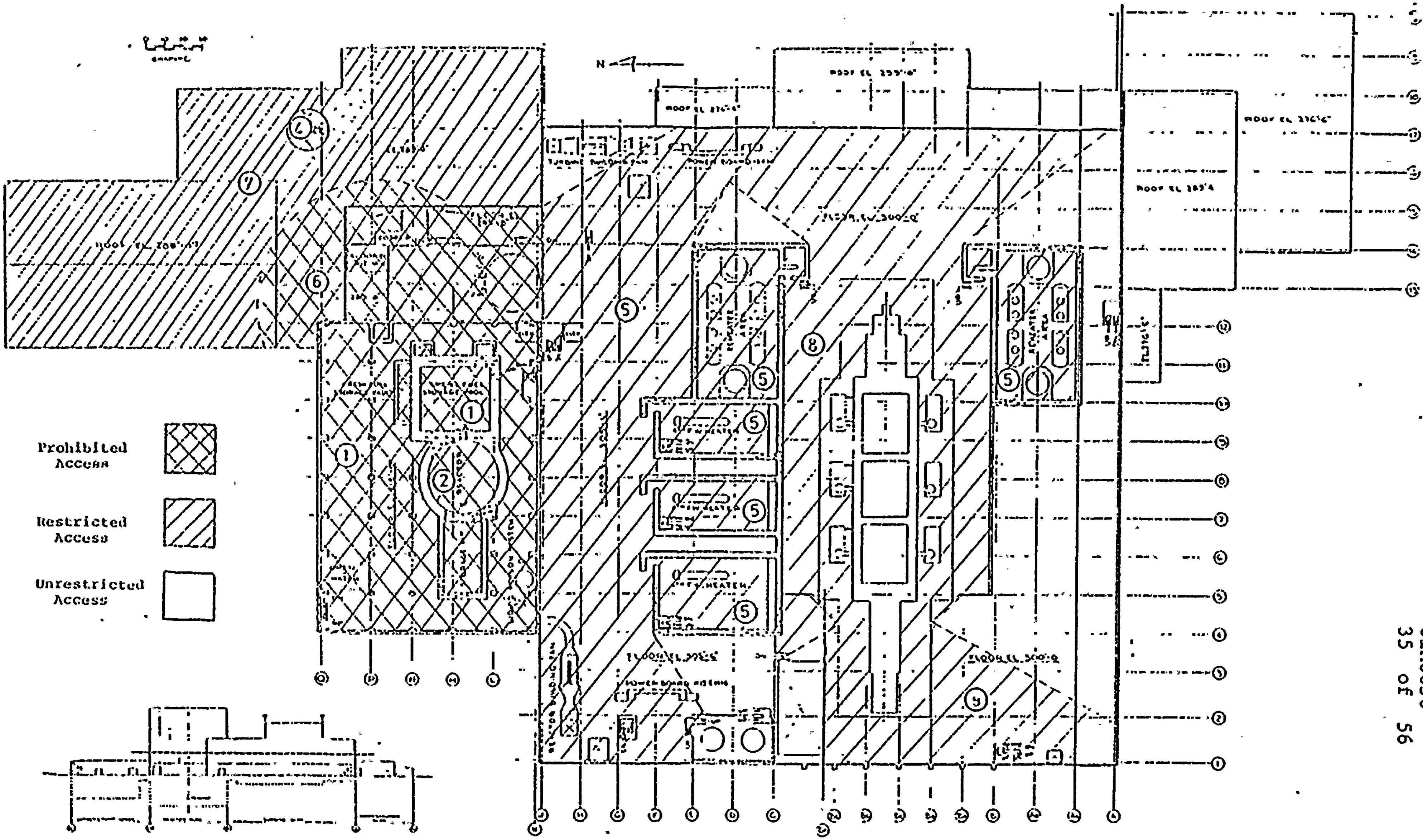


Figure 3.17

RADIATION ZONE MAPS FOR ELEVATIONS 317' - 0" AND 369' - 0"

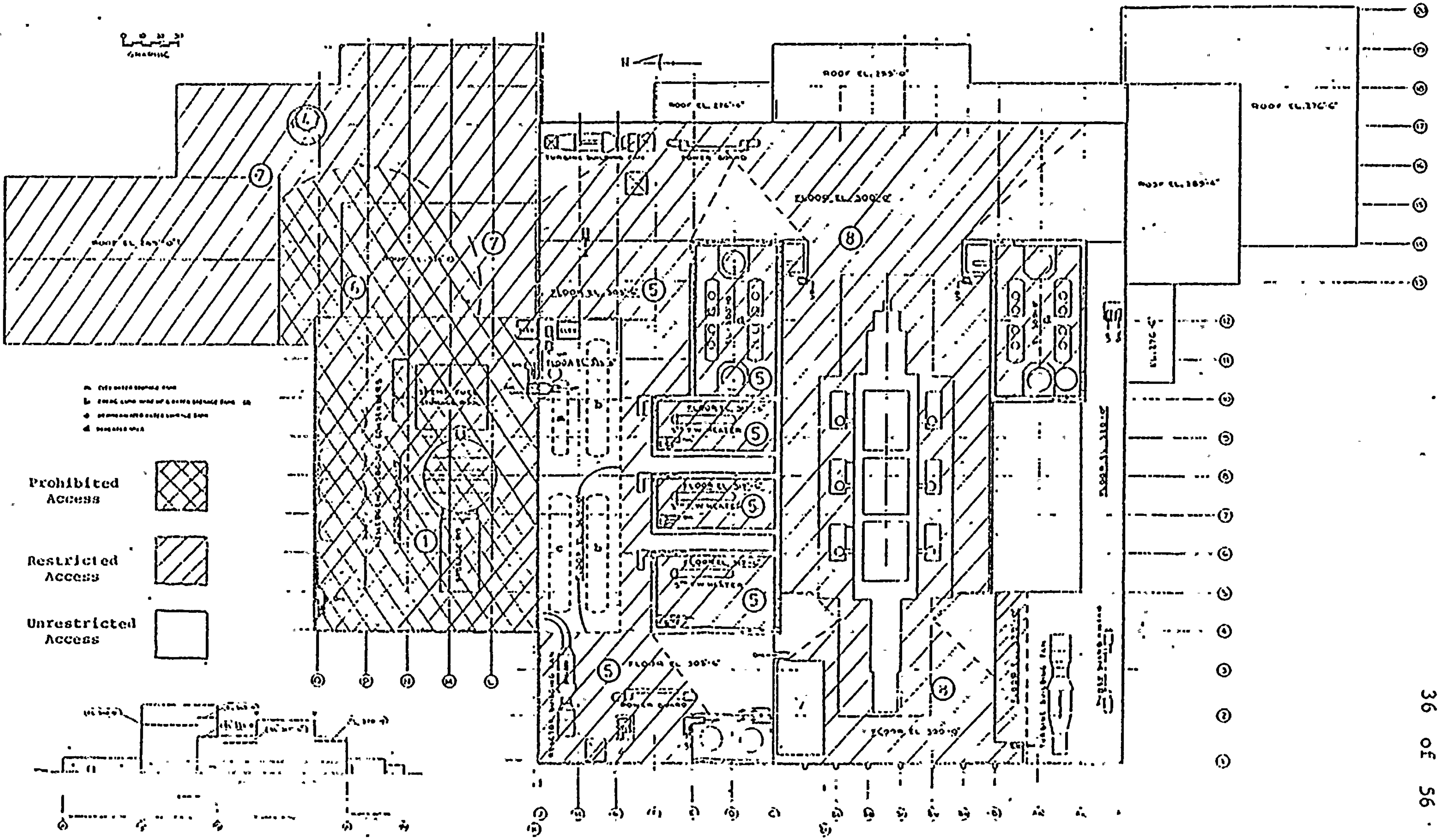


FIGURE 3.18

NOTES:

1. Reactor Building atmosphere contains fission products due to primary containment leakage.

2 Primary containment.

3. Waste building may be contaminated if reactor water inadvertantly is transferred to building for processing.

4. Off-gas stack contains large amounts of noble gases released from primary containment and removed to stack by Reactor Building Emergency Ventilation System.

5. Feedwater system contamination due to possible leakage of feedwater and/or main steam isolation valves.

6. No access due to shine dose from Emergency Ventilation System Filter.

7. Restricted access due to the possibility of excessive shine dose from Emergency Ventilation System Filter.

8. Possible shine dose from turbine due to noble gas accumulation if leakage through feedwater and/or Main Steam Isolation Valves occurs.

4.0 DISCUSSION OF RESULTS AND RECOMMENDATIONS

4.1 DISCUSSION OF RESULTS

The shielding design review has revealed several areas of concern that must be addressed. Airborne dose levels in the Reactor Building, without the CAD system in operation will preclude access to the Reactor Building for at least three weeks following an accident. Operation of the CAD will delay re-entry time further. These dose levels are based on TMI-type source terms and primary containment leakage rate at the technical specification limit. No allowance for any partition factors of iodine is made (i.e. iodine does not plate out, or dissolve in water, but remains airborne). During an accident, actual dose assessments within the Reactor Building will have to be made by air sampling and radiation monitoring by Health Physics Personnel. Because the airborne activity in the Reactor Building is due, in part, to these conservatively calculated radioactive iodine isotopes, the Emergency Reactor Building Ventilation Filter Trains will become a radiation source in the Turbine Auxiliary Building. Changing the filters will be impossible based on these assumptions. However, calculations performed by NES show that the filter trains should not become saturated during the accident, hence filter changes will not be required.

In the event that airborne radioactivity doses do not preclude entry, the Containment Spray System piping will preclude access to the access items. Containment spray lines run in close proximity to required access items.

The H_2-O_2 Monitoring Panels located in the Turbine Building will have an appreciable radiation field. This will be due to containment air flowing through the sample lines. Access to the Reactor Water Sampling Station, as required by Section 2.1.8.a of NUREG-0578, (Reference 1) will be impossible due to the airborne dose rates.

Dose Rates to the Main Control Room, health physics laboratories, and Technical Support Center will be 1.1 mR/hr, 0.02 mR/hr, and 0.4 mR/hr, respectively, due to attenuation of the radiation sources by a distance factor and the several concrete walls and floors in the Turbine Building and Diesel-Generator Building.

4.2 RECOMMENDATIONS

4.2.1 Reactor Building Airborne Doses

Throughout the accident, the iodine isotopes are substantial contributors to the total airborne dose. One possible mitigating action for the magnitude of the airborne doses is the placement of local "sacrificial" charcoal filters in the reactor building. These filters will reduce the total airborne dose rate throughout the building. They should be installed in areas where access is not anticipated at any time following an accident or they should be shielded because they will be an appreciable shine source. These filters will also reduce the plate-out of the iodine on surfaces within the Reactor Building, facilitating recovery and decontamination operations.

4.2.2 Containment Spray System

The Shielding Design Review has identified the Containment Spray System as a major contributor to personnel doses, provided airborne doses in the Reactor Building do not preclude entry. There exist four possible solutions to this problem:

1. Shielding
2. Using raw water instead of torus water
3. Backflushing with raw water, after use
4. Providing a cross-connect spool piece to the Core Spray System such that the water in the Condensate Storage Tank can be available to the Containment Spray System.

Shielding of Containment Spray piping and components for personnel access is not cost-effective, since airborne doses will probably preclude access. In addition, solutions 2, 3, and 4 have to be employed with prudence since they all will have an impact on the dose rates in the Radwaste Building due to an additional volume of water from the torus that will require waste treatment.

4.2.3 Hydrogen-Oxygen, Reactor Water, and Containment Air Sampling

With airborne doses as high as those calculated, all sampling will have to be performed outside of the Reactor Building. The H_2-O_2 monitoring panels is located on Elev. 291' in the Turbine Building. One of the sample lines, located in the panels, can be used for drywell atmosphere sampling.

The Reactor Water Sampling Station is located on Elev. 261' in the Reactor Building. Airborne radiation will preclude access to the station. It is planned to install a sampling station at a suitable location in the Turbine Building. It is advisable that all sampling stations involved with sampling of systems containing accident sources be shielded to facilitate general access in the Turbine Building.

4.2.4 Radiation Area Monitors Near Airlocks

The results indicate that airborne activity in the Reactor Building will make it inaccessible throughout the accident and the early post-accident period. This prohibits operation of equipment within the Reactor Building that has no remote operation capabilities. However, there is a whole spectrum of possible accidents, some of which may not involve appreciable airborne radiation levels within the Reactor Building. Rather than preclude access to the building during any possible accident, area radiation monitors, strategically located, would provide indications to personnel of the radiation levels present in the Reactor Building. Installation of area radiation monitors just inside the Reactor Building near the airlocks on elevations 261' and 340', with readouts positioned near, but not in line of, the airlock doors in the Turbine Building should be considered.

4.2.5 Emergency Condenser Vent Monitors

The main vent line to the atmosphere for each bank of Emergency Condensers is monitored for radiation sources. Normally, the steam vented from the shell side does not contain any radiation sources. If the condenser tubes containing reactor steam should leak, these monitors will isolate that condenser bank upon detection of radiation resulting from the leak. During accident conditions, the radiation levels in

the condensers and from the airborne activity in the Reactor Building, may cause a false reading on the monitor. This will lead to unnecessary isolation of the condensers and thus restrict their proper operation during the accident. High radiation levels will also burn out the monitors. Shielding of the monitors is required to enable them to provide a true reading of the radiation levels in the vent line. However, shielded detectors with remote readouts could be used or a sampling line can be directed to the sampling station located in the Turbine Building. The solution employed must consider that in the event of tube leakage, immediate isolation of the Condensers would be necessary to avoid environmental consequences.

4.2.6 Class 1E Equipment Doses

Class 1E equipment found to receive integrated dose exceeding the damage threshold of the most sensitive material or component is listed in Table 4-1. Recommendations for exposure reduction to the equipment listed is presented in the table. However, credit should be taken for the equipment which will have to function in the very early stages of the accident, e.g. during the first hour of the accident, since they will have performed their safety function before the integrated doses reach the damage threshold.

TABLE 4-1

RECOMMENDATIONS

LOCATION	EQUIPMENT	DAMAGE THRESHOLD (RAD) AND SENSITIVE COMPONENT	TOTAL INTEGRATED DOSE AT 100 DAYS (RAD)
Reactor Building Elev. 281'	Containment Spray Line AOV Position Switch 80-15	10^6 phenolic	1.6×10^6
	Recommended Action: Add shielding on valve, ½" lead equivalent		
	Emergency Condenser Return Isolation Valves 39-05, 06	10^6 phenolic	5.0×10^7
	Recommended Action: Add shielding on valves, 2½" lead equivalent		
Turbine Building Elev. 289'	Various Instrumentation and control equipment for Emergency Vent System, located on and near SE corner of filter bank support structure	10^6 phenolic, capacitors	6.2×10^7
	Recommended Action: Add 2½" lead equivalent shielding		
	Flow Transmitter 202-49A for Emergency Vent	10^6 phenolic, Systemcapacitors	2.8×10^6
	Fans and Dampers and associated instrumentation and control equipment for Emergency Vent System (el. 302' - 0")	10^6 phenolic	4.1×10^6
	Recommended Action: Add 1½" lead equivalent shielding		

TABLE 4-1 Cont'd.

LOCATION	EQUIPMENT	DAMAGE THRESHOLD (RAD) AND SENSITIVE COMPONENT	TOTAL INTEGRATED DOSE AT 100 DAYS (RAD)
Reactor Building Elev. 298'	N_2 Purge Valve 201.2-03	10^6 phenolic	5.4×10^7
	N_2 Purge Valve 201.2-32	10^6 phenolic	5.7×10^7
	Emergency Condenser Isolation Valves 39-07, 08, 09, 10	10^6 phenolic	5.0×10^7
	Recommended Action: Add 2½" lead equivalent shielding		
	deleted ~~RDCLCW Rad. Monitor* RN-02E~~	10^6	1.3×10^3
	Raw Water Monitor* RN-38A1	10^6	1.5×10^5
	Recommended Action: Run sample lines to Sampling Station in Turbine Building and/or use shielded radiation detector with a remote readout.		
Reactor Building Elev. 318'	Level Transmitter IG-06B	10^6 capacitors, phenolic	1.5×10^7
	Level Transmitter IG-06A	10^6 capacitors, phenolic	1.8×10^7
	Flow Transmitter 93-30A, 33A	10^6 capacitors phenolic	2.9×10^7
	H.X. Iso. Valve 93-49 MOV	10^6 polycarbonate, dolrin neoprene, polyimide	1.0×10^7

*Monitors will not perform their functions properly since readings will be off-scale.

TABLE 4-1 Cont'd

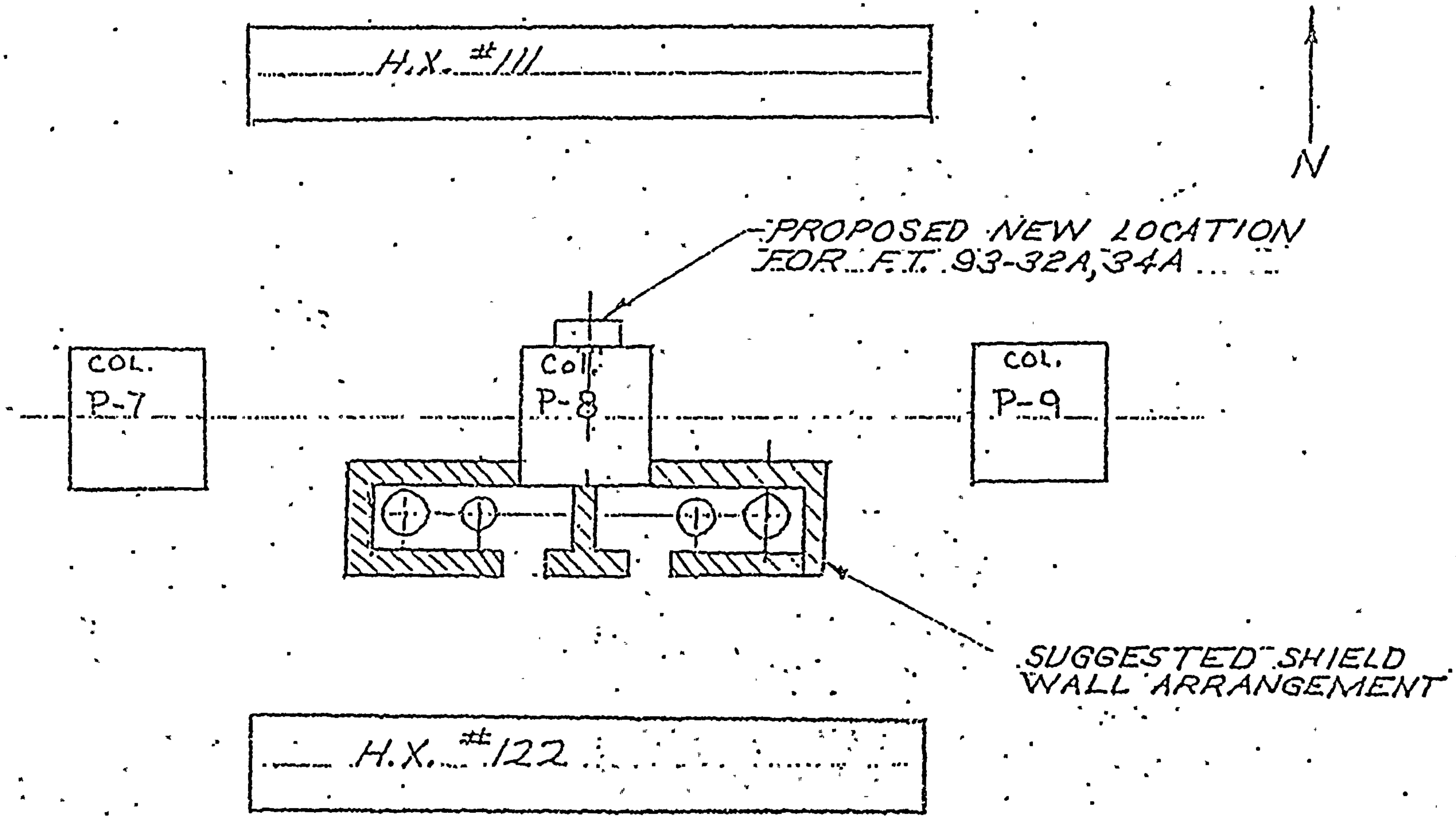
LOCATION	EQUIPMENT	DAMAGE THRESHOLD (RAD) AND SENSITIVE COMPONENT	TOTAL INTEGRATED DOSE AT 100 DAYS (RAD)
Reactor Building Elev. 318'	H.X. Iso. Valve 93-50 MOV	10^6 polycarbonate, dolrin, neoprene, polyimide	1.1×10^7
	H.X. Iso. Valve 93-25 MOV	10^6 polycarbonate, dolrin, neoprene, polyimide	1.0×10^7
	H.X. Iso. Valve 93-26 MOV	10^6 polycarbonate, dolrin, neoprene, polyimide	8.4×10^6
	H.X. Iso. Valve 93-27 MOV	10^6 polycarbonate, dolrin, neoprene, polyimide	1.1×10^7
	H.X. Iso. Valve 93-28 MOV	10^6 polycarbonate, dolrin, neoprene, polyimide	1.3×10^7
	Recommended Action: Enclose Emergency Condenser lines inside shielding with 1½" lead equivalent shielding. Add ½" lead equivalent shadow shield to LT IG-6A, FT 93-30A, 33A (See Figure 4.1).		
Reactor Building Elev. 318'	Flow Transmitters 93-32A, 34A	10^6 capacitors, phenolic	3.2×10^8
	Recommended Action: Relocate FT 93-32A, 93-34A to North side of Col. P-3, 5'-7' above floor. (See Figure 4.1)		

TABLE 4-1 Cont'd

LOCATION	EQUIPMENT	DAMAGE THRESHOLD (RAD) AND SENSITIVE COMPONENT	TOTAL INTEGRATED DOSE AT 100 DAYS (RAD)
Reactor Building Elev. 340'	Rad. Monitor* on Emergency Condenser RNO 4	10^6 phenolic, nylon, capacitors, polycarbonate	1.6×10^7
	Rad. Monitor* on Emergency Condenser RNO 4	10^6 phenolic, nylon, capacitors, polycarbonate	1.7×10^7
	Recommended Action: Add shielding to monitors, 2" lead equivalent to avoid component damage. Run sample lines to Sampling Station in Turbine Building and/or use shielded radiation detector with a remote readout.		
Reactor Building Elev. 340'	AOV's, Position Switches, Level Controls, Valves ~~60-17~~, 17A, ~~60-18~~, 18A 05-01, 02, 03, 04	10^6 phenolic, capacitors, polycarbonate	1.6×10^7
	Recommended Action: Add 2" lead equivalent shielding		

deleted

* Monitors will not perform their functions properly since readings will be off-scale.



REACTOR BLDG-ELEV. 318'

FIGURE 4.1

PRIMARY REFERENCES

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2. Denton, H: "Discussion of Lessons Learned Short Time Requirements," U.S. Nuclear Regulatory Commission, October 30, 1979.

3. "Radiation Sources," G.E. Document No. 22A2703R, Rev. 5, MPL No. A62-4100, 1978.

4. Rockwell, Theodore, (Ed.): "Reactor Shielding Design Manual," 1st Ed., United States Atomic Energy Commission.

5. Biro, George, G., "COSACS Program Input Instructions," Shielding Computer Program Series, Gibbs & Hill, Inc. 1977, Rev. 6B.

6. IE Bulletin #79-01B, NUREG-0588, Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment.

7. Hazard Summary Report for Nine Mile Point Nuclear Station - Unit 1, Appendix E (Figures 3.10 and 3.11).

8. Livolsi, A. Z. and Gabler, H. C.: "LOR2 Isotope Generation and Depletion Code," Babcock & Wilcox, Report NPGD-TM-497, Rev. 1, 1979.

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5. "Final Safety and Analysis Report," Nine Mile Point Nuclear Station, U.S. Atomic Energy Commission Docket 50-220 Exhibit D-2, 1967.

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7. Etherington, Harold (Ed.), "Nuclear Engineers Handbook," McGraw-Hill, Inc. 1958/

8. Lederer, et. al., "Table of the Isotopes," 6th Edition, John Wiley & Sons, Inc. 1967.

APPENDIX A

NRR LESSONS LEARNED TASK FORCE
SHORT-TERM RECOMMENDATIONS

TITLE: Design Review of Plant Shielding of Spaces for Post-Accident Operations (Section 2.1.6.b)

1. INTRODUCTION

10 CFR Part 20 and GDC 19, 60, and 64 Appendix A to 10 CFR Part 50 require the control of radiation exposure associated with plant operations. General Design Criterion 4 requires that systems and components important to safety be designed to accommodate the environmental conditions associated with accidents.

After an accident in which significant core damage occurs, the radiation source terms may approximate those of Regulatory Guides 1.3 and 1.4. In addition, systems that were not designed to contain large radiation sources may become highly radioactive. The resulting radiation fields may make it difficult to effectively perform accident recovery operations or may impair safety equipment.

The purpose of this recommendation is to facilitate post-accident operations using systems that may contain abnormally high levels of radioactivity and to ensure that safety equipment in proximity to the resulting radiation fields is not unduly degraded. Corrective action can consist of design change, additional fixed or portable shielding, post-accident procedure optimization, or equipment upgrading. Systems of interest are identified in recommendation 2.1.6.a.

2. DISCUSSION

After an accident in which significant core damage occurs, the radiation source terms may approximate those of Regulatory Guides 1.3 and 1.4. Large radiation fields, resulting from large radiation sources being contained in systems not designed for such activity, may make it difficult to effectively perform accident recovery operations. Such systems, although not specifically identified to perform post-accident functions, may nevertheless be of significant value after an accident. In addition, vital areas such as control rooms, radwaste panels, emergency power supplies, and instrument areas may fall within the radiation fields of such systems.

Post-accident procedures for the use of such vital areas may be all that is necessary. In other instances, additional permanent or temporary shielding may be valuable. For certain cases, it may be prudent to redesign facilities, components or systems. Remote instrument and control capability may also solve some problems.

3. POSITIONS

With the assumption of a post-accident release of radioactivity equivalent to that described in Regulatory Guides 1.3 and 1.4, each licensee shall perform a radiation and shielding design review of the spaces around systems that may, as a result of an accident, contain highly radioactive materials. The design review should identify the location of vital areas and equipment, such as the control room, radwaste control stations, emergency power supplies, motor control centers, and instrument areas, in which personnel occupancy may be unduly limited or safety equipment may be unduly degraded by the radiation fields during post-accident operations of these systems.

Each licensee shall provide for adequate access to vital areas and protection of safety equipment by design changes, increased permanent or temporary shielding, or post-accident procedural controls. The design review shall determine which types of corrective actions are needed for vital areas throughout the facility.

APPENDIX B

DESIGN REVIEW OF PLANT SHIELDING AND ENVIRONMENTAL QUALIFICATION OF EQUIPMENT FOR SPACES/SYSTEMS WHICH MAY BE USED IN POST-ACCIDENT OPERATIONS (2.1.6.b)

POSITION

With the assumption of a post-accident release of radioactivity equivalent to that described in Regulatory Guides 1.3 and 1.4 (i.e., the equivalent of 50% of the core radioiodine, 100% of the core noble gas inventory, and 1% of the core solids, are contained in the primary coolant), each licensee shall perform a radiation and shielding design review of the spaces around systems that may, as a result of an accident, contain highly radioactive materials. The design review should identify the location of vital areas and equipment, such as the control room, radwaste control stations, emergency power supplies, motor control centers, and instrument areas, in which personnel occupancy may be unduly limited or safety equipment may be unduly degraded by the radiation fields during post-accident operations of these systems.

Each licensee shall provide for adequate access to vital areas and protection of safety equipment by design changes, increased permanent or temporary shielding, or post-accident procedural controls. The design review shall determine which types of corrective actions are needed for vital areas throughout the facility.

CLARIFICATION

Any area which will or may require occupancy to permit an operator to aid in the mitigation of or recovery from an accident is designated as a vital area. In order to assure that personnel can perform necessary post-accident operations in vital areas, we are providing the following guidance to be used by licensees to evaluate the adequacy of radiation protection to the operators:

1. Source Term

The minimum radioactive source term should be equivalent to the source terms recommended in Regulatory Guides 1.3, 1.4 1.7 and Standard Review Plan 15.6.5 with appropriate decay time based on plant design.

A. Liquid Containing Systems: 100% of the core equilibrium noble gas inventory, 50% of the core equilibrium halogen inventory and 1% of all others are assumed to be mixed in the reactor coolant and liquids injected by HPCI and LPCI.

B. Gas Containing Systems: 100% of the core equilibrium noble gas inventory and 25% of the core equilibrium halogen activity are assumed to be mixed in the containment atmosphere. For gas containing lines connected to the primary system (e.g., BWR steam lines) the concentration of radioactivity shall be determined assuming the activity is contained in the gas space in the primary coolant system.

2. Dose Rate Criteria

The dose rate for personnel in a vital area should be such that the guidelines of GDC 19 should not be exceeded during the course of the accident. GDC 19 limits the dose to an operator to 5 Rem whole body or its equivalent to any part of the body. When determining the dose to an operator, care must be taken to determine the necessary occupancy time in a specific area. For example, areas requiring continuous occupancy will require much lower dose rates than areas where minimal occupancy is required. Therefore, allowable dose rates will be based upon expected occupancy, as well as the radioactive source terms and shieldings. However, in order to provide a general design objective, we are providing the following dose rate criteria with alternatives to be documented on a case-by-case basis. The recommended dose rates are average rates in the area. Local hot spots may exceed the dose rate guidelines provided occupancy is not required at the location of the hot spot. These doses are design objectives and are <u>not</u> to be used to limit access in the event of an accident.

A. Areas Requiring Continuous Occupancy: ≤15mr/hr. These areas will require full time occupancy during the course of the accident. The Control Room and onsite technical support center are areas where continuous occupancy will be required. The dose rate for these areas is based on the control room occupancy factors contained in SRP 6.4.

B. Areas Requiring Infrequent Access: GDC 19. These areas may require access on a regular basis, but not continuous occupancy. Shielding should be provided to allow access at a frequency and duration estimated by the licensee. The plant Radiochemical/Chemical Analysis Laboratory, radwaste panel, motor control center, instrumentation locations, and reactor coolant and containment gas sample stations are examples where occupancy may be needed often but not continuously.

NES

REVISION LOG

NUCLEAR ENERGY SERVICES, INC.

DOCUMENT NO. 81A0636

REV. NO.	DATE	PAGE NO.	DESCRIPTION	APPROVAL

NUCLEAR ENERGY SERVICES, INC.

Oct 10, 1980 QUALITY ASSURANCE RECORD

QA10

July 18, 1980
Project No.: 5152
Reference No.: 5152-008

Mr. L. McNeer, PE
Nuclear Generation Engineering
Niagara Mohawk Power Corp.
300 Erie Boulevard West
Syracuse, NY 13202

Dear Larry,

Enclosed please find the list of equipment promised to you in my letter of July 16, 1980. This list contains the remaining Class IE equipment found to be in line of sight of accident sources. NES has performed calculations for this equipment and has found the integrated dose for 0 to 100 days does not exceed the damage threshold of the sensitive component.

All other Class IE equipment external to the containment and within the Reactor Building will only be exposed to the airborne activity. The integrated gamma dose from the airborne activity has been calculated to be, for 0 to 100 days:

5.8×10^5 Rads w/CAD
3.4×10^5 Rads w/o CAD

Do not hesitate to call me if you have any questions.

Sincerely,

NUCLEAR ENERGY SERVICES, INC.
NES Division

M. Jaworsky,
Radiation Protection Engineer

/al
enclosures

CC: Dave Green

v 261	[illegible]str. rack 201.9 sys. pressure transmitters 201.9-80, 201.9-26, flow indicator 201.9-31. ~~AOV~~-48A, ~~AOV~~-49A 201.9 201.9	IC(TTL), capac[illegible]ors, phenolic, silicone	10^6-10^7	1.0×10^4
v 261	flow transmitter 80-76A	IC(TTL) capacitor, phenolic	10^6-10^7	5.6×10^5
v 261 deleted deleted	instr. rack 201.8 sys. ~~press. control valve 201.8-01~~, flow control valve 201.8-02, press. trans. 201.8-35 & 45 temp. element 201.8-26, ~~press reliefs 201.8-13 & 14~~	IC(TTL) capacitor, phenolic	10^6-10^7	2.0×10^4
v 281	instr. rack west instr. rm.	IC(TTL) capacitor, phenolic,polycarbonate	10^6-10^7	5.2×10^5
v 281	instr. rack west instr. rm.	IC(TTL) capacitor, phenolic,polycarbonate	10^6-10^7	4.5×10^5
v 281	instr. rack west instr. rm.	IC(TTL) capacitor, phenolic, polycarbonate	10^6-10^7	4.4×10^5
v 281	Pwr. Board #16	polyester, nylon, phenolic	10^5-10^6	9.0×10^4
v 281	Pwr. Board #16	polyester, nylon, phenolic	10^5-10^6	5.1×10^4
v 281	Pwr. board #16	polyester, nylon, phenolic	10^5-10^6	8.7×10^4
v 281	Pwr. board #16	polyester, nylon, phenolic	10^5-10^6	7.7×10^4
~~v 281~~ Deleted	~~RHCLCW Valve 70-53-AOV, and Position switch~~	~~phenolic~~	~~10^6~~	~~2.6×10^5~~
v 281	Cont. spray vlv. 80-36 AOV, and Position switch	phenolic	10^6	5.6×10^5
v 281	instr. rack east instr. room	IC(TTL) capacitors, phenolic,polycarbonate	10^6-10^7	7.6×10^4

ev 198	Torus level transmitter ~~201.2-461, 201.2-462, 58-04~~ SZ-05 SZ-06 SZ-04	Capacitors, IC (TTL) phenolic	10^6	2.1×10^5
ev 237	~~press switch RD-37~~ not listed	phenolic, polycarbonate	10^6	2.1×10^4
ev 237	scram disch. panel: SOV's Limit Switches, NC-15A, B; NC-16A, 16B; NC-22, ~~RD-08A through RD-08P, 115-66~~ deleted	same	10^6	2.9×10^4
lev 237	CRD Inst. rack @M-4 incl. RD-35, ~~18, 66, 10, 15, 04 05, NG-19, CRD-3233~~ deleted	same	10^6	1.6×10^4
lev 237	~~Core spray valve 40-12 & limit sw.~~ deleted	same	10^6	9.1×10^5
lev 237	Core spray valve 40-06	same	10^6	9.1×10^5
lev 237	Core spray topping pump motors #111, 112	polycarbonate, dolrin, neoprene, polyimide	10^6	2×10^5
lev 237	Valve 201-08 mov	same	10^6	1.5×10^5
lev 237	Valve 68-01 ~~and limit~~ position switch	same	10^6	4.6×10^5
lev 237	Vacuum Breaker VR-5, vacuum switch VcS-68, 11A, 11B and valve operator	phenolic, polyester, polycarbonate	10^6	2.8×10^4
lev 237	~~pressure switch 201.2-87~~ not listed	same	10^6	1.3×10^4
lev 237	Vacuum switch VcS-68-12A, B	phenolic	10^6	9.4×10^4
lev 237	Vacuum switch VcS-68-13A, B	phenolic	10^6	5.9×10^4
lev 261	Flow transmitter 80-56A	IC(TTL), capacitors, phenolic, silicone	10^6-10^7	5.6×10^5

TION	EQUIPMENT	SENSITIVE COMPONENT	THRESHOLD	[illegible]
281	instr. rack east instr. room	IC(TTL) capacitors, phenolic, polycarbonate	10^6-10^7	5.5×10^4
281	cont. spray press. switch #80-60	phenolic	10^6	3.0×10^5
281	201.7 sys. sample valve #201.7-10, 11, 22, 23, 26, 27	phenolic	10^6	3.1×10^5
~~281~~ deleted	~~201.7 sys. sample valve #201.7-10, 11, 22, 23, 26, 27~~	~~phenolic~~	~~10^6~~	~~3.1×10^5~~
v 281	cont. spray vlv. 80-16 AOV, and position switch	phenolic	10^6	5.2×10^5
~~v 281~~	~~Pwr. board #155~~ not on list	~~phenolic, capacitors IC(TTL) RTV, etc.~~	~~10^6-10^7~~	~~4.6×10^4~~
v 281	Pwr. board #167	phenolic, capacitors IC(TTL) RTV, etc.	10^6-10^7	4.4×10^4
v 281	Pwr. board #17	polyester, nylon, phenolic	10^5-10^6	5.5×10^4
v 281	Pwr. board #17	polyester, nylon, phenolic	10^5-10^6	2.0×10^5
v 281	Pwr. board #17	polyester, nylon, phenolic	10^5-10^6	1.4×10^5
~~v 281~~	~~cleanup iso. vlv. limit sw. at column P-12~~ not listed	phenolic	10^6	3.3×10^4
v 298	Raw Wtr. Monitor RN-38A1	phenolic, cap, nylon, polycarbonate	10^6	1.5×10^5
v 298	RN-38A2	phenolic, cap, nylon, polycarbonate	10^6	1.2×10^5
~~v 298~~	~~RN-38A3~~ not listed	phenolic, cap, nylon, polycarbonate	10^6	9.1×10^4

:ATION	EQUIPMENT	SENSITIVE COMPONENT	[illegible]	
~~ev 298~~	~~RN-38A4~~ not listed	phenolic, cap, nylon, polycarbonate	10^6	7.2×10^4
ev 298	~~Powerboard H-10~~ (not listed)	phenolic, cap, RTV, IC(TTL)	10^6-10^7	1.5×10^5
ev 298	~~Powerboard H-10~~ (not listed)	phenolic, cap, RTV, IC(TTL)	10^6-10^7	4.7×10^5
ev 298	~~Powerboard H-10~~ (not listed)	phenolic, cap, RTV, IC(TTL)	10^6-10^7	2.2×10^5
ev 298	inst. rack 201.2 sys. AOV's ~~201.2-132, 134, 396, 131, 361~~, 08, 136, 03. ~~Flow Transmitter 201.2 - 367A~~ not listed	IC(TTL), Cap, Polycarbon, phenolic	10^6-10^7	1.6×10^4
ev 298	~~R861.6W Rad. Mon. RN-02B~~ deleted	phenolic, cap, nylon, polycarbonate	10^6	1.3×10^3