REFERENCE 9

NAMCO CONTROLS

1700 EAST 131ST STREET • CLEVELAND OHIO 44108 • (216) 268-4200 • TELEX 98-5499

REPLY TO: 149 CUCUMBER STREET · JEFFERSON, OHIO 44047 · (216) 576-4070

REPORT NO. QTR 105
DATE AUG. 28, 1980
REVISION 1
COPY NO. 1425

QUALIFICATION OF EA180 SERIES LIMIT SWITCHES FOR USE IN NUCLEAR POWER PLANTS IN COMPLIANCE WITH IEEE STANDARDS 323-1974, 382-1972 AND 344-1975.

THIS REPORT IS AN EXTENSION OF EA180 QUALIFICATION REPORTS DATED SEPTEMBER 5, 1978 AND MARCH 3, 1978.

QTR 105 April 3, 1980

REVISION RECORD

REVISION	DESCRIPTION	PAGE	DATE
0	Rough Draft		4/3/80
1	Revise & 1st Release Revise PP 4-2, 4-3 & 4-6.		7/30/80
2	Revise the following pages: 0-3, 3-2, 3-7, 4-1, 4-4, 4-5, 4-6, 5-1, 5-2, 5-3, 5-4, 6-1, 7-6, 9-1, 9-3, Add Section 11.0		8/28/80

INDEX

SECTION	DESCRIPTION	PAGE
1.0	PURPOSE OF QUALIFICATION TEST REPORT	1-1
2.0	APPLICABLE SPECIFICATIONS AND DRAWINGS	2-1
3.0	GENERIC GROUP IDENTIFICATION, SPECIFICATIONS AND SELECTION FOR TEST	3-1
4.0	SERVICE CONDITIONS, INSTALLATION REQUIREMENTS, MAINTENANCE AND QUALIFIED LIFE	4-1
5.0	TEST SEQUENCE AND RATIONAL FOR TEST CONDITIONS	5-1
6.0	INSPECTION AFTER TEST	6-1
7.0	COMMENTS, SUMMARY AND CONCLUSIONS	7-1
8.0	DESCRIPTION OF PRODUCT IMPROVEMENT CHANGES	8-1
9.0	ATTACHMENTS	9-1
10.0	TEST REPORTS	10-1
11.0	TEST PLAN	11-1

FIGURES

FIGURES		PAGE
1	List of Limit Switches Analyzed for Generic Group (Standard 10° Operation)	3-2
2	List of Limit Switches Analyzed for Generic Group (Short Travel 8° Operation)	3-7
3	List of Limit Switches Analyzed for Generic Group (Standard Maintained Operation)	*
4	List of Limit Switches Analyzed for Generic Group (Short Travel Maintained Operation)	*
5	Installation Instructions EA189 90006	4-2
6	Maintenance Instructions EA189 90051	4-3
7	List of Non-Metallic Materials Used in the Qualified Limit Switch	4-11
8	Arrhenius Curve for Estimated Qualified Life	4-12
9	Resonance Search Plot	7-3
10	Sine Dwell Plot	7-4
11	Identification of Production Switches	3-10

*Not available, tests in process.

1.0 PURPOSES OF QUALIFICATION TEST REPORT:

1.1 This Qualification Test Report (QTR) will extend the original qualification of the EA180 series limit switch to include several product improvement changes. See Section 9.0 for description of these changes.

1.2 The original EA180 Qualification Reports are dated September 5, 1978 and March 3, 1978.

1.3 This QTR is for a series of type tests in support of EA180 series generic group qualification to IEEE Std. 323-1974, 344-1975 and 382-1972. These standards pertain to Class IE safety-related equipment for use in nuclear power plants.

1.4 This QTR summarizes the test reports provided by Acme-Cleveland Development Company and compare them to the requirements of the original test plan.

1.5 This QTR will provide the additional data required by IEEE Std. 323-1974, Section 6.? Equipment Performance Specifications, such as; Performance Characteristics, Ratings, Installation Requirements, Preventative Maintenance, Design Life, Auxiliary Devices Required, Rated Service Conditions, Periodic Quality Control Tests and Estimated Qualified Life.

1.0 PURPOSES OF QUALIFICATION TEST REPORT: (CONT'D.)

1.6 The tests verify the limit switch performance and include; Aging Simulation, Wear Aging, Radiation Exposure, Seismic Qualification and Design Basis Event Environmental Conditions.

1.7 The tests envelope the environmental conditions set forth in Section 4.0.

1.8 Justification for test requirements and/or conditions will be provided where necessary.

1.9 Note: It is the user's responsibility to determine the acceptability of the tests methods, procedures and specifications for a specific application.

2.0 APPLICABLE SPECIFICATIONS AND DRAWINGS:

2.1 The listed IEEE standards were used as guidelines in the preparation and performance of this qualification program.

2.2 IEEE Std. 323-1974 - Std. for Qualifying Class IE Equipment for Nuclear Power Generating Stations.

2.3 IEEE Std. 382-1972/ANSI N41.6 - IEEE Trial-Use Guide For Type Test of Class IE Electric Valve Operators for Nuclear Power Generating Stations.

2.4 IEEE Std. 344-1975 - Recommended Practice for Seismic Qualification of Class IE Equipment for Nuclear Power Generating Stations.

2.5 Namco Controls Test Plan

No. LP10767-3 Test Plan for Qualification of Series EA180 and EA740 Limit Switches.

2.6 Namco Controls Drawings

2.6.1 EA180-11302 Limit Switch Assembly

2.6.2 EA180-14302 Limit Switch Assembly

3.0 GENERIC GROUP IDENTIFICATION, SPECIFICATIONS AND SELECTION FOR TEST

3.1 Generic Group Qualification provided by type test T.R. 3613-PP (Section 10.1). The generic group of EA180 limit switches qualified by T.R. 3613-PP is described as the "standard" series limit switch with a ten (10) degree trip travel, three (3) mounting types and two (2) modes of operation.

3.1.1 The selection of the EA180 limit switch to be used for test was based upon an Engineering analysis of the six (6) limit switch part numbers listed in Figure 1.

The analysis was based upon computation of the allowable tensile and shear areas and strength of the fasteners for the various methods of mounting and attachment of the back cover.

It was concluded that the EA180-11302, standard mounting, represented the most conservative (most severe) conditions for test.

3.1.2 The direction of rotation to operate the switch does not affect the test program because the switch mechanism is symmetrical. The test sequence also provides for testing in the operated and unoperated condition.

3.0 GENERIC GROUP IDENTIFICATION, SPECIFICATIONS AND SELECTION FOR TEST (CONT'D.)

List of Limit Switches
In Standard Operating (10°)
Generic Group

PART NUMBER	MOUNTING		ROTATION *
	TYPE	DESCRIPTION	
EA180-11302	STD	Two threaded holes on either side of housing	CW
EA180-12302	STD		CCW
EA180-21302	Style 1	Four holes through wide bottom cover	CW
EA180-22302	Style 1		CCW
EA180-31302	Style 2	Four holes through long bottom cover	CW
EA180-32302	Style 2		CCW

*Direction of rotation of lever shaft to operate switch.
View-facing lever shaft.

Figure 1

3.0 GENERIC GROUP IDENTIFICATION, SPECIFICATIONS AND SELECTION FOR TEST (CONT'D.)

3.1.3 With exception of the back cover all other components of the listed limit switch part numbers are common.

3.2 Selection and identification of the limit switch for test per T.R. 3613-PP.

3.2.1 The EA180-11302 limit switch used in this test was one chosen at random from several assembled on the Namco Controls production line by Production personnel. All parts were per bill of materials EZ10683-90 and subjected to standard inspection procedures.

3.2.2 Identification

The test switch was marked with the following:

Part Number	EA180-11302
Engineering Number	EZ10683-90
Date of Manufacture	3979
Factory Order Number	13658
Test Number	138-90

3.2.3 Throughout test report T.R. 3613-PP this switch is referred to as No. 138-90.

3.3 Specifications for qualified limit switch generic group, per T.R. 3613-PP, IEEE 323-74, 6.2(2). The specifications for the EA180-11302 group limit switch are as follows:

3.0 GENERIC GROUP IDENTIFICATION, SPECIFICATIONS AND SELECTION FOR TEST (CONT'D.)

3.3.1 The switch is a heavy duty, double pole, double throw, butt contact, quick break and quick make type.

3.3.2 Nameplate rating:

125VAC - 20A

250VAC - 15A

480VAC - 10A

600VAC - 5A

Power Factor of Load 75-100%

125VDC - 5A

250VDC - 1.5A

3.3.3 Operating data

Pretravel - 10°

Differential Travel - 8°

Recommended Travel - 13°

Maximum Torque during Pretravel - 21 In. Lbs.

Note: When operated the limit switch lever shaft is spring loaded and will return to the original position if released.

3.3.4 Enclosure type

The switch enclosure meets the requirements of NEMA 1, 4 & 13.

3.3.5 See assembly drawing EA180-11302 for other detailed information such as size and shape.

3.0 GENERIC GROUP IDENTIFICATION, SPECIFICATIONS AND SELECTION FOR TEST (CONT'D.)

List of Limit Switches
In Short Travel (8°) Operating
Generic Group

PART NUMBER	MOUNTING		ROTATION *
	TYPE	DESCRIPTION	
EA180-14302	STD	Two threaded holes on either side of housing	CW
EA180-15302	STD		CCW
EA180-24302	Style 1	Four holes through wide bottom cover	CW
EA180-25302	Style 1		CCW
EA180-34302	Style 2	Four holes through long bottom cover	CW
EA180-35302	Style 2		CCW

*Direction of rotation of lever shaft to operate switch. View-facing lever shaft.

Figure 2

3.0 GENERIC GROUP IDENTIFICATION, SPECIFICATIONS AND SELECTION FOR TEST (CONT'D.)

3.5 Specifications for qualified limit switch generic short travel group, IEEE 323-74, 6.2 (2).

The specifications for the EA180 14302 group limit switch are as follows:

3.5.1 The switch is a heavy duty, double pole, double throw, butt contact, quick break and quick make type.

3.5.2 Nameplate rating:

125VAC - 20A

250VAC - 15A

480VAC - 10A

600VAC - 5A

Power factor of load 75-100%

125VAC - 5A

250VAC - 1.5A

3.5.3 Operating data:

Pretravel - 6° 30'

Differential travel - 4°

Recommended travel - 7°

Maximum torque during pretravel - 38 In. Lbs.

Note: When operated the limit switch lever shaft is spring loaded and will return to the original position if released.

3.0 GENERIC GROUP IDENTIFICATION, SPECIFICATIONS AND SELECTION FOR TEST (CONT'D.)

3.3.6 Production released bill of materials for switch part numbers qualified to this report are identified with QTR 105. First release was Revision H.

3.3.7 Production manufactured switches are identified with the following as shown in Figure 11:

Part Number

Ratings

B/M Revision

Factory Order Code

Date Code

3.0 GENERIC GROUP IDENTIFICATION, SPECIFICATIONS AND SELECTION FOR TEST (CONT'D.)

3.4 Generic group qualification of "short travel" series limit switches.

3.4.1 The generic group of EA180 14302 short travel limit switches listed in Figure 2 is qualified by similarity to switches tested in T.R. 3613-PP (Section 10.1) and supplementary tests (Section 10.2).

3.4.2 Similarity analysis. An Engineering comparitive analysis of the short travel limit switch with the standard EA180 determined the only difference is in the latching mechanism.

3.4.3 A short travel switch #83 (EA180 14302) was subjected to heat aging, wear tests, radiation exposure, seismic test and plant induced vibration simulation. (Section 10.2)

3.4.4 Conclusion: The EA180-14302 short travel series of limit switches is qualified by similarity to switches tested in T.R. 3613-PP (Section 10.1). The mechanical differences in the latching mechanism did not affect qualification as illustrated by supplementary test reported in Section 10.2.

3.0 GENERIC GROUP IDENTIFICATION, SPECIFICATIONS AND SELECTION FOR TEST (CONT'D.)

3.5.4 Enclosure type

The switch enclosure meets the requirements of NEMA 1, 4 & 13.

3.5.5 See assembly drawing EA180 14302 for other detailed information such as size and shape.

3.5.6 Production released bill of materials for switches qualified to this report are identified with QTR 105. First release was Revision H.

3.5.7 Production manufactured switches are identified with the following, as shown in Figure 11:

Part Number

Ratings

Date Code

B/M Revision

Factory Order Code

3.0 GENERIC GROUP IDENTIFICATION, SPECIFICATIONS AND SELECTION FOR TEST (CONT'D.)

Identification of Production Switches

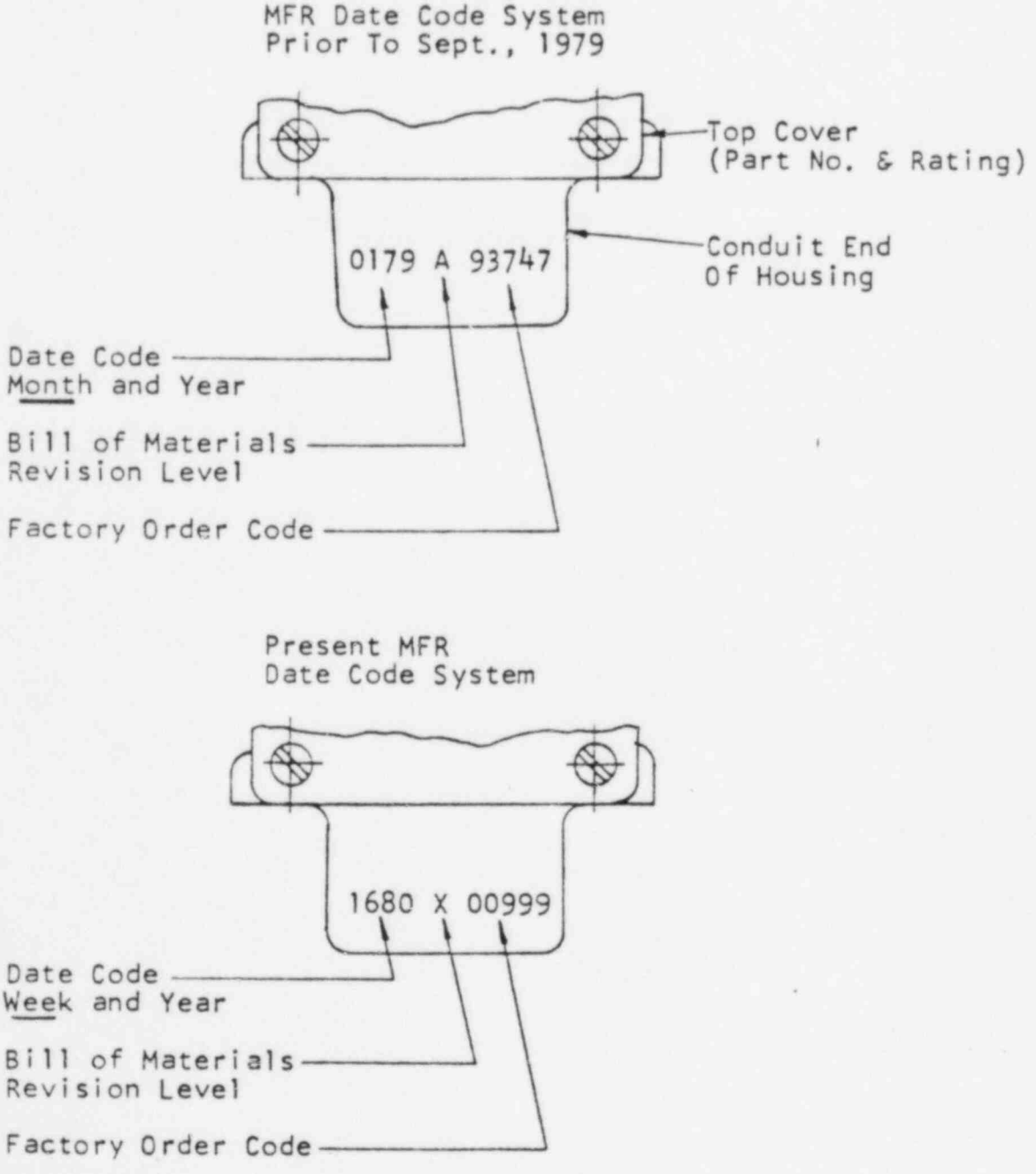


FIGURE 11

QTR 105

April 3, 1980

CERTIFICATION

THIS QUALIFICATION TEST REPORT IS A TRUE AND ACCURATE PRESENTATION BASED UPON THE ENGINEERING DATA AND TEST REPORTS AVAILABLE AT THE TIME.

John R. Bendokaitis 7/31/80
John R. Bendokaitis
Project Engineer
Nuclear Switch Coordinator

4.0 SERVICE CONDITIONS, INSTALLATION REQUIREMENTS, MAINTENANCE AND QUALIFIED LIFE (REF. IEEE 323-1974, SECTION 6.2)

4.1 Installation and connection requirements.

See EA189 90006 (Figure 5) for special instructions.

4.2 Preventive maintenance.

For preventive maintenance during installed life of the limit switch, see EA189 90051 (Figure 6). Replacement parts kit numbers are provided in these instructions.

4.3 Design life.

The mechanical design life is 500,000 cycles (Min.).
Electrical design life is 500,000 cycles (Min.).
The above design life estimations are based upon normal ambient conditions.

4.4 Auxiliary devices required for proper function of the limit switch.

Although it was not considered a part of the qualification test, an operating lever is required for proper operation of the limit switch.
The Namco Controls catalog lists operating levers of many configurations and materials.
It is the users responsibility to chose one suitable for the application.

QTR 105

4-2

FIGURE 5

EA189-90006

INSTALLATION INSTRUCTIONS
EA180 NUCLEAR SWITCH
SILICONE GASKETS

THIS SWITCH IS DESIGNED FOR USE IN THE INNER CONTAINMENT AREA OF A NUCLEAR POWER GENERATING STATION. TO MAINTAIN SWITCH INTEGRITY THE FOLLOWING INSTRUCTIONS MUST BE FOLLOWED.

1.0 ELECTRICAL CONNECTIONS

- 1.1 WIRE PASSAGE THROUGH SWITCH CONDUIT ENTRANCE MUST BE SEALED IN SUCH A WAY AS TO MAINTAIN THE SWITCH INTEGRITY UNDER REQUIRED SERVICE CONDITIONS.
- 1.2 WIRE TERMINALS SHALL NOT BE OF ZINC OR ZINC PLATED MATERIAL.
- 1.3 SOLDERED WIRE ENDS MUST BE CLEAN AND FREE FROM FLUX.

2.0 INSTALLATION OF TOP COVER

- 2.1 ALIGNMENT OF SCREW HOLES OF COVER AND GASKET SHOULD BE CHECKED.
- 2.2 TORQUE SCREWS IN A STAGGERED PATTERN, FROM SIDE TO SIDE.
- 2.3 TOP COVER SCREWS MUST HAVE BELLEVILLE WASHER AND O-RING.
- 2.4 TORQUE TOP COVER SCREWS 20 INCH POUNDS.
- 2.5 GASKETS TORN AROUND SCREW HOLES OR OTHERWISE DAMAGED MUST BE REPLACED.

3.0 DO NOT REMOVE BOTTOM COVERS, CHECK SCREWS FOR TIGHTNESS, MUST BE 20 INCH POUNDS.

NOTE: THE ABOVE INSTRUCTIONS ARE TO BE PRINTED ON 40-60# BOND PAPER APPROX. 4 X 6. FOLD ONCE LENGTHWISE AND PACK WITH SWITCH.

CUST PART NO	ASS'Y NO.	REF NO. EZ10683-89	NAMCO CONTROLS An Acme-Cleveland Company CLEVELAND, OHIO U.S.A.
DATE / CHANGE / ZONE / LTR	UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS .XX ± .01, .XXX ± .005, ANGULAR ± 0°30'. REMOVE ALL SHARP EDGES. ALL MACHINED SURFACES 125 V	DR NLM CK DATE 1-23-80 SUPERSEDES SCALE	TITLE: INSTALLATION INSTRUCTIONS MATERIAL: P.M- STOCK SIZE DO NOT SCALE EA189-90006

NOTICE THE INFORMATION CONTAINED HEREON IS THE PROPERTY OF THE NAMCO CONTROLS, A DIVISION OF THE ACME-CLEVELAND CORP. AND IS SUPPLIED IN CONFIDENCE IN CONNECTION WITH OUR WORK. IT MAY NOT BE COPIED OR USED IN ANY MANNER THAT WOULD BE DETRIMENTAL TO OUR INTERESTS.

PRINTING 40-71 34968

JULY 30, 1980

MAINTENANCE INSTRUCTIONS

TYPE OF SWITCH: EA180 11302 REV. H AND OTHER MODELS AS LISTED
DESCRIPTION : EA180 NUCLEAR SWITCH WITH SILICONE GASKETS
PERIOD OF MFG.: FROM FEBRUARY, 1980

THESE INSTRUCTIONS ARE TO BE USED FOR THE FOLLOWING SWITCH PART NUMBERS AND CORRESPONDING REVISION LEVELS.

PART NUMBER	REVISION LETTER(S)
EA180 11302 - - - -	H
EA180 12302 - - - -	H
EA180 13302 - - - -	H
EA180 14302 - - - -	H
EA180 15302 - - - -	H
EA180 21302 - - - -	H
EA180 22302 - - - -	H
EA180 23302 - - - -	H
EA180 24302 - - - -	H
EA180 25302 - - - -	H
EA180 31302 - - - -	H
EA180 32302 - - - -	H
EA180 33302 - - - -	H
EA180 34302 - - - -	H
EA180 35302 - - - -	H

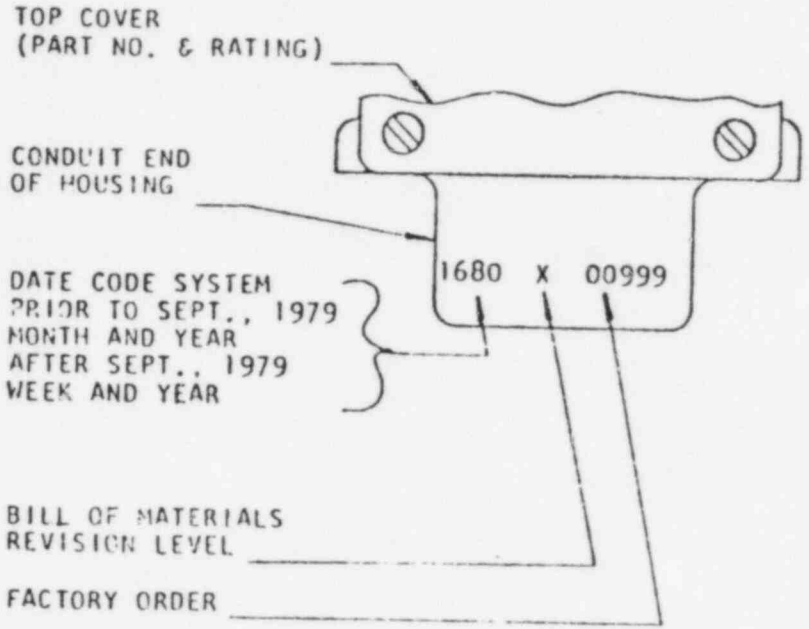


FIGURE 6

4-3

QTR 105

SEPTEMBER 16, 1980

CUST PART NO	ASS'Y NO	REF NO

M	L	K	J	H	G	F	E	D	C	B	A	DIM

B A5557 T.W. 9/16/80 DATE
CHANGE

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS
XX ± 01
XXX ± 005
ANGULAR ± 0°30'
REMOVE ALL SHARP EDGES
ALL MACHINED SURFACES 125√

NOTICE: THE INFORMATION CONTAINED HEREIN IS THE PROPERTY OF THE NAMCO CONTROLS A DIVISION OF THE ACME-CLEVELAND CORP. AND IS SUPPLIED IN CONFIDENCE AND MAY NOT BE COPIED OR USED IN ANY MANNER FOR WHICH IT IS NOT DESIGNED OR LOANED.

DR	TW
CK	M.K.
	9/16/80
DATE	9/16/80
SUPERSEDES	6/15/80
SCALE	

NAMCO CONTROLS
An Acme Cleveland Company
CLEVELAND, OHIO U.S.A.

TITLE: MAINTENANCE INSTRUCTIONS

MATERIAL	DO NOT SCALE
RM-	EA189 90051 PAGE 1 OF 3
STOCK SIZE	

DRAWING 4042134966

MAINTENANCE INSTRUCTIONS

TYPE OF SWITCH: EA180 11302 REV. H AND OTHER MODELS AS LISTED
DESCRIPTION : EA180 NUCLEAR SWITCH WITH SILICONE GASKETS
PERIOD OF MFG.: FROM FEBRUARY, 1980

1.0 UNSCHEDULED MAINTENANCE:

IN THE EVENT THAT THE SWITCH DOES NOT FUNCTION PROPERLY.

1.1 CHECK MECHANICAL OPERATION, REMOVE SWITCH IF SLUGGISH, REMOVE BOTTOM COVER, RELUBRICATE STICKING COMPONENTS, USE NYE 438 OIL. DO NOT LUBRICATE ELECTRICAL SIDE.
1.2 INSTALL BOTTOM COVER, REPLACE GASKET IF DAMAGED (4.4). TORQUE SCREWS TO 20 IN. LBS. OR AS SPECIFIED IN GASKET KIT.
1.3 IF SWITCH DOES NOT CARRY OPERATING CURRENT, REMOVE POWER, REMOVE TOP COVER, CHECK OPERATION. CLEAN CONTACTS (4.1). IF CLOSED CONTACT RESISTANCE REMAINS GREATER THAN ONE OHM, SEE 2.3.
1.4 INSTALL TOP COVER, REPLACE GASKET IF DAMAGED (4.3). TORQUE SCREWS TO 20 IN. LBS. OR AS SPECIFIED IN GASKET KIT.
1.5 REPLACE BOOT IF DAMAGED (4.7).

2.0 SCHEDULED MAINTENANCE:

SEE SERVICE TEMPERATURE VS. SERVICE TIME CHART BELOW TO DETERMINE WHEN THE FOLLOWING MAINTENANCE SHOULD BE PERFORMED.

SERVICE TEMPERATURE	SERVICE TIME
40° C	20 YEARS
45° C	10 YEARS
50° C	5 YEARS
60° C	3 YEARS

2.1 REMOVE SWITCH. REMOVE BOTTOM COVER AND BOOT. REPLACE LEVER SHAFT AND O-RING ASSEMBLY (4.8). LUBRICATE MOVING PARTS (4.2) . INSTALL BOTTOM COVER AND REPLACE BOTTOM COVER GASKET AND SCREWS (4.4). TORQUE BOTTOM COVER SCREWS TO 20 IN. LBS. OR AS SPECIFIED IN GASKET KIT. REPLACE BOOT (4.7).
2.2 REMOVE TOP COVER. CLEAN CONTACTS (4.1).
2.3 REPLACE CONTACT LEVER ASSEMBLY (4.5) THEN CONTACT BLOCK ASSEMBLY (4.6) IF ANY CLOSED CONTACT RESISTANCE REMAINS ABOVE ONE OHM.
2.4 INSTALL TOP COVER AND REPLACE TOP COVER GASKET AND SCREWS (4.3).. TORQUE TOP COVER SCREWS TO 20 IN. LBS. OR AS SPECIFIED IN GASKET KIT.

CUST PART NO	ASS'Y NO	REF NO

												CHG.	DATE
												PER ECS 4-3.1	CHANGE
M	L	K	J	G	F	E	D	C	B	A	DWG

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS
XX ± 01
XXX ± 005
ANGULAR ± 0°30'
REMOVE ALL SHARP EDGES
ALL MACHINED SURFACES

NOTICE: THE INFORMATION CONTAINED HEREIN IS THE PROPERTY OF THE NAMCO CONTROLS A DIVISION OF THE ACME CLEVELAND CORP. AND IS SUPPLIED IN CONFIDENCE AND UNDER THE AGREEMENT THAT IT WILL NOT BE LOANED OR USED IN ANY MANNER THAT MAY BE DETRIMENTAL TO OUR INTERESTS

DR	CK	DATE	SUPERSEDES	SCALE
TJ	M.K.	9/16/80	3-5-80	

NAMCO CONTROLS
An Acme Cleveland Company
CLEVELAND, OHIO U.S.A.

TITLE: MAINTENANCE INSTRUCTIONS

MATERIAL: RM-

STOCK SIZE:

DO NOT SCALE

EA189 90051
PAGE 2 OF 3

HRUNING 10-31-79 6956

4-3.1 FIGURE 6 CONT'D.

QTR 105 SEPTEMBER 16, 1980

MAINTENANCE INSTRUCTIONS

TYPE OF SWITCH: EA180 11302 REV. H AND OTHER MODELS AS LISTED
DESCRIPTION : EA180 NUCLEAR SWITCH WITH SILICONE GASKETS
PERIOD OF MFG.: FROM FEBRUARY, 1980

3.0 SCHEDULED MAINTENANCE:

EVERY 20 YEARS IF SWITCH WAS CONTINUOUSLY EXPOSED TO SERVICE TEMPERATURE HIGHER THAN 50° C.

3.1 REMOVE SWITCH. REMOVE TOP COVER. REMOVE AND REPLACE CONTACT BLOCK ASSEMBLY (4.6) AND CONTACT LEVER ASSEMBLY (4.5). INSTALL TOP COVER AND REPLACE TOP COVER GASKET IF DAMAGED (4.3). TORQUE TOP COVER SCREWS TO 20 IN. LBS. OR AS SPECIFIED IN GASKET KIT.

4.0 RECOMMENDED INSTRUCTIONS AND REPLACEMENT KITS:

4.1 CONTACT CLEANING: CLEAN ALL DEPOSITS FROM CONTACTS WITH CLEAN ALCOHOL OR ACETONE USING Q-TIP TYPE APPLICATOR.

4.2 LUBRICATION PROCEDURE - EA181 10160 (LUBRICANT MANUFACTURER: WILLIAM F. NYE, NEW BEDFORD, MASS.)

4.3 TOP COVER GASKET KIT - EA181 10102

4.4 BOTTOM COVER GASKET KIT - EA181 10120

4.5 CONTACT LEVER KIT - EA181 10130

4.6 CONTACT BLOCK KIT - EA181 10140

4.7 BOOT KIT - EA181 10151

4.8 LEVER SHAFT AND O-RING ASSEMBLY KIT - EA181 10170 (FOR STANDARD SWITCHES)

LEVER SHAFT AND O-RING ASSEMBLY KIT (SHORT TRAVEL) - EA181 10171 (FOR SHORT TRAVEL SWITCHES EA180 X4302)
EA180 X5302)
EA180 X6302)

FIGURE 6 CONT'D.

4-3.2

QTR 105

SEPTEMBER 17, 1980

CUST PART NO	ASS'Y NO	REF NO

ZONE	CHANGE	DATE
B	45557 Tm	3/14/80
A		

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS
XX ± 01
XXX ± 005
ANGULAR ± 0°30'
REMOVE ALL SHARP EDGES
ALL MACHINED SURFACES √

DR	TW
CK	H.K.
DATE	9/16/80
SUPERSEDES	6-5-80
SCALE	

NAMCO CONTROLS
An Acme Cleveland Company
CLEVELAND, OHIO U.S.A.

TITLE: MAINTENANCE INSTRUCTIONS

MATERIAL | DO NOT SCALE

PM-

STOCK SIZE | EA189 90051 PAGE 3 OF 3

BRUNING 40-21 34969

4.0 SERVICE CONDITIONS, INSTALLATION REQUIREMENTS, MAINTENANCE AND QUALIFIED LIFE (REF. IEEE 323-1974, SECTION 6.2) (CONT'D.)

4.5 Normal service environmental conditions.

The test enveloped the following rated service conditions:

4.5.1 Temperature : Room Temperature to +90° C (194°F)

4.5.2 Pressure : Ambient (atm)

4.5.3 Humidity : 0 to 100% R.H.

4.5.4 Radiation : Total exposure 204×10^6 Rads Gamma

4.5.5 Seismic : O.B.E.

1 - 4 Hz. 0.6 - 9.52 g's

4 -35 Hz. 9.52 g's

Plant induced vibration simulation 333,333 cycles @ 100 Hz. at .75 g's.

4.6 Design Basis Event conditions.

4.6.1 Environmental conditions for this type test were derived from IEEE 323-1974, Appendix A, for pressurized water reactors and boiling water reactors.

See Figure 3 of the test report for pressure/temperature profile obtained.

4.6.2 Radiation total exposure:

204×10^6 Rads Gamma

4.6.3 Seismic: SSE (Same as O.B.E.)

1 - 4 Hz. 0.6 - 9.52 g's

4 - 35 Hz. 9.52 g's

4.0 SERVICE CONDITIONS, INSTALLATION REQUIREMENTS, MAINTENANCE AND QUALIFIED LIFE (REF. IEEE 323-1974, SECTION 6.2) (CONT'D.)

4.7 Operating cycles.

4.7.1 Test

The test switch was operated with electrical load for a total of over 100,300 cycles, 100,200 cycles wear cycling and a minimum of 100 cycles during the other tests.

4.7.2 Periodic testing

As a Quality Control procedure, randomly selected switches will be heat aged for 400 hours at 120° C, then operated for a minimum of 100,000 cycles.

4.0 SERVICE CONDITIONS, INSTALLATION REQUIREMENTS, MAINTENANCE AND QUALIFIED LIFE (REF. IEEE 323-1974, SECTION 6.2) (CONT'D.)

4.8 Estimation of Qualified Life

The purpose of this section is to provide an estimation of qualified life for the EA180 series limit switches enveloped by this report.

Qualified life is defined as "the period of time for which satisfactory performance can be demonstrated for a specific set of service conditions." (1)

The qualification test subjected the limit switch to several accelerated aging tests which included thermal aging at 120° C for 400 hours (5.1).

A primary consideration in estimating qualified life is to first determine the aging mechanism to which the component materials are most susceptible.

The limit switch is composed of metallic and organic components. (Figure 7)

The metallic components, per standard practice in the nuclear industry, are considered to be immune to debilitative aging in the temperature range of this test.

Organic components are susceptible to thermal aging in varying degrees and rates. It was decided to determine the qualified life of these components

4.8 Estimation of Qualified Life (Cont'd.)

through the use of the Arrhenius law (2) to mathematically extrapolate the thermal aging time/temperature to service conditions.

As explained later on in this section an activation energy number of 0.8 eV is considered to be very conservative for the elastomeric parts of the limit switch. (2)

Based upon the 0.8 eV the qualified life of the EA180 series limit switch is 5.0 years at 55.0°C, Figure 8. The qualified life can be extended to 40 years by periodic maintenance and replacement of the elastomeric components as recommended by Maintenance Procedure EA189 90051 (Figure 6).

The organic components can be divided into three (3) groups:

A. Polymeric Lubricants

B. Thermoset Plastic Contact Carrier and Contact Block

C. Elastomeric Seals

The synthetic hydrocarbon grease has a rating of 250° F (121° C) and the aromatic ether based oil is stable to over 475° F (246° C). (3) Neither the lubricant manufacturer nor extensive searches of the current chemical literature concerning lubricant has proven useful in

4.8 Estimation of Qualified Life (Cont'd.)

discovering the thermal aging characteristics of these lubricants. However, due to the ratings of these lubricants and the service conditions that they will be subject to it is Namco Controls' carefully drawn opinion that the application and amount of lubricant applied will be of much greater consequence that changes due to the passage of time. The qualified life of the lubricant is controlled by the maintenance procedure.

The thermoset plastic parts are made of an asbestos filled phenolic with a temperature index of 150° C. (4) The manufacturer of the material was not able to provide activation energy data, however, a number of widely varying values have been located for other phenolics, the lowest value being 0.96 eV. (5)

The elastomeric seals for the limit switch consist of the siiicone rubber gaskets and an ethylene propylene o'ring shaft seal. The ethylene propylene boot serves only as an oil retainer and dust shield and therefore, not considered as a seal.

A study and test by Parker Seals (6) concluded that the o'ring seal life appeared to be independent of thermal aging temperatures below 200° F (93° C) and that seal life for ambient temperatures of 55° C to

4.8 Estimation of Qualified Life (Cont'd.)

75° C ranged from 5 to 15 years. Parker was unable to provide an activation energy number.

The manufacturer of the silicone rubber gasket material was not able to supply aging data on the specific compound used, however, data (8) on this type of material indicates a normal service life of 10 to 20 years at 250° F (121° C). A study by Martin Marietta (7) indicates an activation energy number of 1.14 for silicones.

As previously stated; based upon the above and through contacts with others in the nuclear industry (2) an activation energy number of 0.8 eV is considered to be very conservative for the elastomeric parts of the limit switch.

Namco Controls recognizes the importance of thermal aging as a part of qualification and has therefore established a test program to investigate the thermal aging characteristics of the limit switches and of the materials used in them.

This section will be amended as new information becomes available from these tests and other sources.

This statement is based upon the best Engineering information available to us at this time.

4.8 Estimation of Qualified Life (Cont'd.)

Bibliography

(1) IEEE Standard 323-1974, Qualifying Class IE Equipment for Nuclear Power Generating Stations

(2) Namco Controls' Report LP 10835
Thermal Aging Data

(3) Namco Controls' Report LP 10836
Lubricant Data, Thermal Aging

(4) Namco Controls' Report 10837
Thermoset Plastic Data, Thermal Aging

(5) Durez Division of Hooker Chemicals and Plastics Corporation: North Tonawanda, New York;
A Test to Determine Thermal Aging Characteristics of Certain Materials, November, 1969.

(6) Parker Seals, Culver City, California, 90230;
Stress Relaxation Long Term Aging,
E740 Nuclear Report No. 10,4781, January 10, 1979.

(7) Martin Marietta Corporation, Denver, Colorado;
Long Life Assurance Study for Manned Space Craft Long Life Hardware, Volume I, Summary of Long Life Assurance Guidelines, December, 1972.

(8) Namco Controls' Report LP 10838
Silicone Rubber Data, Thermal Aging

4.0 SERVICE CONDITIONS, INSTALLATION REQUIREMENTS, MAINTENANCE AND QUALIFIED LIFE (REF. IEEE 323-1974, SECTION 6.2) (CONT'D.)

List of Non-Metallic
Materials Used in the
Qualified Limit Switch

Material	Where Used
Silicone rubber	Top cover gasket Bottom cover gasket
EPDM	O ring (lever shaft) O ring (cover screws) Boot (lever shaft)
Synthetic hydrocarbon grease w/fluorocarbon	Lubricant
Aromatic ether based oil	Lubricant
Thermoset plastic Phenolic-asbestos filled	Contact block Contact carrier

Figure 7

ARRHENIUS CURVE FOR
ESTIMATED QUALIFIED LIFE

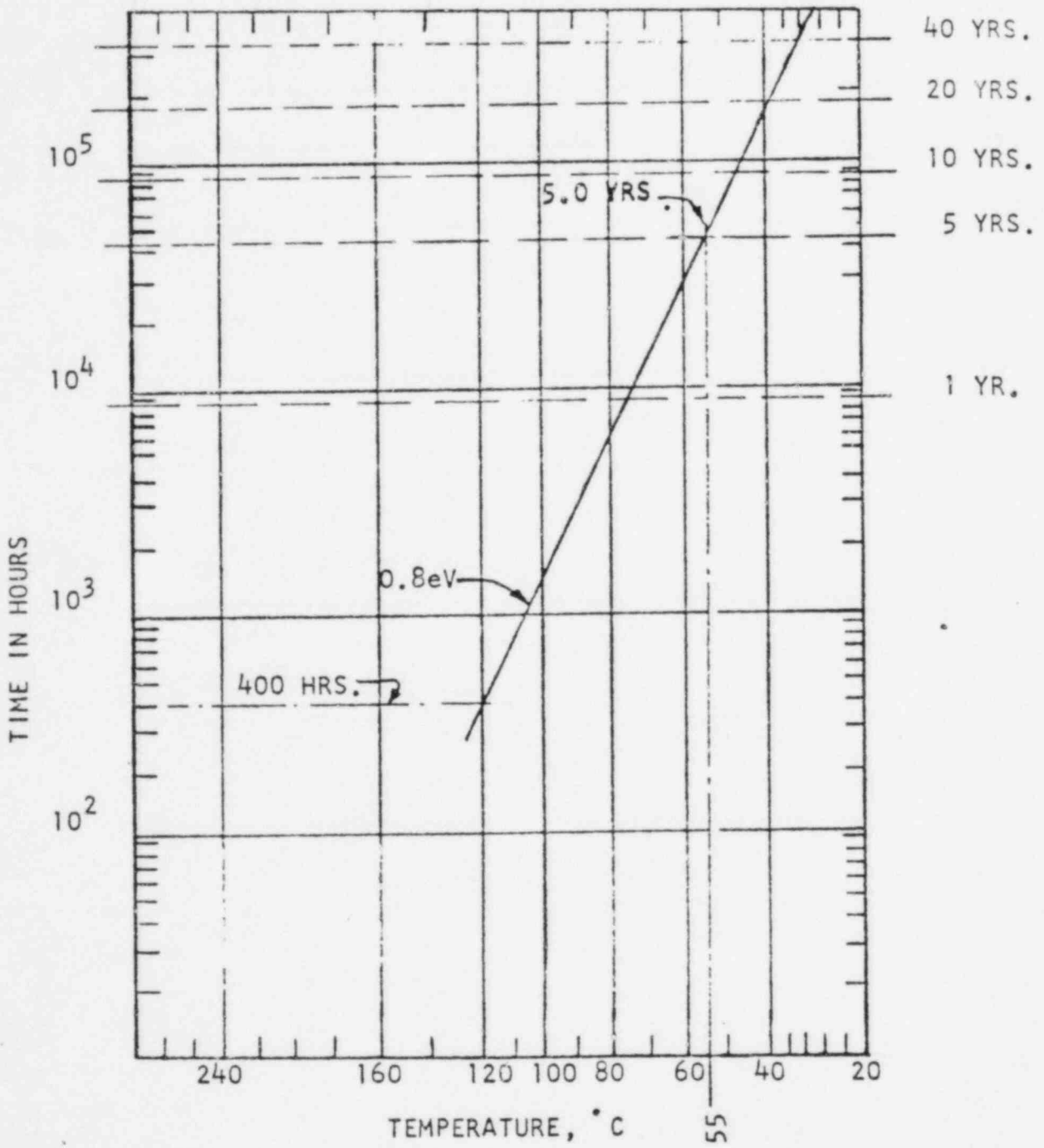


FIGURE 8

5.0 TEST SEQUENCE AND RATIONAL FOR TEST CONDITIONS

5.1 Test sequence for T.R. 3613-PP.

The test sequence was conducted per Test Plan LP10767-3. This test sequence was chosen because it presents the limit switch with the most severe (conservative) conditions in keeping with the IEEE standard guidelines:

inspect for damage.

Test for baseline data.

Thermal aged, 400 hours @ 120° C.

Performance test.

Mechanical wear age.

Performance test.

Total radiation exposure 204 X 10^6 rads.

Performance test.

Seismic testing.

Performance test.

DBE environmental test.

Performance test.

Final inspection.

5.2 Rational for electrical loads used during qualification testing of nuclear switches.

The Namco Controls' qualification test procedure includes mechanical aging of the switch for 100,000 cycles, minimum, with an electrical load of 500 milliamps at 100 volts DC on the contacts.

5.0 TEST SEQUENCE AND RATIONAL FOR TEST CONDITIONS (CONT'D.)

5.2 Rational for electrical loads used during qualification testing of nuclear switches. (Cont'd.)

The purpose of this test is to simulate the lifetime switching function.

The design/nameplate ratings of these switches are the same as the equivalent commercial versions which are UL and CSA listed. (Snap switches per UL1054) The electrical ratings are for resistive loads. As an example, the 125VDC, 5 amp rating is for continuous loads and make or break conditions (See Section 3.3).

Our experience with this series of switches has been that when they are operated at rated voltages and currents, the contact surfaces tend to be self cleaning and/or the potential of the circuit is sufficient to break down films or oxides that might form on the contact faces. On the other hand, low voltages/low currents may not break down the films and/or oxides, therefore, provide little contact surface renewal.

Testing a switch with two different potentials (V/A) is impractical and would not represent a true switch application.

5.0 TEST SEQUENCE AND RATIONAL FOR TEST CONDITIONS (CONT'D.)

5.2 Rational for electrical loads used during qualification testing of nuclear switches. (Cont'd.)

Therefore, we chose 100 volts DC and 500 milliamps (.5 amps) resistive as being the representative conservative contact loading for mechanical aging. An electrical load of 86 milliamps (.086 amps), 100 volts DC was used to check for proper operation of each circuit during all other test procedures.

5.3 Rational for total radiation exposure.

See the test plan (Page 19 of 37F).

It is Namco Controls Engineering's opinion that the combined normal and DBE exposure is the most conservative radiation test condition.

5.4 Rational for single axis sinusoidal seismic testing.

Section 6.6.2 of IEEE 344-1975 provides for single axis sinusoidal seismic testing if there are no resonances or interactions in the frequency range required.

Previous Engineering analysis of switches similar to the EA180 series found that no natural frequencies below 46.6 Hz. exists on the electrical side of the switch.

Engineering analysis did indicate that the natural frequency of the latch (Item 19) is 10.8 Hz. and 67.07 Hz. for the internal lever. Previous biaxial testing of a similar switch (FIRL Report FC3879)

5.0 TEST SEQUENCE AND RATIONAL FOR TEST CONDITONS (CONT'D.)

5.4 Rational for single axis sinusoidal seismic testing. (Cont'd.)

and the cross coupling tests in T.R. 3613-PP proved that cross coupling is not a factor during seismic testing.

5.5 Rational for DBE environmental test.

The DBE conditions of T.R. 3613-PP were more severe than test plan requirements. Test plan requirements were derived from IEEE 323-1974, Appendix A, for pressurized water reactors and boiling water reactors and IEEE 382-1972.

6.0 INSPECTION AFTER TEST

After the completion of all tests and final examination at the test facility the limit switch was returned to Namco Controls for Engineering review.

The memo of February 29, 1980, Page 6-2, is a record of this review. None of the listed items were considered to be failure mode criteria. The switch functioned properly during performance testing.

NAMCO CONTROLS

QTR 105

April 3, 1980
DATE: FEBRUARY 29, 198

TO: LP10767-3 OFFICE:

FROM: G. COVELL OFFICE:

SUBJECT: IEEE QUALIFICATION TEST PROGRAM

OBJECTIVE:

Review EA180 Switch #138-90 which has completed Qualification Testing.

OBSERVATIONS:

Contact Resistance:

AB - .2626 OHMS
CD - .0183 "
EF - .1206 "
GH - .0531 "

1. Zero torque to loosen contact block screws.
2. Operative lever shaft moist from o ring to operating lever, (Nye 438 Oil).
3. Shaft dry from o ring to boot groove.
4. EPDM boot dry.
5. Contact lever shaft had a slight film of Nye 438 Oil on it.
6. Plating on roller flaking off.
7. Top and bottom cover gaskets cracked and brittle (Cohrlastic Gaskets).
8. Most of the Nye 734A Grease had dried out.
9. Normal wear on contacts.
10. Slight amount of grease on roller, slide and torsion spring.

GC/nlm
cc: J. Bendokaitis
L. Browning
J. Buzogany
T. Wood

7.0 COMMENTS, SUMMARY AND CONCLUSIONS

7.1 Conclusion

Based upon our review of the test report T.R. 3613-PP it is our opinion that the EA180-11302/EZ10683-90 series limit switch passed the performance limits, in Section 7 of Test Plan LP10767-3, throughout the tests.

Performance limits:

Closed circuit current remained within .001 amperes of .086 amperes @ 100VDC.

Open circuit resistance (insulation resistance) remained greater than 50,000 OHMS (5 Megohms).

Closed circuits did not open, for more than 2 milliseconds, during seismic testing.

7.2 Failure to transfer, Page 6 of T.R. 3613-PP.

Based upon the Engineering review of the test switch and the test set-up, it is our opinion that the one failure to transfer was a random case that may have been aggravated by the test set-up.

7.3 Seismic qualification of the EA180-11302 series switches was conducted by Dr. E. J. Walters and Associates, June, 1977, (Section 10.1, Appendix B). The following comments refer to this report.

7.3.1 Switches #32, 33 and 45 are mechanical and electrically similar to #138-90.

7.0 COMMENTS, SUMMARY AND CONCLUSIONS (CONT'D.)

7.3.2 Switches #32, 33 and 45 were subjected to thermal aging, wear aging and radiation exposure (204×10^6 Rads) prior to seismic testing.

7.3.3 Resonance search, see Figure 9 for a plot of acceleration amplitude (g) versus frequency (Hz.) for this test.

7.3.4 Fragility test, see Figure 10 for a plot of acceleration amplitude (g) versus frequency (Hz.) for this test. A plot of sine dwell point from test T.R. 3613-PP, switch #138-90 is included to raise the tested g level.

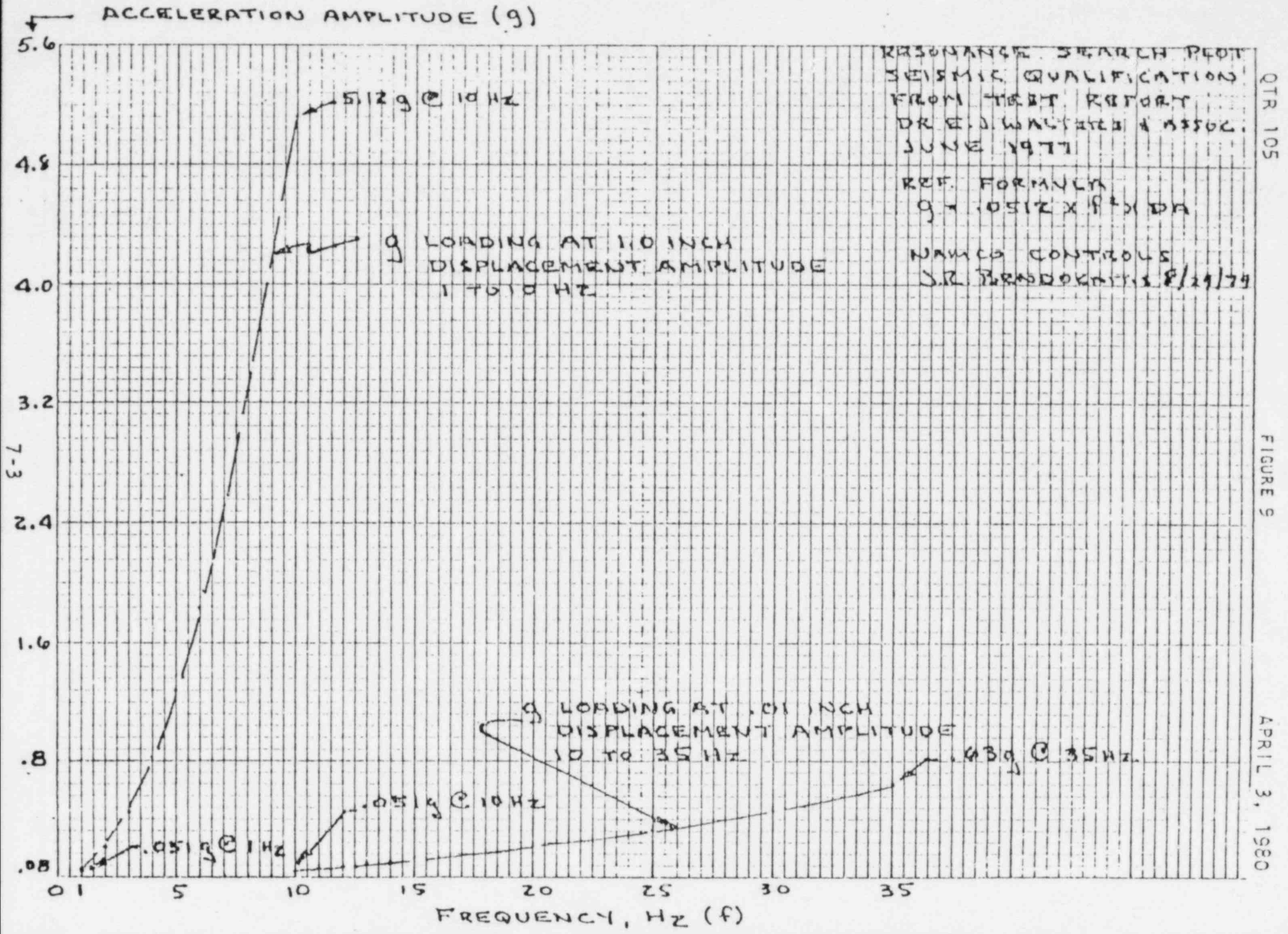
Note: All curves represent test limits because no contact openings (exceeding 2 msec) were encountered.

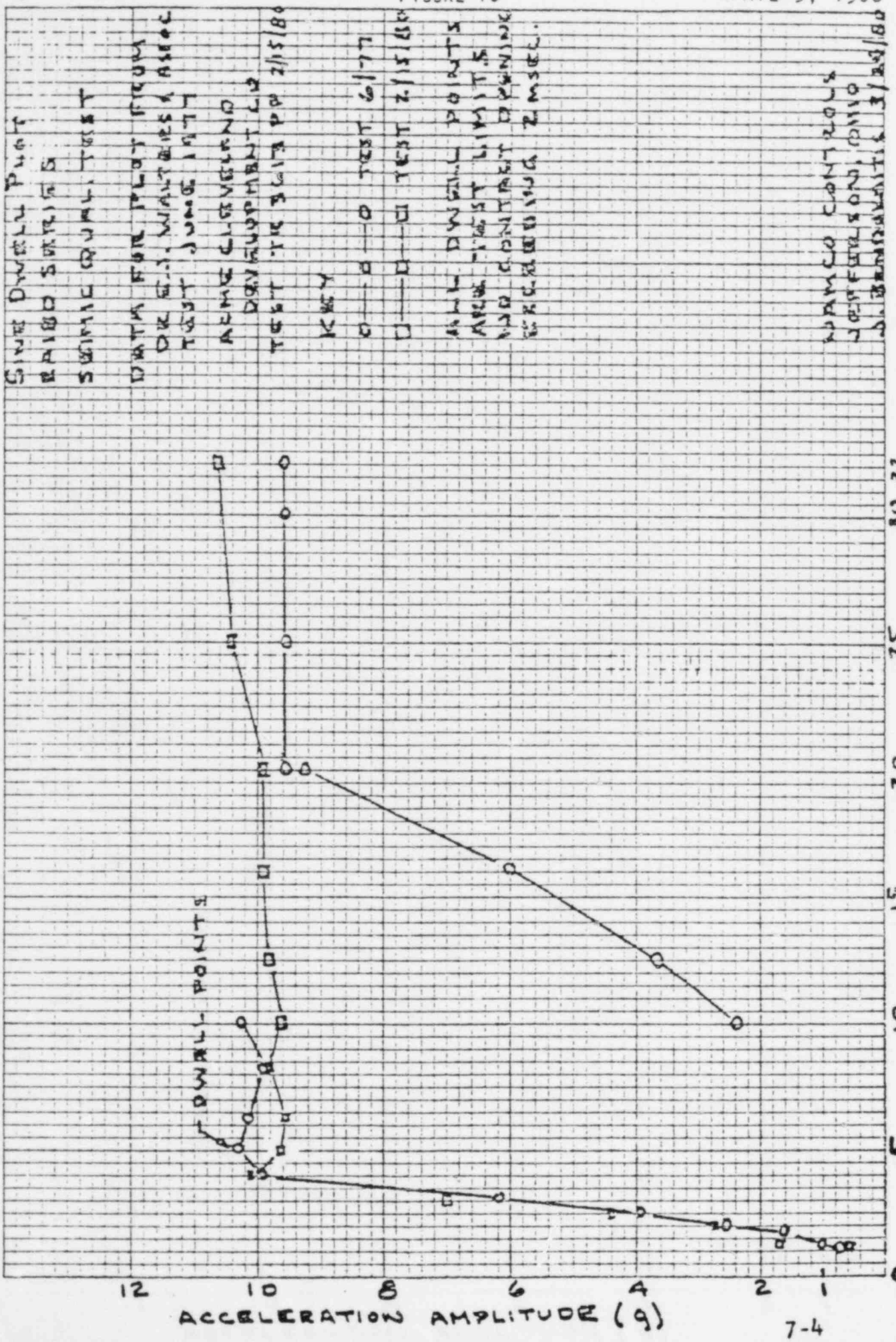
7.3.5 Switch mounting, standard switch mounting (side of housing) was used for all tests.

7.3.6 Switches #32, 33 and 45 were not subjected to plant induced vibration.

7.4 OBE seismic test requirements of IEEE 344-1975, Section 6.1.4.

The OBE test requires that the limit switch be subjected to 5 OBE's and 1 SSE.




ACCELERATION AMPLITUDE (g)
12
10
8
6
4
2
1
0
5
10
15
20
25
30 FREQUENCY, H

7.0 COMMENTS, SUMMARY AND CONCLUSIONS (CONT'D.)

7.4 OBE seismic test requirements of IEEE 344-1975. Section 6.1.4. (Cont'd.)

This requirement has been exceeded during fragility testing. This test subjects the limit switch to a series of 60 second (minimum) sine dwells at sixteen frequencies in each of the three (3) axis. The sine dwell tests provides a minimum of 9,018 stress cycles per axis for a total of 27,054 (minimum) for the test.

For log data regarding fragility testing see Section 10.1, Page 6 of 14B and Pages 6, 7, & 8 of 19D.

7.5 Seismic qualification of #138-90 limit switch.

Limit switch #138-90 is qualified by similarity to switches #32, 33 and 45 per Dr. E. J. Walters' report, Section 6.1, Appendix B. Additional fragility testing was performed in the 10-20 Hz. range per T. R. 3613-PP.

Limit switch #138-90 was subjected to seismic conditioning which included all the sine dwell and plant induced vibration test with circuits energized throughout the tests. Resonance search testing is not required.

7.0 COMMENTS, SUMMARY AND CONCLUSIONS (CONT'D.)

7.6 Conduit sealing, the test report states that teflon tape was used to seal the conduit threads during LOCA test, it must be noted that teflon tape was not used during radiation simulation and further, that no attempt was made to qualify a type of thread sealant. During installation of the limit switch it is the customers responsibility to maintain the integrity of the switch enclosure.

8.0 DESCRIPTION OF PRODUCT IMPROVEMENT CHANGES

8.1 Limit switch #138-90 was made to bill of materials EZ10683-90/EA180-11302 and incorporated the following product improvement changes: (B/M Item No.)

Item 7 Bushing (for contact lever shaft)
Changed from bronze to P/M bronze, oil impregnated.

Item 17 Latch Stud
Changed finish from zinc plating to nickel plating.

Item 27 Contact Block
Changed material from glass filled polyester to asbestos filled phenolic thermoset plastic.

Item 85 Contact Carrier
Changed material from glass filled polyester to asbestos filled phenolic thermoset plastic.

Item 95 Lever (internal)
Material changed from bronwite to brass.

Item 100 Lever Shaft
Added oil groove.

Item 112 Top Cover
Added chamfer to screw holes for o ring.

8.0 DESCRIPTION OF PRODUCT IMPROVEMENT CHANGES

8.1 Limit switch #138-90 was made to bill of materials EZ10683-90/EA180-11302 and incorporated the following product improvement changes: (B/M Item No.) (Cont'd.)

Item 116 Top Cover Screw Assembly

Was: #8-32 Binding Head Screw with Lockwasher.

Now: Special #8-32 SEMS Screw with Belleville washer and EPDM o ring.

Item 114 Top Cover Gasket

Was: Impregnated NBR/Asbestos

Now: Silicone rubber

Item 128 Bottom Cover Gasket

Was: Impregnated NBR/Asbestos

Now: Silicone rubber

Item 131 Bottom Cover Screw Assembly

EPDM o ring added to a special flat head screw.

Item 133 Boot

Material changed from silicone rubber to EPDM.

9.0 ATTACHMENTS

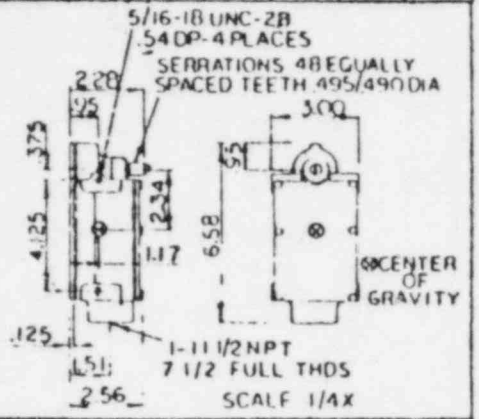
9.2 EA180 11302 Limit Switch Assembly

9.3 EA180 14302 Limit Switch Assembly

9.4 E1060 53300 Operating Lever Assembly

EA180 11302

ASSY NO	ROT	DIM W	DIM X	DIM Y	DIM Z
EA180 11302	CW	—	—	—	—
EA180 21302	CW	—	—	3.687	3.812
EA180 31302	CW	2.250	5.625	—	—
EA180 12302	CCW	—	—	—	—
EA180 22302	CCW	—	—	3.687	3.812
EA180 32302	CCW	2.250	5.625	—	—

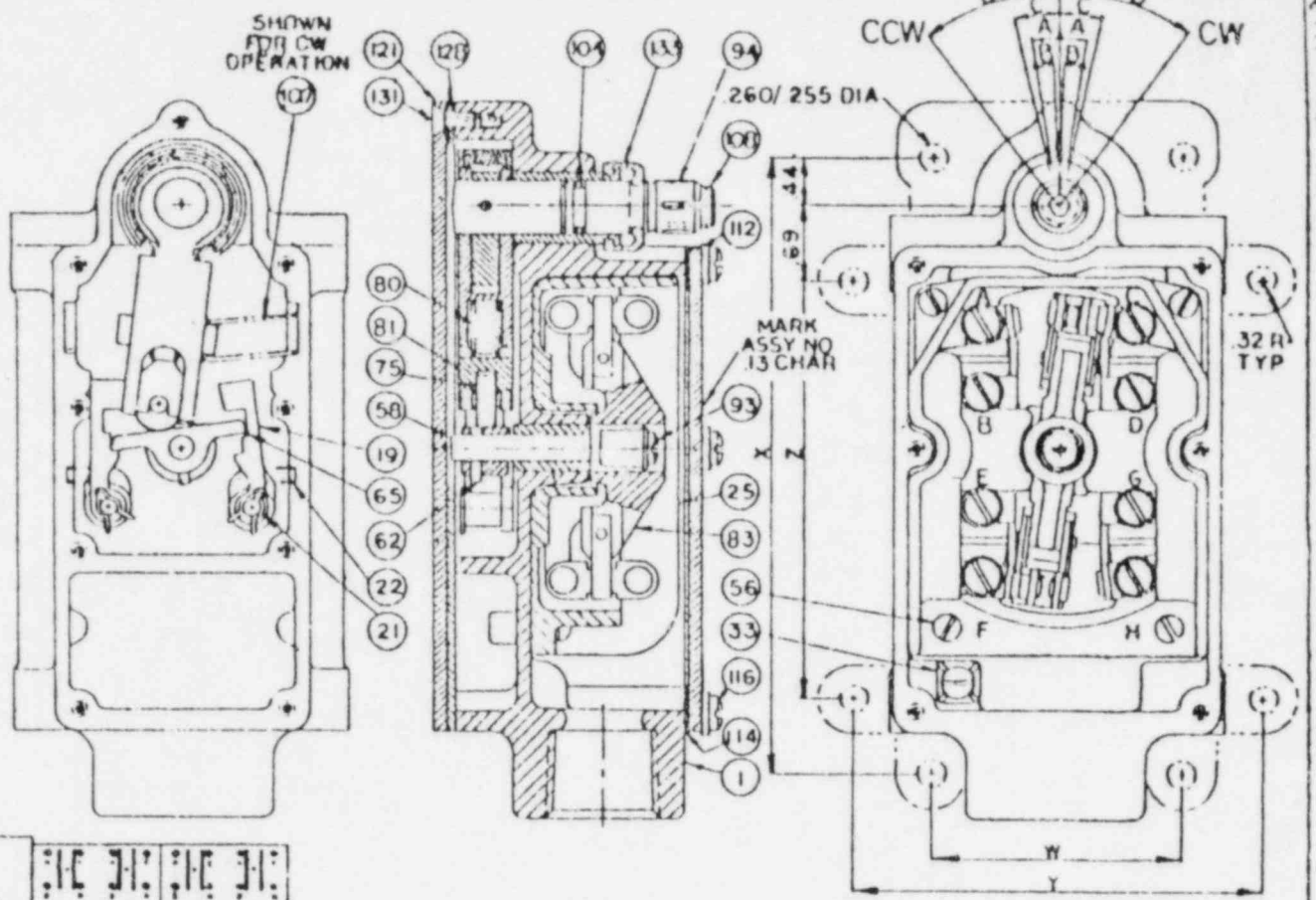


CONTINUOUS CURRENT RATING
75-100% POWER FACTOR

125 VAC	20 AMPS	600 VAC	5 AMPS
250 VAC	15 AMPS	125 VDC	5 AMPS
480 VAC	10 AMPS	250 VDC	1.5 AMPS

A PRETRAVEL	10°
B DIFFERENTIAL TRAVEL	8°
C RECOMMENDED TRAVEL	13°
D TOTAL TRAVEL	38°
E MAX TORQUE DURING PRETRAVEL	21 LB-IN
F MAX TORQUE AT TOTAL TRAVEL	33 LB-IN

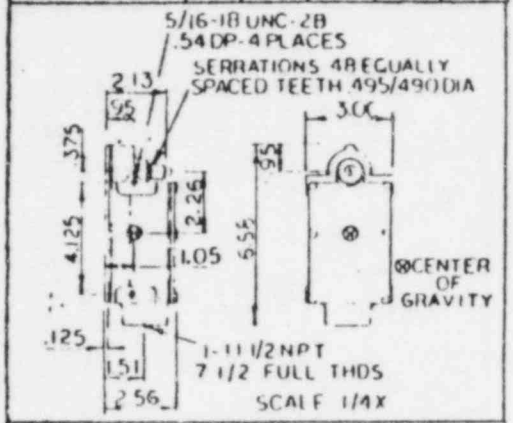
1 HEAVY DUTY CONTACT ARRANGEMENT IS DOUBLE POLE (POLE 1: A-B & C-D, POLE 2: E-F & G-H) DOUBLE THROW BUTT CONTACTS, QUICK MAKE - QUICK BREAK WITH EIGHT TERMINALS, FOUR FOR NORMALLY OPEN & FOUR FOR NORMALLY CLOSED
2 NEMA ENCLOSURE TYPES 1, 4 & 13
3 OPERATING LEVER (NOT SHOWN) IS ADJUSTABLE IN 7°30' INCREMENTS THRU 167°
4 ADEQUATE WIRING SPACE FOR NINE NO 12 AWG CONDUCTORS
5 ASSY SPEC
6 LUBE SPEC
7 INSTALLATION INSTRUCTIONS PER
8 OPERATING TEMPERATURE -20°C TO +90°C
9 WEIGHT 4.5 LBS
10 SHORT TERM EXPOSURE TO +175°C
11 PROCESS PER QCB-101



CUST PART NO	ASS'D NO	REF NO	
UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS .XX ± .01, .XXX ± .005, ANGULAR ± 0°30', REMOVE ALL SHARP EDGES, ALL MACHINED SURFACES 125	A R	NAMCO CONTROLS, An Acme Cleveland Company, CLEVELAND OHIO U.S.A. (21)	
	1-23-80	D2400 NUCLEAR SWITCH	
	1-3-79	RM	EA180 11302
	FULL		

EA170-14302

ASSY NO	RQT	DIM W	DIM X	DIM Y	DIM Z
EA170 14302	CW	—	—	—	—
EA170 24302	CW	—	—	3.687	3.812
EA170 34302	CW	2.250	5.625	—	—
EA170 15302	CCW	—	—	—	—
EA170 25302	CCW	—	—	3.687	3.812
EA170 35302	CCW	2.250	5.625	—	—

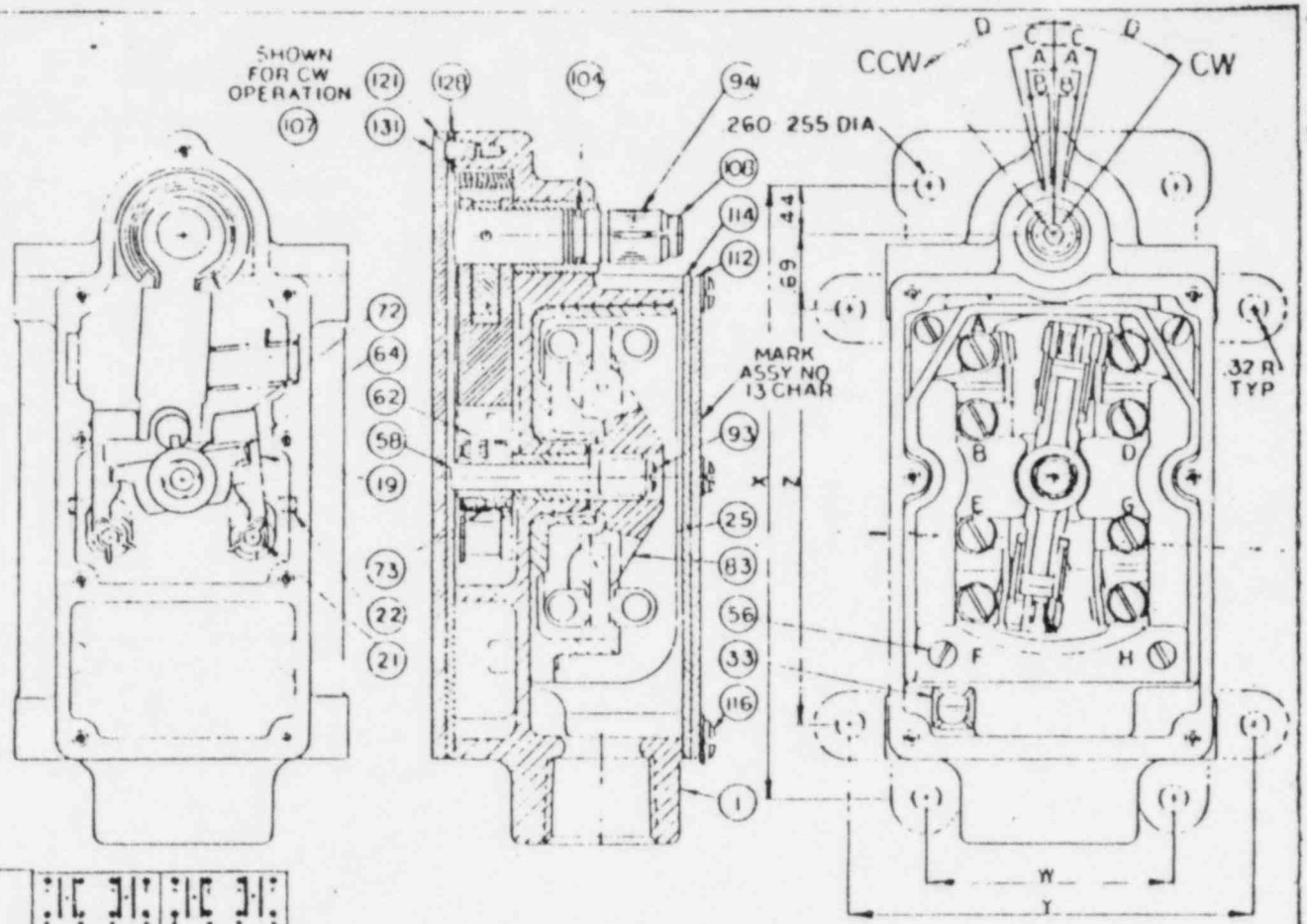


CONTINUOUS CURRENT RATING.
75°C AMBIENT 90% POWER FACTOR

125 VAC 20 AMPS	600 VAC 5 AMPS
250 VAC 15 AMPS	125 VDC 5 AMPS
480 VAC 10 AMPS	250 VDC 15 AMPS

A PRE TRAVEL	6°30'
B DIFFERENTIAL TRAVEL	4°
C RECOMMENDED TRAVEL	7°
D TOTAL TRAVEL	36°
E MAX TORQUE DURING PRE TRAVEL	32 LB-IN
F MAX TORQUE AT TOTAL TRAVEL	45 LB-IN

1. HEAVY DUTY CONTACT ARRANGEMENT IS DOUBLE POLE (POLE 1: A B & C D; POLE 2: E F & G H) DOUBLE THROW BUTT CONTACTS, QUICK MAKE - QUICK BREAK WITH EIGHT TERMINALS, FOUR FOR NORMALLY OPEN & FOUR FOR NORMALLY CLOSED.
2. NEMA ENCLOSURE TYPES 1, 4 & 13
3. OPERATING LEVER (NOT SHOWN) IS ADJUSTABLE IN 7°30' INCREMENTS, THRU 173°
4. ADEQUATE WIRING SPACE FOR NINE NO. 12 AWG CONDUCTORS
5. ASSY SPEC:
6. CLUTCH SPEC:
7. INSTALLATION INSTRUCTIONS:
8. OPERATING TEMPERATURE -20°C TO +90°C
9. WEIGHT 3 LBS
10. PROCESS PER QCB-101



CUST PART NO | ASS'Y NO | REF NO

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS
XX ± .01
XXX ± .005
ANGULAR ± 0°30
REMOVE ALL SHARP EDGES
ALL MACHINED SURFACES 125 V

DR	JSD.
DATE	4-14-80
SUPERSEDES	1-3-79
SCALE	FULL

NAMCO CONTROLS
An Acme Cleveland Company
CLEVELAND, OHIO U.S.A.

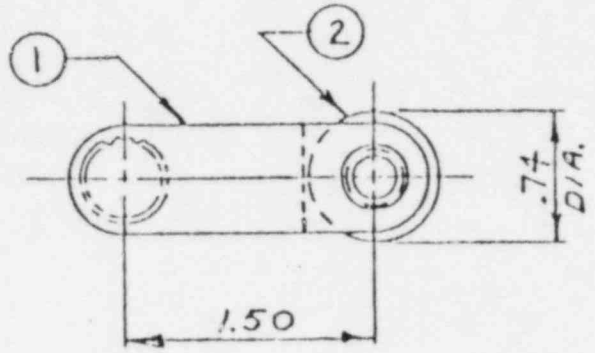
D2400 RAD. ENV. SWITCH
SHORT TRAVEL

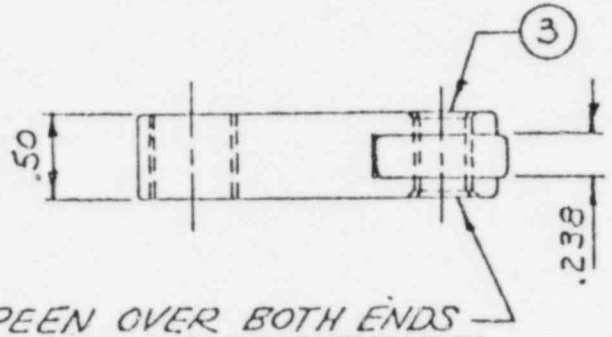
MATERIAL	DO NOT SCALE
RM-	EA170-14302

CTR 105

	PART NO.	REF. NO.	ITEM 2	REMARKS
EL060 53300	EL060 53300	D1260-RU	EL021 33014	BeCu ROLLER
©	EL060 53301	EZ10619-5,	EL021 33017	NITRONIC 60 ROLLER

OPERATION		DEPT.	JIG
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			





PEEN OVER BOTH ENDS

SEE B/M FOR P/N

REMOVE ALL SHARP EDGES
UNLESS OTHERWISE SPECIFIED

ALL FRACTIONAL DIMENSIONS
± .010 UNLESS NOTED.

CUST. PART No. LAYOUT No. ASSM. No. ORDER No.

REVISIONS	DATE	
C	3-6-77	ADDED EL060 53301
A	9-12-62	

1st SERIAL
LAST SERIAL
SUPERSEDES
SUPERSEDED BY
REMARKS

No. REQ'D.
DR. DELOSIER
TR.
CK.

STOCK SIZE
THE NATIONAL ACME CO. CLEVELAND, OHIO
OPERATING LEVER ASSEM.
MATERIAL
SCALE FULL DATE 4-13-59
EL060 53300

QTR 105

AUGUST 28, 1980

4-6

10.0 TEST REPORTS

This section contains a copy of all the listed test reports.

10.1 Type test T.R. 3613-PP

Dated February 15, 1980, Revision 0

10.2 Supplementary Testing for Short Travel Switches.

An excerpt from EA180 Qualification Test Report Revision 1, dated September 5, 1978.

ACME-CLEVELAND DEVELOPMENT COMPANY
6225 ALPHA DRIVE • HIGHLAND HEIGHTS, OHIO 44143 • (216) 473-0300

T.R. 3613-PP

TESTS OF LIMIT SWITCH #138-90

FEBRUARY 15, 1980

REVISION 0

T.R. 3613-PP

TABLE OF CONTENTS

	Page
CERTIFICATION	
T.R. 3613-PP (BODY OF REPORT)	1-7
FIGURES 1-3	1-3
APPENDICES	
APPENDIX A Letter from M. Bruce of Georgia Institute of Technology to E. L. Solem Regarding Switch Irradiation	1-4
APPENDIX B Seismic Qualification Test of Limit Control Switches Dated June 1977 by Dr. E. J. Walter & Associates	1-14
APPENDIX C Cross Coupling	1-4
APPENDIX D Data Sheets	1-19
APPENDIX E Equipment Calibration Listings	1

CERTIFICATION

The undersigned certify that this report presents a true account of the tests conducted and the results obtained:

James J. Patsey — 2/19/80
J. J. Patsey, Date
R & D Technician

Edward L. Solem — 2/18/80
E. L. Solem, Date
Development Engineer

APPROVED BY: Thomas J. Skingle — Feb-18, 1980
T. J. Skingle, P. E., Date
Corporate Manager
Materials R & D

Robert L. Nekola — Feb 19, 1980
R. L. Nekola, P. E., Date
General Manager
Acme-Cleveland Development Company

TEST REPORT NO.:	T.R. 3613-PP
DATE:	2/15/80
TITLE OF TEST:	TESTS OF LIMIT SWITCH #138-90 AS PER TEST PLAN LP-10767-3, REVISION 1
SIZES AND KINDS OF SWITCHES:	One Namco Controls limit switch Model EZ-10683-90/EA-180-11302
PURPOSE OF TEST:	To establish the performance characteristics of the switch under normal and abnormal conditions.
TEST REQUESTED BY:	Namco Controls
PREVIOUS HISTORY AND REFERENCES:	E.R. 1418 All Series 3613 test reports Test Plan LP-10767-3, Rev. 1, dated 7/26/79

PROCEDURE FOLLOWED

The following tests were carried out at or under contract to Acme-Cleveland Development Company, the research center for the Acme-Cleveland Corporation.

The tests consisted of the following parts:

1. Thermal aging for 400 hours at 120°C (248°F).
2. Mechanical wear aging for 100,200 actuation cycles under electrical load of 0.5 amps at 100 volts DC.
3. Irradiation to a level of 204 megarads of gamma radiation.
4. Seismic testing to a maximum of 9.52 g's in the 1-35 Hz range.
5. DBE testing to a maximum 196°C (346°F) at 70 PSIG.

The test procedure will be presented in the order in which it was performed. Paragraph references are provided in parentheses for correlation with the test plan.

E L S

Throughout the testing the following equipment was used to determine the performance level of the units.[1] A megohm meter measured the resistance between contacts when open. A test circuit measured the load current between contacts when closed. This circuit consisted of a 100 volt DC power supply, appropriate voltage and current meters, and a load bank set to pass 86 milliamps.

Inspection and Preparation (6.1)

The switch identity was recorded and the switch wired and assembled as called for by the test plan.

Initial Test (6.2.1 and 6.2.2)

Open and closed circuit performance was measured and recorded for purposes of providing base-line data. Trip angle and torque tests (identified as Functional Test - 6.2.1.3 of the test plan) were deferred until after the Mechanical Wear Aging.

Thermal Aging (6.3)

The thermal aging test consisted of exposing the unit to a temperature of 120°C (248°F) for 400 hours. A thermometer was placed such that the switch was between it and the heat source. This thermometer was monitored during thermal aging. During the time of this test the conduit opening of the switch was sealed. A Performance Test (6.2.2) was performed at the conclusion of the thermal aging.

Mechanical Wear Aging (6.4)

The switch was subjected to 100,200 actuation cycles. The actuation was accomplished by a cam mechanism operating at 70 actuations per minute. The electrical loading during this part of the test was 0.5 amps at 100 volts DC. Per-

[1] Calibration dates are contained in Appendix E.

EJS

formance (6.2.2) and Base-line Functional (6.2.1.3) tests were performed after mechanical wear aging.

Irradiation (6.5)

Irradiation was performed by the Frank H. Neely Nuclear Research Center of Georgia Institute of Technology. Their certification is contained in Appendix A. Irradiation was carried out to a level of 204 megarads. Gamma radiation from a cobalt 60 source at 1.173 Mev and 1.332 Mev. was used. The irradiation was carried out at a rate of 0.91 megarads per hour. The Performance Test (6.2.2) was performed after the irradiation.

Seismic Testing (6.6)

Single axis tests were performed in each of the three axes. This testing included Resonance Search (6.6.8), Fragility Test (6.6.9), and Plant Induced Vibration Simulation (6.6.10). The analysis of cross coupling in this model switch is presented in Appendix C.

The Seismic tests (see Appendix B) were performed on a different Model EA-180 switch. These tests cover the Resonance Search (6.6.8) and most of the Fragility Test (6.6.9) required by the referenced test plan. The testing of Appendix B was conducted at a reduced g level in the 10-20 Hz frequency range of the Fragility test. Therefore, full fragility testint was performed on the present switch in this frequency range.

The performance instrumentation for this test was the same as that for Appendix B. A Nicolet Explorer III oscil-

EJL

loscope was, however, substituted for the Tektronix. The Fragility Test was performed on a mechanical shaker. The input motion of the shaker was monitored by an accelerometer.

The test spectrum for the Fragility Test (6.6.9) is given in Table I. Note that either acceleration or displacement may be the independent variable.

TABLE I

SEISMIC TEST SPECTRUM (INPUT MOTION)
(See Also Figure 1)

Frequency	Peak Acceleration	Peak to Peak Displacement
1-4 Hz	0.6-9.52 g's	12"
4-35 Hz	9.52 g's	12"-.091"

The data acquisition portion of the tests covered in Appendix B were not repeated on the switch (#138-90) presently under test. However, this switch (#138-90) was subjected to all vibrations which are a part of the Fragility Test in order to simulate the post-seismic condition before subjecting the switch to DBE testing.[1]

The Plant Induced Vibration Test (6.6.10) was run on Switch #138-90 at 100 Hz using a B & K electrodynamic shaker. Table motion was monitored by a BBN accelerometer.

The Performance Test (6.2.2) was run after Seismic testing.

DBE Test (6.7)

The temperature pressure profile for the test is given in Figure 3.[2]

---

[1] The switch circuits were energized and the switch exercised in this test as it would have been in full testing.

[2] The recorded pressure/temperature data are presented on Pages 9 of 19 (D) and 13-19 of 19 (D).

The first four days of DBE testing were performed in a chamber of 12" height and 8" diameter. The switch was mounted in the chamber in a horizontal position such that the lever shaft pointed upwards. The switch was attached by means of a threaded pipe. Teflon tape was used for sealing the pipe threads. This pipe ran through an O-ring type feed-through in the chamber. The electrical connections from the switch were run through this same pipe. Actuation of the switch was provided by a rotary feed-through in the top of the chamber.

The switch was subjected to a caustic spray during this portion of the DBE test. The flow rate of the spray was 230 cc's per minute providing the necessary coverage of 0.15 gallons per minute per square foot of cross-section. The pH of the spray was maintained between 10 and 11. The spray was composed of boric acid, water, sodium thiosulfate and sodium hydroxide and was recycled during the entire time. Spraying was initiated following each transient temperature rise. The switch was submerged in caustic spray at temperature during some portions of this test due to the instability of the recycling system.

The rate of temperature rise during the two transients of the DBE test was somewhat slower than shown in Figure 2. The data are summarized in Figure 3 and Page 9 of Appendix D.

The switch was transferred from the high pressure chamber to the low pressure chamber following the first four days of the DBE test. It remained in this low pressure chamber for the rest of the 30-day DBE period.

EJ

Two data acquisition methods were used during the DBE. The temperature was recorded on a strip chart recorder via a thermocouple. During the transient sections of the DBE the digital readout from the thermocouple as well as the reading of the pressure gauge were recorded on video tape. The data are recorded on Scene 138 of this tape which is on file in the library of the Acme-Cleveland Development Company.

The switch was actuated and data recorded during the peak level of the DBE and at other times as noted in Figure 3. Additional data were taken during the long-term portion and at the conclusion of the test.

RESULTS

During all phases of the test the open contact resistance of the switch remained above 5 megohms. The closed circuit current remained within 0.001 amps of the specified load.

At one point in the DBE test the switch failed to transfer when released after actuation. The switch did transfer after a second actuation provided a small additional lever arm rotation. The lever arm was not pushed back toward the unactuated position.

Detailed performance data are presented in Appendix D.

CONCLUSIONS

The switch failed to Transfer (7.4) one time during DBE testing. No other Performance Limits (7) as specified by the test plan were encountered during the tests.

The tests were carried out from October of 1979 to January of 1980.

ELS/J.JP:cr

Enclosures

E L. L

FIGURES

FIGURE 1

SEISMIC INPUT MOTION

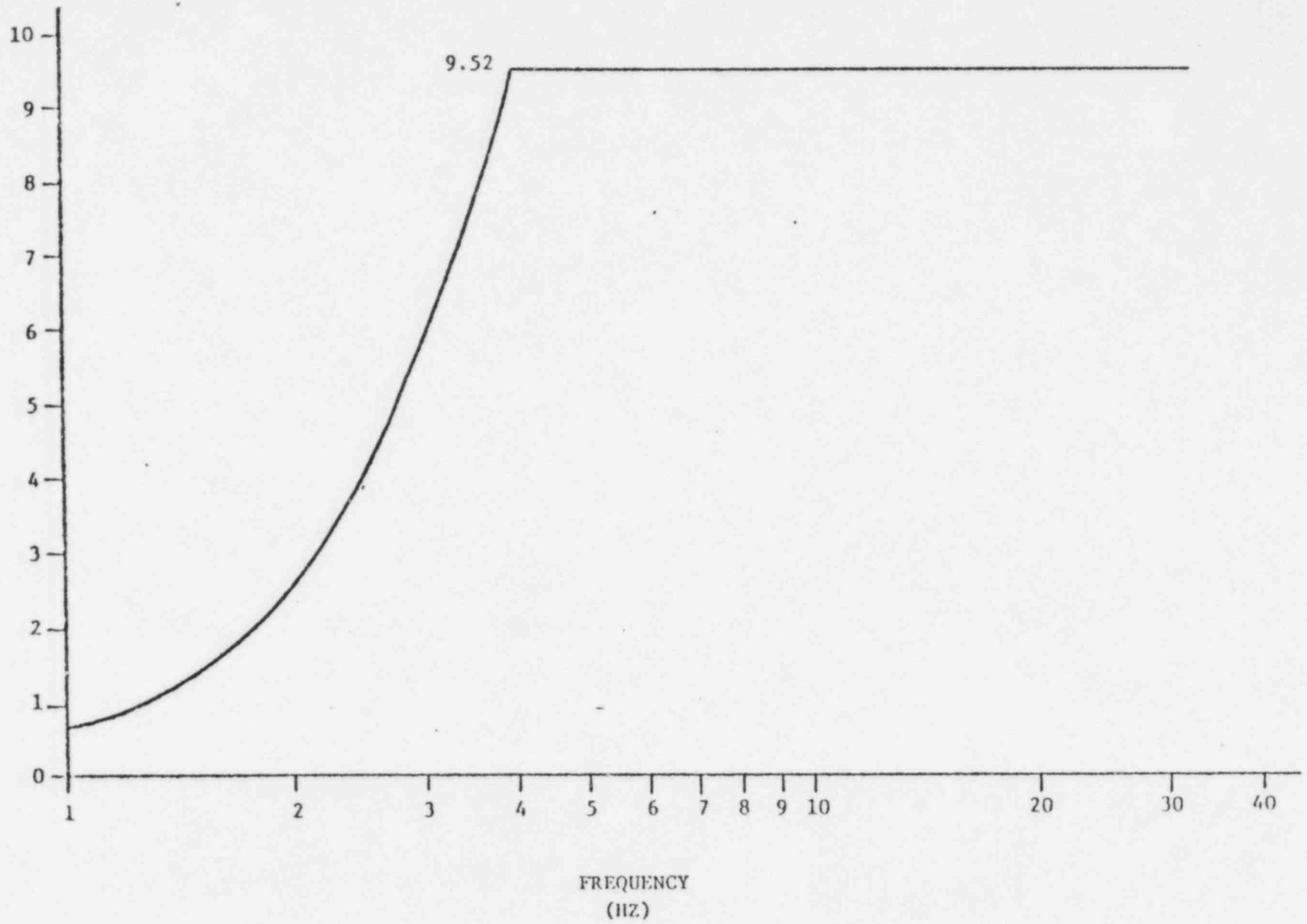


FIGURE 2

TEST CHAMBER PROFILE FOR ACCIDENT ENVIRONMENT SIMULATION
(TAKEN FROM IEEE STD 382-1972)

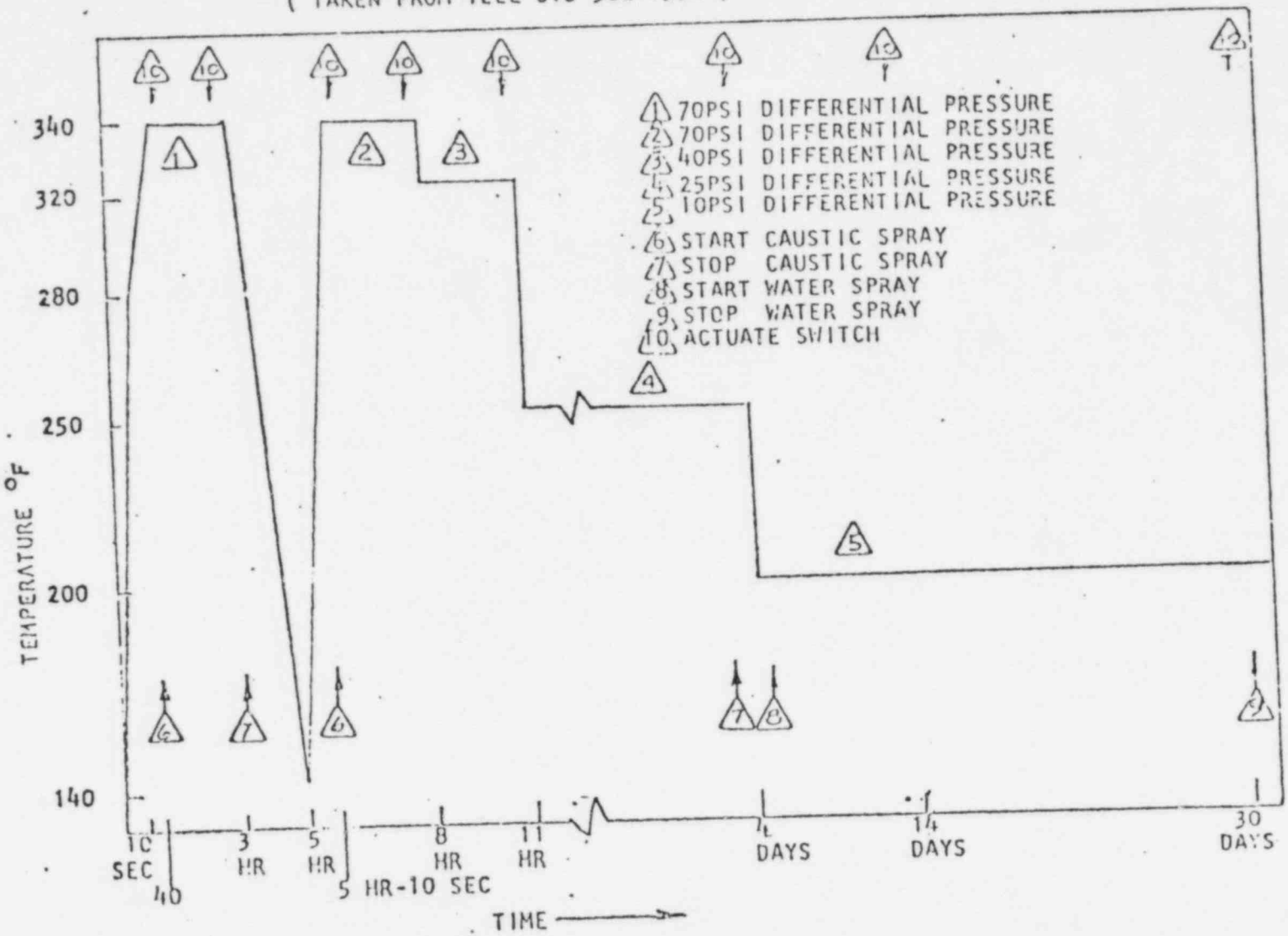
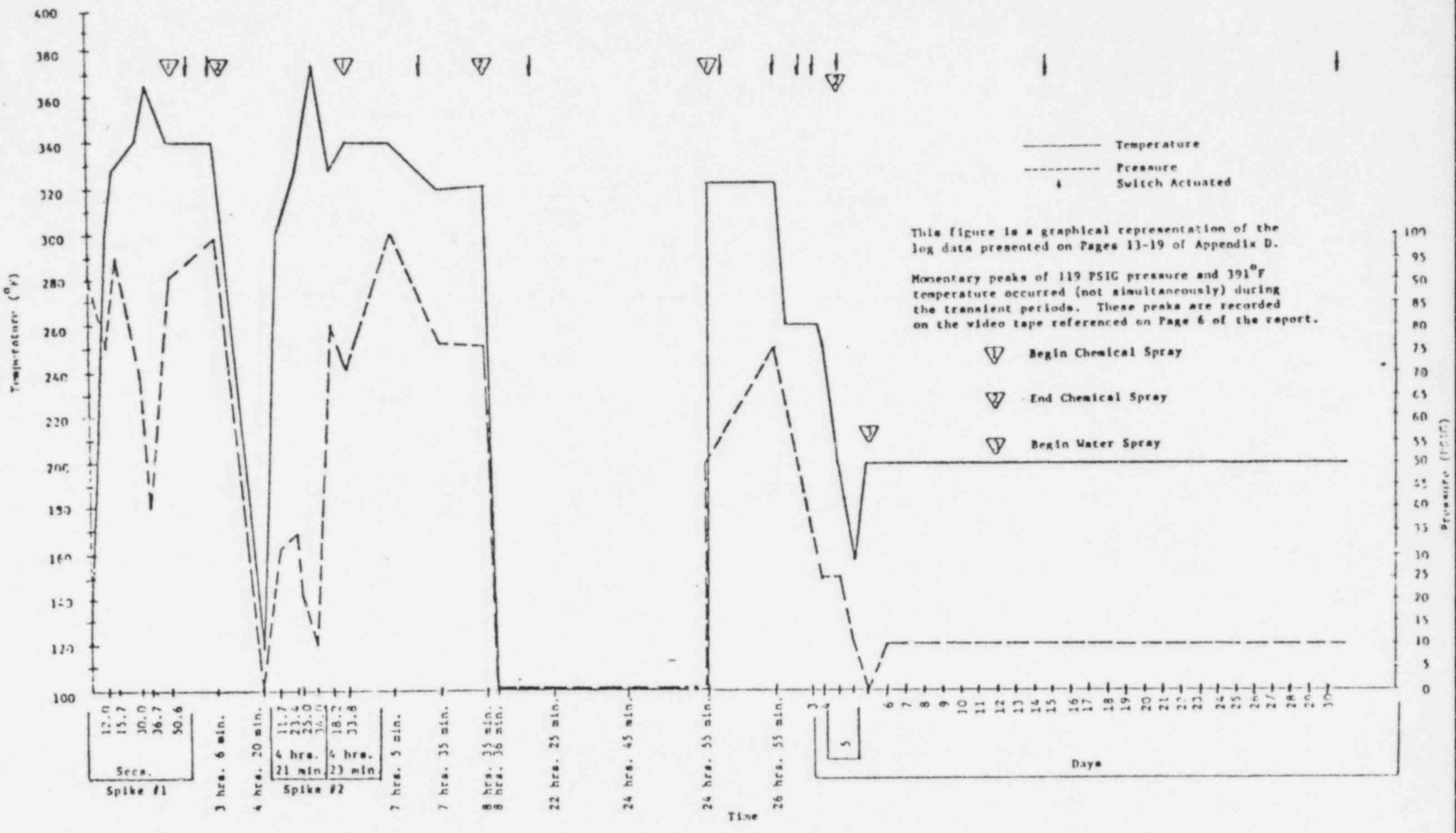


FIGURE 3

TEST CHAMBER PROFILE FOR ACCIDENT ENVIRONMENT SIMULATION
(As Recorded)



APPENDIX A

RADIATION EXPOSURE

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF NUCLEAR ENGINEERING
ATLANTA, GEORGIA 30332

FRANK H. NEELY
NUCLEAR RESEARCH CENTER
TELEPHONE: (404) 894-3600

November 20, 1979

Mr. E.L. Solem
Development Engineer
Acme-Cleveland Development Co.
625 Alpha Drive
Highland Heights, Ohio 44143

Dear Mr. Solem:

Pursuant to your instructions seven limit switches and nine small items were irradiated in our hot cell facility using Cobalt 60 (gamma energies 1.173 Mev; 1.332 MeV) to a total dose of 2.04 X 10^8 rads (air) or 2.3 X 10^8 rads (air) as indicated below.

We certify the specific parameters of this irradiation to be:

Test I - 204 Megarads

Irradiation Period:	Total of 9 days, 8 hours and 15 minutes P-1 November 5-November 12, 6 days 15 hours and 15 minutes P-2 November 16 - November 19, 2 days 17 hours and 0 minutes
Dose Rate:	9.1 X 10^5 rad/hour
Total Dose:	2.04 X 10^8 rads (air)
Specimen Id:	(Switch) 134-63 (Switch) 136-90 (Switch) 131-2 (Switch) 138-90 (Switch) 137-67 (Switch) 97 (Switch) 96

Hexseal APM
346
0
308
100
400
NPC-80
2 unlabeled items

Test II - 230 Megarads

Irradiation Period:	Total of 10 days 12 hours and 45 minutes P-1 and P-2 of Test I and P-3, November 19 - November 20, 1 day 4 hours and 30 minutes
Dose Rate:	9.1×10^5 rad/hour
Total Dose:	2.3×10^8 rads (air)
Specimen Id:	(Switch) 134-63 (Switch) 136-90 2 unlables items Hexseal APM 346 308 100 400 0
Dosimetry:	Thermoluminescent dosimeters of lithium borate. (Harshaw TL-800) calibrated with a Farmer Dosimeter model 2502/3. Farmer unit calibrated using NBS cobalt 60 at M.D. Anderson Hospital, Houston, Texas.

The last date of TLD calibration was March 12, 1979; the last date of Farmer unit calibration was July 27, 1979. If you require additional information please contact me at (404) 894-3608.

GEORGIA INSTITUTE OF TECHNOLOGY

Margaret Bruce

Margaret Bruce
Research Scientist

MB:lrm

IRR. REF. Number 79629

Irr. Ref. Number C 29

Account Number _____

Sponsor/Address Marco Contiole / Acme - Cleveland

Job Description: (7) Tinit containers (9) small specimen
2.01 11 Rads 131-2, 132-20, 137-17,
97, 96 and NPC-80

Scheduled Start: _____

Budget:

P.S. _____ hr. @ _____ = _____

M&S _____ = _____

Hot Cell _____ @ _____ = _____

Gamma Pool _____ @ _____ = _____

Other _____ = _____

Total Contract _____

2 drops 11 Cs. now + 1 more
Actual Start 11-5-79 1655 (4:55 pm) Stop 5:10 pm 11/12/79

+ Resin 2 drops 17 Cs
~~Completion~~ 2nd Start 11-16-79 (1730 - 5:30 pm) 2nd Stop 11-19-79 10:30 AM

~~Removed~~ 2.04 x 10^8 specimens

1 day 4 hrs 3 min
Restart 11-19-79 at 1225 (12:25 pm) - Stop 11-20-79 1655 pm

Smearable contamination on specimn after test < 100 d/m / 100 Cm²

Jim Boyd
Radiological Safety Officer

Irradiation of specimen(s) performed by Jerry E. Taylor

Page 3 of 4 (A)

Dosimeter Readings

A 1610 inch → 1690 × 99.6 rad(H$_2$O)/cc × .9017 rad(air)/rad(H$_2$O) × 60 min/hr × 1/20 hr =

B 1770 — "

etc.

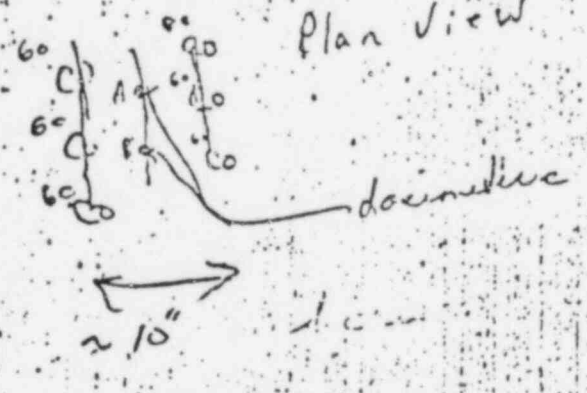
9.1×10^5 rad (air)/hr

Irradiation Geometry

"Sketch showing source positions, dosimeter position, and position of test specimen during irradiation"

Photo attached to original

Dosimeter 2 — horizontal center ~ 5" above Co bottom



Calculations

$\frac{2.04 \times 10^8}{9.1 \times 10^5}$ = 224 hours 11 min (9 days 8 hr 11 min)

actual — 9 days 8 hrs 15 min

$\frac{2.3 \times 10^8}{9.1 \times 10^5}$ = 252 hr 45 min = 10 days 12 hr 45 min

actual — 10 days - 12 hrs 45 min

APPENDIX B

SEISMIC QUALIFICATION TEST

SEISMIC QUALIFICATION TEST
OF
LIMIT CONTROL SWITCHES
June 1977

Prepared for

NAMCO Controls
An Acme-Cleveland Company
Jefferson, Ohio

10-21

Dr. Edward J. Walter & Associates
Vibration and Sound Consultants
P.O. BOX 321 • CHESTERLAND, OHIO 44026 • (216) 729-7415

Dr. Edward J. Walter & Associates
Vibration and Sound Consultants
P.O. BOX 171 • CHESTERLAND, OHIO 44026 • TELEPHONE: (216) 729-7415

1. PURPOSE

Four Limit Control Switches manufactured by NAMCO Controls were subjected to a seismic qualification test for Class 1E equipment to be used in nuclear-powered electrical generating plants. The four switches are a representative sample of EA180-11302 and EA740-80100 limit switches and the seismic test results will be considered as representative of the characteristics of each switch series. The tests involved single-axis sinusoidal vibration in each of three mutually perpendicular axes parallel to the major dimensions of the switch, in accordance with IEEE 382-1972, 323-1974, and 344-1975. The test program was conducted by Dr. Edward J. Walter and Associates at the John Carroll University Seismological Laboratory, Cleveland, Ohio. NAMCO representatives were present during various stages of the tests and monitored parts of the test program.

2. IDENTIFICATION OF SWITCHES

The following switches were subjected to the seismic test procedure. All switches were manufactured by NAMCO

Switch Sample Number	
Switch No. 32	Snap-Lock. Limit Switch EA180-11302 Ampere Rating

Volts	AC	DC
125	20	5
250	15	1.5
480	10	
600	5	

NAMCO Controls
An Acme-Cleveland Company
Cleveland, Ohio U.S.A.

Switch No. 33 — Same as Switch No. 32

Switch No. 45 — Same as Switch No. 32

Switch No. 38 — Snap-Lock. Limit Switch
EA740-80100
Ampere Rating

Volts	AC	DC
125	20	5
250	15	1.5
480	10	
600	5	

NAMCO Controls
An Acme-Cleveland Company
Cleveland, Ohio U.S.A.

~~Switch No. 58 — Same as Switch No. 38~~

3. TEST EQUIPMENT

The test equipment consisted of two different shake tables. The first shake table was a mechanical device for large amplitude - low frequency vibration. Maximum peak to peak displacement was twelve inches, giving a single amplitude of six inches. Displacements down to .025 inches single amplitude could be achieved. The mechanical shake table was used to test over the frequency range 1-20 Hz. The second device was an electro-dynamic shake table for small amplitude - high frequency vibration. Peak to Peak displacement up to 0.4 inches could be achieved. The electrodynamic shake table was used to test over the frequency range 20-35 Hz. Both shake tables were monitored for wave form by an accelerometer mounted on the table.

During the test procedure the switch was energized electrically with 125 volts DC at 1/2 amp. and monitored continuously for contact opening of 2 milliseconds or greater. The switch was tripped from the actuated position to the unactuated and back during the test procedure and monitored for contact opening.

4. SEISMIC TEST PROCEDURE

Each switch was individually mounted on the shake table with one of its major axes parallel to the direction of table motion. After completion of this test the switch was reoriented on the table with its second major axis parallel to the table motion, and similarly for the third major axis. Special fixtures for mounting the switches and activating them had to be fabricated.

Part I - Resonance Search

In each orientation each switch was subjected to a continuous sine sweep from 1 to 35 Hz at a rate of one octave per minute. This sine sweep was run as follows:

Frequency Hz	Displacement inches
1-10	1.0
10-35	0.01

Part II - Fragility Test

In each orientation, each switch was subjected to a sine dwell test in 1/3 octave bands over the frequency ranges 1-35 Hz. The switch was vibrated for a minimum of 60 seconds at each dwell point, beginning with 15 seconds of vibration in the unactuated position. The switch was then actuated by a manual tripping device and vibrated for 30 seconds in the actuated position. After this, the switch was released by the manual tripping device and vibrated for 15 seconds in the unactuated position. The switch was the double throw type.

During the vibration test, the switch contacts were monitored for opening by a light indicator circuit. If the light indicator circuit signaled a contact opening, the duration of opening was then monitored on an oscilliscope. The criteria for seismic failure was a contact opening of 2.0 milli-seconds or greater. Both the Normally Open (NO) contacts and the Normally Closed (NC) contacts were monitored during the tests.

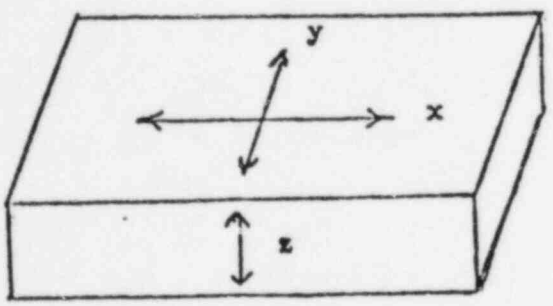
The trip angle of each switch was also monitored during the vibration test. This was done by monitoring the switch angle position on the oscilliscope. The variation in the trip angle position should not exceed 0.060 inches while being subjected to the vibration test.

The dwell test was run in 1/3 octave bands at the following frequencies and vibration specifications.

Dwell Points

Frequency Hz	Vibration Specifications
1.0	$1 \leqslant f \leqslant 4$
1.25	Displacement - 12.0 inches pp.
1.6	giving 9.52 g's
2.0	at 4 Hz
2.5	
3.15	
4.0	
	$4 < f < 10$ - acceleration 9.52 g
5.0	Displacement - 8.0 inches pp.
6.3	Displacement - 5.0 inches pp.
8.0	Displacement - 3.0 inches pp.
10.0	$10 \leqslant f < 20$
12.5	Displacement - 0.45 inches pp.
16.0	
20.0	
25.0	$20 < f < 35$ - acceleration 9.52 g
32.0	Displacement - 0.4 inches pp.

The table motion was constrained to specific displacements as specified or as required to produce the specified acceleration. Wave shape was monitored by an accelerometer mounted on the table. The planes of vibration relative to the switch configuration are shown in the following diagram and each switch was subjected to 54 distinct vibration tests.



5. TEST RESULTS

All switches performed with no malfunctions in the sine sweep from 1 Hz to 35 Hz. Also, no resonances were observed during the sine sweep test.

In the sine dwell test of 60 second duration during which the switch was actuated and released, no malfunctions were observed.

The test circuit did indicate a reaction to a small voltage change which when monitored on the oscilloscope was less than 2.0 milli-seconds and hence not within the definition of switch failure.* The various frequencies for each switch at which such an indication occurred is shown in the following table.

f Hz	Switch			
	33	32	45	38
1.0		x		x
1.25	x			x
1.6	x	x	x	x
2.0	x		x	x
2.5	x	x		x
3.15	x			x
4.0		x	x	
5.0				x
6.3	x	x		
8.0	x			x
10.0	x			
12.5	x			x
16.0	x		x	x
20.0	x			
25.0	x	x	x	x
32.0	x	x		

All the above switch contact openings were of duration less than 2.0 milli-seconds.

*See page 14 (B)

The trip position of each of the switches remained within the required limit and at no time deviated from the original position by more than 0.060 inches at the end of the two inch arm. In fact, the changes noted were small compared to the tolerance limit.

The test results are facility limited and therefore do not indicate the ultimate capability or the vibration level at which switch failure will occur. Each switch was subjected to 54 distinct vibration tests which lasted for 60 seconds or greater so that minimally each switch was vibrated for 54 minutes. Checks for frequency and wave shape and other manual operations extended the total vibration time by perhaps a factor of two or three.

6. CONCLUSIONS

The limit control switches performed satisfactorily without failure when vibration tested in accord with the specifications presented herein.

No contact opening of 2 milli-seconds or greater occurred during the tests.

No resonance frequencies were noted during the test.

7. CERTIFICATION

The undersigned certify that this report presents a true account of the tests conducted and the results obtained.

Edward J. Walter, Ph.D.

Edward J. Walter, Jr.

James DiSiena

EQUIPMENT USED

Calidyne Electrodynamic Shaker, Model B44

Mechanical Shake Table

Tektronix Storage Oscilloscope Type 564

Shure Brothers Accelerometer Model 62CP, calibrated August, 1977

Brush-Clevite Recorder Mark II

Dr. Edward J. Walter & Associates
Vibration and Sound Consultants
P.O. BOX 171 • CHESTERLAND, OHIO 44026 • TELEPHONE: (216) 729-7415

Vibration Tests of Limit Control Switches
NAMCO Controls
An Acme-Cleveland Company
September, 1977

Switch Tested
Switch No. 32 - EA 180-11302

Vibration Tests

The purpose of the test was to determine whether cross-coupling would cause the switch to trip, and thus fail. The roller and spring were removed and the switch was vibrated in the Y-component. No failures were observed during the test procedure. The displacement, maximum frequency, and g-loading at which the switch was vibrated are given in the following table:

Displacement inches pp	Frequency in Hz	Acceleration g's
12.1	4.5	13.6
10.1	5.0	12.6
7.9	5.5	12.0
6.3	6.5	13.4
5.0	6.7	11.6
4.0	7.2	10.6
3.1	10.5	17.5
2.5	12.5	19.8
2.0	14.0	19.8
1.6	16.0	20.3
0.5	21.0	11.0
0.4	22.0	9.6

Test results indicate that failure due to cross-coupling in the Y-component did not occur.

Edward J. Walter
DR. EDWARD J. WALTER AND ASSOCIATES

October 5, 1977

Dr. Edward J. Walter & Associates
Vibration and Sound Consultants
P.O. BOX 171 • CHESTERLAND, OHIO 44026 • TELEPHONE: (216) 729-7415

February 14, 1980

Acme Cleveland Development Company
625 Alpha Drive
Highland Heights, OH 44143

Re: Vibration Tests
Switch No. 32,EA-180-11302

Attn.: Mr. Ed Solem

Dear Mr. Solem:

This is in reference to your letter of January 15, 1980 concerning our report of the vibration test for Switch No. 32, EA-180-11302, to determine whether cross-coupling would cause the switch to trip and thus fail.

The test procedure is the same as that described in our report of June, 1977, where Switch No. 32,EA-180-11302 was subjected to the seismic qualification test. In the test of Switch No. 32 for cross-coupling, the switch was tested in the Y-component as specified by the Acme Cleveland Development Company. No failure was observed during the test procedure.

Sincerely,

Edward J. Walter

Edward J. Walter, Ph.D.

EJW:apm

Behavior Of The Test Circuit

The test circuit was designed to detect switch openings of more than a pre-set time. For the purpose of these tests the time was set at 2 milliseconds. During the seismic tests it was reported that the circuit was triggering. Therefore, personnel from Acme-Cleveland Development Company observed the situation.

It was found by use of an oscilliscope that the circuit was responding not to contact openings but to small changes in voltage due to increases in contac- resistance as the contacts moved over one another. Although the decrease in voltage may have lasted for considerable times, no contact openings of more than 2 milliseconds were observed in that instance. At that point it was decided that whenever the circuit was triggered the oscilliscope would be used (by Dr. Edward J. Walter & Associates' personnel) to determine if there was a contact opening of more than 2 milliseconds or not.

Edward Solem 7/13/77

E. Solem Date
Metallurgical Engineer

APPENDIX C

CROSS COUPLING ANALYSIS

APPENDIX C

ANALYSIS OF CROSS COUPLING

Abstract

The following analysis was undertaken in order to establish that significant cross coupling does not exist in the switch mechanism under test. The inherent constraints on the motion of moving parts were used as a basis for the analysis. In one case it was necessary to establish the non-existence of significant cross coupling experimentally.

APPENDIX C

SEISMIC TESTING/CROSS COUPLING

All of the parts and assemblies of which the switch is comprised may be classified into three categories depending upon the geometric constraints upon their movement within the unit. The first category is components free to revolve about an axis but which have balanced angular masses about the axis. The second category is components which are free to rotate about an axis within a range the limits of which are 9° to either side of a principal axis of the switch. The third category is parts which are constrained to linear movement in a line which is within 9° of a principal axis of the switch.

The contact lever arm assembly (83) is in the first category. As the angular moment of inertia of this component is balanced about the central axis, vibration will not result in any torque about the axis. Therefore, it is not necessary to consider this component in the analysis of cross coupling.

Components belonging to the second category are the lever shaft assembly (94), the latches (19), and the rocker arm (65).

The parts belonging to the third class are the contact carrier plate assemblies which are located at the ends of the contact lever assembly (83) and the roller assembly (75, 80, and 81).

The linear motions of Category 3 components, except (75, 80, and 81) and the tangential motions of the Category 2 components, are all within 9° of the Y axis. Therefore, a vibration with a deviation of 9° from the Y axis would cause a higher g loading along the direction of motion of these components than motion directly along the Y axis.

Therefore, the g levels used in single axis testing should be multiplied by a factor of .98 (i.e., cosine of 9°) in order to compensate for possible effects due to multi-axis vibration.

Movement of components (75, 80, and 81) is within 9° of the X axis. Therefore, it could cross couple with the Y axis movements of the other Category 2 and Category 3 components. The X axis movements of (75, 80, and 81) cannot cause any Y axis movements directly. They can, however, allow Y axis movements of (65) and (94). It is shown below that movements of (94) cannot occur at 10 g's due to the preloaded force of Spring (107):

A	B	C	D	E	F	G
Preload[1] Force (107)	Weight of Non-Cylindrical Parts of (94)	Weight of (81)	Total Off Axis Weight (B + C)	Mechanical Advantage	Effective[2] Weight (D x E)	Minimum g Loading for Movement (A/F)
3,220 gm	53.9 gm	12.9 gm	66.8 gm	2	133.6 gm	24.1 g's

In order to determine that movement of (65) due to cross coupling was not a factor in these tests a separate test was run with components (75, 80, and 81) completely removed.[3] This conservatively simulates any cross coupling between components (75, 80, and 81) and (65).

Due to the above considerations, cross coupling is not considered limiting in this unit; and therefore, single axis vibration testing is considered suitable.

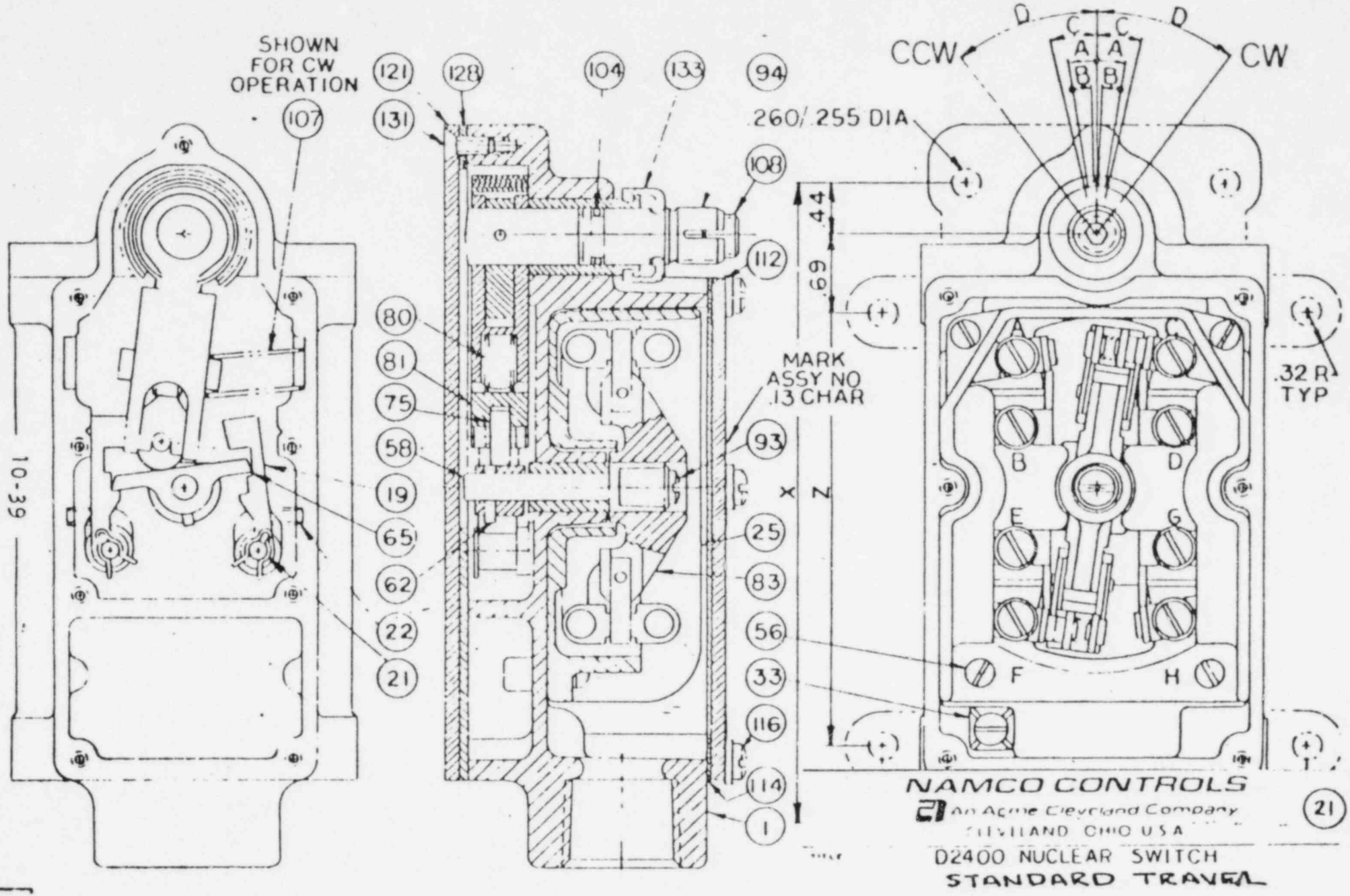
ELS:cr

---

[1] Blueprint specified minimum.

[2] All mass is conservatively assumed to be concentrated at the end of the lever shaft assembly.

[3] See Page 12(B).


SHOWN FOR CW OPERATION
107
121
131
128
104
133
94
260/.255 DIA
108
112
80
81
75
58
19
65
62
22
21
93
25
83
56
33
116
114
1
MARK ASSY NO .13 CHAR
.44
.69
X
Z
CCW
CW
D
C
A
B
.32 R TYP
E
G
F
H
10-39
NAMCO CONTROLS
An Acme Cleveland Company
CLEVELAND OHIO USA
D2400 NUCLEAR SWITCH
STANDARD TRAVEL
21

APPENDIX D

DATA SHEETS

INITIAL INSPECTION

SWITCH MODEL: EZ-10683-90 (EA-180-11302)

SWITCH NUMBER: 138-90

SHIPPING DAMAGE: None

TYPE OF WIRE: CSA-CL-1251 Crosslink (Belden)

TYPE OF LUGS: Sta-Kon B14-8 (78-6210-80320)
No 18-14 AWG

GASKET INSTALLATION TORQUE: FRONT: 20 in·lbs.
REAR: Installed at Manufacturing

SIGNED: J P.

DATE: 10/3/79

HEAT AGING

SWITCH NO.: 138-90
MODEL NO.: EZ-10683-90/EA-180-11302
TESTED FROM/TO: 10/4/79 - 10/22/79

DATE	TIME	TEMPERATURE °C	TEMPERATURE °F
10/4/79	8:00 a.m.	120	248
10/22/79	8:30 a.m.	120	248
Removed Switch			

ELECTRICAL MEASUREMENTS

LOAD: .086 amps at 100 volts DC

	INITIAL (10/3/79)	FINAL (10/22/79)	OTHER ( )
MEGGAR			
1	1000 M*	Inf.	
2	1000 M*	Inf.	
3	1000 M*	Inf.	
4	1000 M*	Inf.	
CONDUCTIVITY (AMPS)			
1	.086	.086	
2	.086	.086	
3	.086	.086	
4	.086	.086	
CONTACT RESISTANCE (IN OHMS)--BEFORE TEST			
1	.05		
2	.05		
3	.06		
4	.05		

COMMENTS

Pre-travel torque 19 lb·in. to trip switch.

SIGNED: [signature]

*Meter measured between 1000 M and infinity.

DATE: 10/22/79

WEAR CYCLING

SWITCH NO.: 138-90
MODEL NO.: EZ-10683-90/EA-180-11302

NO. OF CYCLES: 100,200

CYCLE RATE: 70 RPM

METHOD: CAM

ELECTRICAL LOAD: 0.5 amps at 100 volts DC

ELECTRICAL MEASUREMENTS

LOAD: .086 amps at 100 volts DC

	INITIAL ( )	FINAL ( )	OTHER ( )
MEGGAR			
1	Inf.	Inf.	
2	Inf.	Inf.	
3	Inf.	Inf.	
4	Inf.	Inf.	
CONDUCTIVITY (AMPS)			
1	.086	.086	
2	.086	.086	
3	.086	.086	
4	.086	.086	
CONTACT RESISTANCE (IN OHMS)			
1			
2			
3			
4			

COMMENTS

Pre-Travel Torque: 19 lb·in.
Pre-Travel: 11° } Before and
Total Travel: 13° } after test

SIGNED: [signature]

DATE: 10/24/79

IRRADIATION

SWITCH NO.: 138-90
MODEL NO.: EZ-10683-90/EA-180-11302

IRRADIATED

AT:	Georgia Tech University
FROM/TO:	10/29/79 - 11/20/79
TOTAL IRRADIATION:	204 megarads
ENERGY LEVEL:	1.173 Mev. and 1.332 Mev
SOURCE:	Cobalt 60 gamma
RATE:	9.1×10^5 rads/hour

ELECTRICAL MEASUREMENTS

LOAD: .086 amps at 100 volts DC

	INITIAL (10/29/79)	FINAL (12/5/79)	OTHER ( )
MEGGAR			
1	Inf.	Inf.	
2	Inf.	Inf.	
3	Inf.	Inf.	
4	Inf.	Inf.	
CONDUCTIVITY (AMPS)			
1	.086	.086	
2	.086	.086	
3	.086	.086	
4	.086	.086	

COMMENTS

SIGNED: J.P.

DATE: 12/5/79

SEISMIC TEST

SWITCH NO.: 138-90
MODEL NO.: EZ-10683-90/EA-180-11302

TESTED BY: ACDC

REPORT REF.: Conditioning Test: 1-10 Hz
25-32 Hz

Measured trip angle and electrical performance from 10-20 Hz.

COMMENTS:

ELECTRICAL MEASUREMENTS

LOAD: .0.5 amps at 125 volts DC

	(12/12/79)	(1/4/80)
MEGGAR		
1	Inf.	Inf.
2	Inf.	Inf.
3	Inf.	Inf.
4	Inf.	Inf.
CONDUCTIVITY (AMPS)		
1	.086	.086
2	.086	.086
3	.086	.086
4	.086	.086

SIGNED: J.D.

DATE: 1/4/80

SEISMIC TEST

SWITCH NO.: 138-90
AXIS: X
ACCELEROMETER CALIBRATION (mV/g): 28.87 mV/g

CODES

V = No contact opening in excess of performance limit.
- = Opening detection circuit activated.
x = Contact opening in excess of performance limits.

Frequency (Hz)	Period (Sec.$^{-1}$)	Accelerometer Output (mV-pp)	Displacement (Inches)	Max. g (g's)	Normally Open			Normally Closed			Pre-Travel Angle	Reset Angle
					Mech.	Seismic	Osc.	Mech.	Seismic	Osc.		
1.0	1	34.0 *	6	.612								
1.25	0.8	54.5 *	6	.956								
1.6	.625	95.0 *	6	1.567								
2.0	.50	154.8*	6	2.448								
2.5	.40	243.0*	6	3.825								
3.15	.317	401.5*	6	6.07								
4.0	.25	585.0	5.83	9.52								
5.0	.2	553.5	3.73	9.52								
6.3	.159	550.0	2.35	9.52								
8.0	.125	570.5	1.46	9.52								
10.0	.100	569.5	.933	9.52	-	V	V	-	V	V	10.2	1.5
12.5	.08	598.0	.597	9.52	-	V	V	-	V	V	10.2	1.9
16.0	.0625	615.0	.365	9.52	-	-	V**	-	V	V	9.5	1.6
20.0	.050	575.0	.233	9.52	-	V	V	-	V	V	9.6	1.6
25.0	.040	703.0	.149	9.52								
32.0	.0312	657.0	.091	9.52								

COMMENTS: Plant Induced Vibration Test - The switch was vibrated 333,333 cycles at a frequency of 100 Hz and .75 g's.

* Below 4 Hz displacement and frequency measurements have been found to be more accurate than the accelerometer.

** .5 ms contact bounce.

Signed: JR

Date: 1/3/80 and 1/4/80

SEISMIC TEST

CODES

V = No contact opening in excess of performance limit.
- = Opening detection circuit activated.
x = Contact opening in excess of performance limits.

SWITCH NO.: 138-90
AXIS: Y
ACCELEROMETER CALIBRATION (mV/g): 28.87 mV/g

Frequency (Hz)	Period (Sec.$^{-1}$)	Accelerometer Output (mV)	Displacement (Inches)	Max. g (g's)	Normally Open			Normally Closed			Pre-Travel Angle	Reset Angle
					Mech.	Seismic	Osc.	Mech.	Seismic	Osc.		
1.0	1		6	.612								
1.25	0.8	37.7 *	6	.956								
1.6	.625	101.04	6	1.567								
2.0	.50	160.2*	6	2.448								
2.5	.40	252.0*	6	3.825								
3.15	.317	406.0*	6	6.07								
4.0	.25	606.0	5.83	9.52								
5.0	.2	554.5	3.73	9.52								
6.3	.159	554.5	2.35	9.52								
8.0	.125	565.5	1.46	9.52								
10.0	.100	562.0	.933	9.52	-	V	V	-	V	V	9.8	1.7
12.5	.08	596.0	.597	9.52	-	V	V	-	V	V	10.1	1.9
16.0	.0625	569.5	.365	9.52	-	V	V	-	V	V	10.1	1.9
20.0	.050	584.5	.233	9.52	-	V	V	-	V	V	10.2	1.8
25.0	.040	601.0	.149	9.52								
32.0	.0312	632.5	.091	9.52								

COMMENTS:

Plant Induced Vibration Test - The switch was vibrated 333,333 cycles at a frequency of 100 Hz and .75 g's.

* Below 4 Hz displacement and frequency measurements have been found to be more accurate than the accelerometer.

Signed: [signature]

Date: 1/2/80 and 1/3/80

SEISMIC TEST

SWITCH NO.: 138-90
AXIS: Z
ACCELEROMETER CALIBRATION (mV/g): 28.87 mV/g

CODES

V = No contact opening in excess of performance limit.
- = Opening detection circuit activated.
x = Contact opening in excess of performance limits.

Frequency (Hz)	Period (Sec.$^{-1}$)	Accelerometer Output (mV-pp)	Displacement (Inches)	Max. g (g's)	Normally Open			Normally Closed			Pre-Travel Angle	Reset Angle
					Mech.	Seismic	Osc.	Mech.	Seismic	Osc.		
1.0	1	33.2 *	6	.612								
1.25	0.8	56.7 *	6	.956								
1.6	.625	100.3*	6	1.567								
2.0	.50	157.0*	6	2.448								
2.5	.40	253.0*	6	3.825								
3.15	.317	402.0*	6	6.07								
4.0	.25	570.0	5.83	9.52								
5.0	.2	563.0	3.73	9.52								
6.3	.159	558.5	2.35	9.52								
8.0	.125	590.5	1.46	9.52								
10.0	.100	555.5	.933	9.52	-	-	V**	-	V	V	10.2	1.7
12.5	.08	566.5	.597	9.52	-	V	V	-	V	V	10.1	1.7
16.0	.0625	613.0	.365	9.52	-	V	V	-	V	V	9.9	1.8
20.0	.050	672.0	.233	9.52	-	V	V	-	V	V	10.0	1.6
25.0	.040	745.5	.149	9.52								
32.0	.0312	725.0	.091	9.52								

COMMENTS:

Plant Induced Vibration Test - The switch was vibrated 333,333 cycles at a frequency of 100 Hz and .75 g's.

* Below 4 Hz displacement and frequency measurements have been found to be more accurate than the accelerometer.

** .5 ms contact bounce.

Signed: J. [illegible]

Date: 12/21/79 and 1/2/79

DBE TEST
(Summary of Transients)

SWITCH NO.: 138-90
MODEL NO.: EZ-10683-90/EA-180-11302

PROFILE REF.: IEEE Standard 382

CAUSTIC SPRAY: NaOH, Boric Acid, Sodium Thiosulphate

PROFILE (ACTUAL)

NO.	FROM TEMP. (°F)	ELAPSED TIME	TO TEMP. (°F)	PRESSURE (PSIG)	CAUSTIC FLOW (CC'S/MIN.)	COMMENTS
1	120	12 sec.	300	75	--	Torque to trip switch was 21 lb·in.
2	120	16.7 sec.	328	95	--	
3	120	30 sec.	340	68	--	
4	340	3 hrs.	340	80-105	200-250	
5	340	1 hr., 15 min.	120	--	200-250	
6	120	11.7 sec.	300	32	--	
7	120	23.4 sec.	328	34	--	
8	120	25 sec.	340	22	--	
9	340	2 hr., 45 min.	340	85-110	200-250	

*Originally 0 PSIG.

SIGNED: J.B.

DATE: 2/7/80

DBE TEST

SWITCH NO.: 138-90
MODEL NO.: EZ-10683-90/EA-180-11302
ELECTRICAL LOAD: .086 amps at 100 volts DC

The closed contact resistance after the test was:

Contact	Resistance (in Ohms)
1	3.4
2	8.1
3	.09
4	1.1

ELECTRICAL MEASUREMENTS

*See Page 15 of 19 (D).

DATE	TIME	ELAPSED TIME	MEGGAR 1	MEGGAR 2	MEGGAR 3	MEGGAR 4	CONDUCTIVITY (AMPS) 1	CONDUCTIVITY (AMPS) 2	CONDUCTIVITY (AMPS) 3	CONDUCTIVITY (AMPS) 4	COMMENTS
1/5/80	2:15 p.m.		Inf.	Inf.	Inf.	Inf.	.086	.086	.086	.086	Installed in chamber.
1/7/80	7:50 a.m.		Inf.	Inf.	Inf.	Inf.	.086	.086	.086	.086	Before test.
1/7/80	8:30 a.m.		Inf.	Inf.	Inf.	Inf.	.086	.086	.086	.086	At 120°F.
1/7/80	9:40 a.m.		5M	5M	5M	5M	.086	.086	.086	.086	At 340°F 90-105 PSI
1/7/80	12:15 p.m.		7M	7M	7M	7M	.086	.086	.086	.086	At 340°F 90-105 PSI
1/7/80	4:30 p.m.		12M	12M	12M	12M	.086	.086	.086	.086	At 320°F
1/8/80	7:40 a.m.		Inf.	Inf.	Inf.	Inf.	.086	.086	.086	.086	At 86°F. Hard to move lever arm--was sticking. *
1/8/80	10:45 a.m.		18M	18M	18M	18M	.086	.086	.086	.086	At 320°F
1/8/80	12:10 p.m.		18M	18M	18M	18M	.086	.086	.086	.086	At 320°F.
1/8/80	1:30 p.m.			150M		300M	.086	.086			250°F at 25 PSI
1/12/80	8:00 a.m.		800M	400M	300M	400M	.086	.086	.086	.086	Before dropping temp. 250°F to 200°F;
											Initially hard to actuate switch.
1/12/80	12:45 p.m.										Install switch in low pressure chamber.
1/22/80	1:00 p.m.		Above 1000M	Above 1000M	Above 1000M	Above 1000M	.086	.086	.086	.086	200°F actuated switch.
2/7/80			Inf.	Inf.	Inf.	Inf.	.086	.086	.086	.086	After taking switch out of low temp. and pressure chamber.

SIGNED: JF DATE: 1/7/80

CAUSTIC SPRAY COMPOSITION
(BY BATCH)

Distilled Water	18 liters
H_3BO_3	311.8 grams
*NaOH	150.0 grams
$Na_2S_2O_3$	285.8 grams

*Plus any additional required to increase pH to between 10 and 11.

SIGNED: Dawn M Price

DATE: 2/19/80

DBE TEST

SWITCH NO.: 138-90
MODEL NO.: EZ-10683-90/EA-180-11302

FINAL EXAMINATION

GASKETS: Top gasket intact - sealed well. The silicone is hard to the touch.

The bottom gasket had small cracks at the center screws and near one back screw hole. A large crack was at the back bottom compartment.

CONTACTS: Contact block very clean.
Slight corrosion on contacts.

BLOCK: Contact block very clean.

O-RING: The O-ring was resilient, and there was lubricant around the O-ring and shaft.

GREASE: The grease was present on all surfaces on which it was applied.

OTHER: When bubble testing the switch after LOCA, there was a slight leak at the top plate center screws and a slight leak at the back two bottom screws and at the gasket near the screws.

SIGNED: [signature]

DATE: 2/7/80

DBE TEST

PAGE NO.: 1 of 7

SWITCH NO.: 138-90 MODEL NO.: EZ-10683-90/EA-180-11302 TESTED FROM/TO: 1/7/80 - 2/7/80

DATE	TIME	ELAPSED TIME	TEMPERATURE (°F)	PRESSURE (PSI)	CAUSTIC FLOW (CC'S/MIN.)	WATER LEVEL (IN.)	pH	COMMENTS
1/7/80	8:05 a.m.		71				10.5	Preheat Lindberg superheater to 800°F and set steam generator to 175 PSI.
								Let tank heat up.
1/7/80	8:32 a.m.		250				10.5	Apply superheat for preheat temperature.
1/7/80	9:00 a.m.		250					Drop temperature control to off. Add 60 PSI air for cool down.
1/7/80	9:15 a.m.		120	90				Set controller to #1.
1/7/80	9:15 a.m.	12 sec.	300	75				
1/7/80	9:15 a.m.	16.7 sec.	328	95				
1/7/80	9:15 a.m.	30 sec.	340	68				
1/7/80	9:15 a.m.	36.7 sec.	366	40				
1/7/80	9:15 a.m.	50.6 sec.	340	93				Tank temperature 340°F.
1/7/80	9:20 a.m.		340	80-100	200-250			Turn on Control #2. (Start spray at 9:20 a.m.)
1/7/80	9:30 a.m.		340	80-100	200-250			Turn Lindberg to 1200°F.
1/7/80	9:40 a.m.		340	90-110	200-250			Turn Lindberg to 1300°F.
1/7/80	9:48 a.m.		340	95-105	200-250			Turn down valve on chamber outlet.
1/7/80	10:00 a.m.		339-342	95-105	200-250			Turn down steam generator to 160 PSI.
1/7/80	10:05 a.m.		340-343	93-105	210			
1/7/80	10:10 a.m.		340-342	93-103	210			Drop pressure on steam generator to 140 PSI.

SIGNED: JP

DATE: 1/7/80

DBE TEST

PAGE NO.: 2 of 7

SWITCH NO.: 138-90 MODEL NO.: EZ-10683-90/EA-180-11302 TESTED FROM/TO: 1/7/80 - 2/7/80

DATE	TIME	ELAPSED TIME	TEMPERATURE (°F)	PRESSURE (PSI)	CAUSTIC FLOW (CC'S/MIN.)	WATER LEVEL (IN.)	pH	COMMENTS
1/7/80	10:20 a.m.		340-343	93-103	210			
1/7/80	10:45 a.m.		340-343	93-103	210			Increase steam generator to 160 PSI.
1/7/80	11:00 a.m.		340-343	93-103	210-230			Tank lost all caustic solution. Turn temperature off.
1/7/80	12:19 p.m.		340-343	93-105	210-240		10.5	
1/7/80	12:21 p.m.		340-343	93-105	210-240			Turn control to off. Drop temperature to 120°F.
1/7/80	12:30 p.m.		192	25 (air pressure)				
1/7/80	1:35 p.m.		120					Put 63 quarts of solution in tank.
1/7/80	1:36 p.m.	11.7 sec.	300	32				Start second spike.
1/7/80	1:36 p.m.	23.4 sec.	328	34				
1/7/80	1:36 p.m.	25 sec.	340	22				
1/7/80	1:36 p.m.	34 sec.	373	10				
1/7/80	1:38 p.m.	18.2 sec.	328	80				
1/7/80	1:38 p.m.	33.8 sec.	340	73				
1/7/80	1:42 p.m.		340	85-115	210-240			Control #2 and spray on.
1/7/80	1:48 p.m.		340	80-106				Tank temperature 310°F (set).
1/7/80	2:10 p.m.		340-347	87-110	210			
1/7/80	2:50 p.m.		340-345	90-112	230-250			Tank temperature 315°F.

SIGNED: JB

DATE: 1/7/80

DBL TEST

PAGE NO.: 3 of 7

SWITCH NO.: 138-90 MODEL NO.: EZ-10683-90/EA-180-11302 TESTED FROM/TO: 1/7/80 - 2/7/80

DATE	TIME	ELAPSED TIME	TEMPERATURE (°F)	PRESSURE (PSI)	CAUSTIC FLOW (CC'S/MIN.)	WATER LEVEL (IN.)	pH	COMMENTS
1/7/80	3:55 p.m.		340-343	90-110	210-230			Drop tank temperature to 250°F. Water in tank dropped below three-fourths.
1/7/80	4:20 p.m.		340-343	90-110	210-230		10.2	
1/7/80	4:50 p.m.		320	67-87	210			Temperature reached 320°F.
1/7/80	5:17 p.m.		320-324	67-85	210-230			Half inch of water in tank sight glass.
1/7/80	5:36 p.m.		320-324	67-85	210-230			Heater light on in tank.
1/7/80	5:50 p.m.		320-324	67-85	210-230			Shut down system after one hour at 320°F.
1/7/80	*							
1/8/80	7:40 a.m.		86				10.5	Lost caustic solution in tank. Added caustic and started to preheat tank at 9:00 a.m.
1/8/80	10:00 a.m.		86					Started test. Increased temperature to 320°F. Control #1 on.
1/8/80	10:10 a.m.		320-325	40-60				
1/8/80	10:15 a.m.		320-325	40-60	220			Start caustic. Control #2 on.
1/8/80	10:20 a.m.		320-325	32-52	230			
1/8/80	10:50 a.m.		320-326	50-80	220			
1/8/80	11:10 a.m.		320-326	50-80	220			
1/8/80	11:30 a.m.		318-325	62-82	220			
1/8/80	12:10 p.m.		320-326	65-85	210			

* The test was stopped overnight because of the loss of caustic solution. At 7:40 a.m. on 1/8/80 the switch was actuated and the electricals were taken. The chamber was then heated up to 320°F. It took more than the average force to actuate the switch. When the switch lever arm was moved to the actuated position and then released, the lever arm did not return until pushed further in the direction of the actuation and then released. Repeating the actuation, this time the lever arm returned, moving the contacts to the normally closed position. This was the only time that the switch failed to actuate throughout the test.

SIGNED: J.B.

DATE: 1/7-8/80

Page 15 of 19 (D)

10-55

DBE TEST

PAGE NO.: 4 of 7

SWITCH NO.: 138-90 MODEL NO.: EZ-10683-90/EA-180-11302 TESTED FROM/TO: 1/7/80 - 2/7/80

DATE	TIME	ELAPSED TIME	TEMPERATURE (°F)	PRESSURE (PSI)	CAUSTIC FLOW (CC'S/MIN.)	WATER LEVEL (IN.)	pH	COMMENTS
1/8/80	12:15 p.m.		320-326	65-85	210			Decrease temperature to 250°F and pressure to 25 PSI. Add air.
1/8/80	12:30 p.m.		240-250	25	220	3"		Temperature is varying.
1/8/80	1:00 p.m.		240-250	25	220	2"		Continue four-day test (at Control #5).
1/8/80	2:00 p.m.		240-250	25	220			Temperature varies because of the addition of air to maintain 25 PSI in chamber.
1/8/80	3:00 p.m.		245-250	25	220	2"		
1/8/80	3:55 p.m.		245-250	25	220	2"		
1/8/80	7:00 p.m.		245-250	25	230	2"		
1/8/80	11:45 p.m.		245-250	25	230	2"		
1/9/80	7:40 a.m.		243-247	25	235	2"		
1/9/80	1:00 p.m.		251-253	25	235	2"		
1/9/80	3:45 p.m.		251-252	25	235	2"		
1/9/80	5:45 p.m.		251-252	25	235	2"		
1/9/80	8:30 p.m.		252-253	25	240	1.5"		
1/10/80	0:05 a.m.		252-253	25	240	1.5"		
1/10/80	7:40 a.m.		250-251	25	250	1.5"		
1/10/80	12:20 p.m.		250-251	25	250	1.5"		

SIGNED: [signature]

DATE: 1/8-10/80

DBE TEST

PAGE NO.: 5 of 7

SWITCH NO.: 138-90 MODEL NO.: EZ-10683-90/EA-180-11302 TESTED FROM/TO: 1/7/80 - 2/7/80

DATE	TIME	ELAPSED TIME	TEMPERATURE (^{o}F)	PRESSURE (PSI)	CAUSTIC FLOW (CC'S/MIN.)	WATER LEVEL (IN.)	pH	COMMENTS
1/10/80	5:55 p.m.		250-251	25	250	3"		
1/10/80	9:00 p.m.		249-251	25	250	2"		
1/11/80	0:10 a.m.		252-254	25	250	3.5"		
1/11/80	8:20 a.m.		250-252	25	250	3.5"		
1/11/80	12:15 p.m.		250-252	25	250	3.5"		
1/11/80	5:15 p.m.		250-252	25	250	2"		
1/11/80	7:45 p.m.		251-253	25	250	2"		
1/12/80	7:45 a.m.		250-252	25	250	2"		
1/12/80	8:00 a.m.		250-252	25	250	3"		Drop temperature to 200^{o}F.
1/12/80	8:30 a.m.		200	10	250	3"		Reached temperature and pressure.
1/12/80	9:00 a.m.		201-204	10	250	3"		
1/12/80	9:50 a.m.		198-200	10	250	3"		
1/12/80	10:10 a.m.		198-200	10	250	3"	10.8	Turn down unit.
1/12/80	12:45 p.m.		158					Installed switch in low temperature and pressure chamber. Apply 480 cc/minute distilled water spray.
1/12/80	1:00 p.m.		200	10	96			Reached temperature and pressure.
1/12/80	2:00 p.m.		200		96			Dropped pressure to repair chamber.

SIGNED: JP

DATE: 1/10-12/80

DBE TEST

PAGE NO.: 6 of 7

SWITCH NO.: 138-90 MODEL NO.: EZ-10683-90/EA-180-11302 TESTED FROM/TO: 1/7/80 - 2/7/80

DATE	TIME	ELAPSED TIME	TEMPERATURE (°F)	PRESSURE (PSI)	CAUSTIC FLOW (CC'S/MIN.)	WATER LEVEL (IN.)	pH	COMMENTS
1/12/80	3:00 p.m.		200	8	96			
1/12/80	3:30 p.m.		200	10	96			
1/14/80	7:40 a.m.		200	10	96			
1/15/80	7:40 a.m.		200	10	96			
1/15/80	7:40 a.m.		200	10	96			
1/16/80	7:45 a.m.		200	10	96			
1/17/80	7:40 a.m.		200	10	96			
1/18/80	7:45 a.m.		200	10	96			
1/19/80	7:40 a.m.		200	10	96			
1/21/80	7:40 a.m.		200	10	96			
1/22/80	7:35 a.m.		200	10	96			Actuated the switch according to specifications at 1:00 p.m.
1/23/80	7:35 a.m.		200	10	96			
1/24/80	7:35 a.m.		200	10	96			
1/25/80	7:35 a.m.		200	10	96			
1/26/80	7:40 a.m.		200	10	96			
1/28/80	7:40 a.m.		200	10	96			
1/29/80	7:33 a.m.		200	10	96			

SIGNED: J.B.

DATE: 1/12-29/80

10-58

Page 18 of 19 (8)

DBE TEST

PAGE NO.: 7 of 7

SWITCH NO.: 138-90

MODEL NO.: EZ-10683-90/EA-180-11302

TESTED FROM/TO: 1/7/80 - 2/7/80

DATE	TIME	ELAPSED TIME	TEMPERATURE (°F)	PRESSURE (PSI)	CAUSTIC FLOW (CC'S/MIN.)	WATER LEVEL (IN.)	pH	COMMENTS
1/30/80	7:35 a.m.		200	10	96			
1/31/80	7:40 a.m.		200	10	96			
2/1/80	7:45 a.m.		200	10	96			
2/4/80	7:50 a.m.		200	10	96			
2/5/80	7:45 a.m.		200	10	96			
2/6/80	7:40 a.m.		200	10	96			
2/7/80	7:40 a.m.		200	10	96			Removed the switch from the chamber at 9:15 a.m.

SIGNED: JB

DATE: 1/30/80 - 2/7/80

APPENDIX E

EQUIPMENT CALIBRATION

Equipment	Calibrated
Tektronix Model 564 Oscilloscope (Time Base)	9/6/77
Shure Model 62 CP Accelerometer	7/77
Seismic Test Circuit (Time Base)	11/1/78
Biddle "Meggar" Model 8679ARK	9/17/79
Weston Model 911/DC Voltmeter (Serial #S-71774-67)	9/17/79
Weston Model 81/DC Milliammeter (Serial #S-96236)	9/17/79
Brooks Flow Meter Model 110-05F1B1A (Serial #7608H66892)	12/5/79
Brooks Flow Meter Model 1110-05F1A1A (Serial #7708H37890)	12/5/79
Thermocouple and YEW Type 2809 Digital Readout (Serial #9028)	9/15/79
Sears Pressure Gauge	12/12/79
Video Logic Video Tape System (Time Base)	11/19/77
Thermometer (Thermal Aging)	9/15/79
Thermometer (DBE)	9/17/79
Data Precision Multimeter Model 5740 (Serial #9421)	6/8/79
Ametek Pressure Gauge Model 58G0300BM2GEG (Ser. #91585)	9/27/79
Fluke Current Shunt Model A-90 (Serial #246)	9/16/79
Nicolet Explorer III Oscilloscope: Mainframe Model 2090-3B (Serial #801756)	12/7/79
Plug-In Model 206-2 (Serial #1171)	12/7/79
*Bourns Cermet Potentiometer Model 3852-A-282-502-A (Rotational Movement)	1/15/80

*Not traceable to NBS.

ELS
2/15/80

10.2 SHORT TRAVEL SUPPLEMENT

10.0 TEST REPORTS (CONT'D).

10.2 Supplementary Testing for Short Travel Switches.

An excerpt from EA180 Qualification Test Report, Revision 1, dated September 5, 1978.

A copy of this report is included in this section.

Those switches of the EA-180 series which contain a short travel mechanism differ internally from the standard travel versions in some respects. It was, therefore, felt that it was necessary to test a short travel model up through the seismic portion of the test in order to verify that the internal mechanism of this switch was not subject to seismic failure.

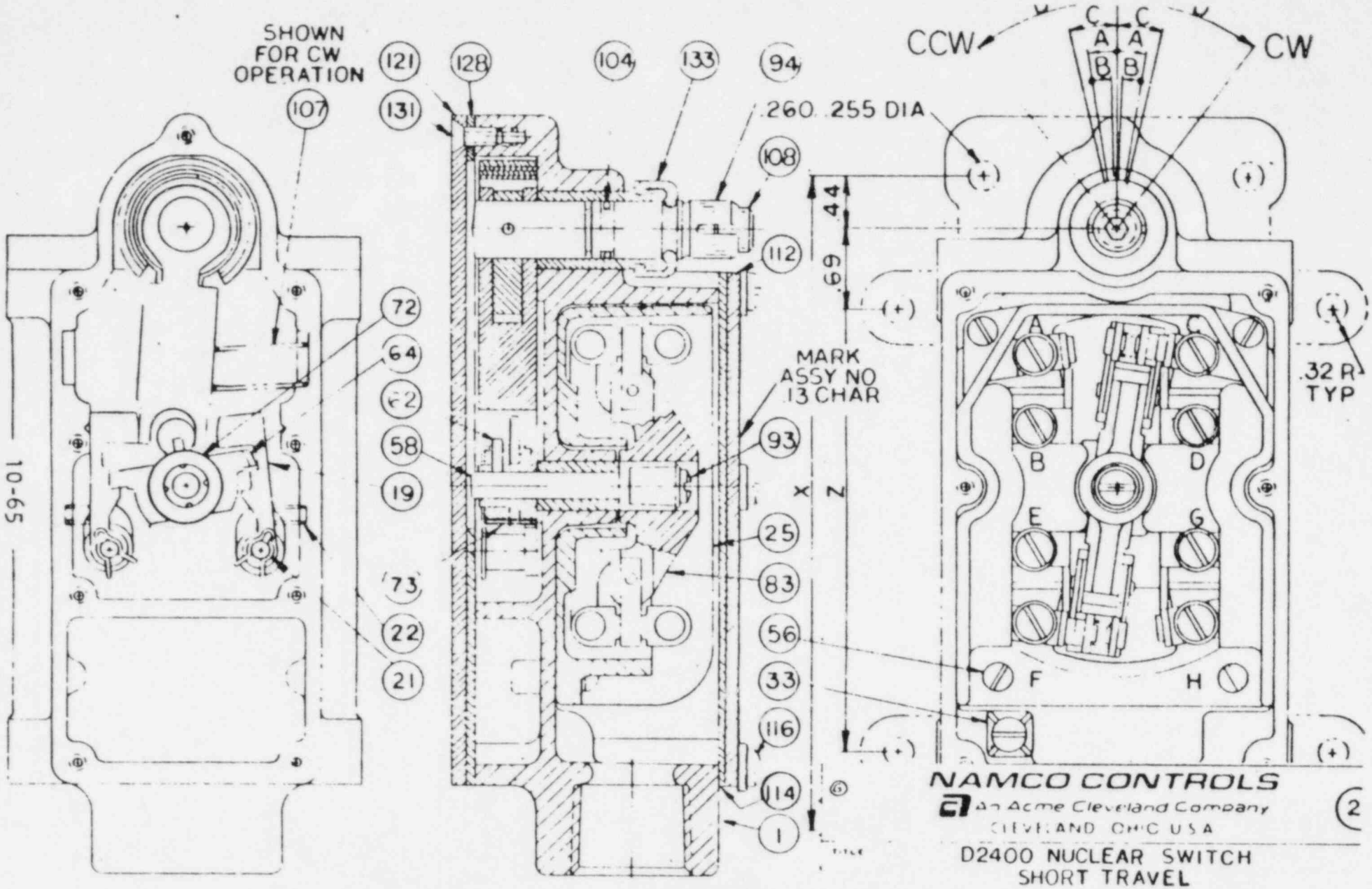
The tests conducted were the same as those conducted on the switch #61 in the body of the report except that the LOCA tests were not performed.

The short travel switch which was tested (#83, Model EA-180-14302, Rev. C) maintained optimal electrical performance throughout all portions of this test. During the seismic testing the trip position of this switch was observed to change - as noted in the seismic report. The maximum change was .107" and the direction of change was such that the switch would actuate earlier in the tripping cycle than it had prior to the seismic testing.

Cross coupling tests were not necessary for this switch as they were for the long travel mechanism. This was because the parts #75, 80 and 81 of the normal long travel mechanism (see page 5 of the main body of the report) are not present in this switch, and part 62 which replaces these parts is not subject to movement in the X axis.

It was not considered necessary to LOCA test this switch because short travel versions of the switch covered in the main body of this report will be built with identical sealing mechanisms (i.e. gaskets and O-rings) to switch #61.

E L L


SHOWN FOR CW OPERATION
107
121
131
128
104
133
94
260 .255 DIA
108
112
.44
.69
MARK ASSY NO 13 CHAR
93
X
Z
72
64
62
58
19
25
83
73
22
21
56
33
116
114
1
10-65
CCW
CW
A
B
C
.32 R TYP
NAMCO CONTROLS
An Acme Cleveland Company
CLEVELAND OHIO U.S.A.
D2400 NUCLEAR SWITCH
SHORT TRAVEL
2

March 1, 1978

TEST FOR SHORT TRAVEL SWITCH #83 , EZ1067-51/EA18014302

The switch was heat aged at 200°F in a high humidity chamber from 12/23/77 to 1/1/78.

The open contact resistance on a Meggar instrument measured above 1000 megohms (infinity) before and after the heat age test and the closed contacts passed a current of .086 amps at 100 V.D.C.

The switch was wear life cycle tested for 100,000 cycles at 70 RPM using a cam to actuate the lever arm. The load on the switch was .5 amps @ 100 V.D.C. The test was from 1/3/78 to 1/4/78.

After the wear cycle test the contact resistance was over 1000 megohms (infinity) and the closed contact current was .086 amps.

The switch was irradiated at Isomedix, Inc. from 1/12/78 to 1/31/78.

The switch was irradiated with a cobalt 60 source. The total irradiation applied was 204 Mrads with an energy level of 1.25 Mev. at 1.2 Mrad/hr. rate.

The open and closed contact resistance and current were the same values as before the irradiation test.

The switch was seismic tested by Dr. Edward J. Walter & Associates from 2/1/78 to 2/13/78.

The seismic tests consisted of fragility test and plant induced vibration simulation.

After the seismic test the open contact resistance was above 1000 megohms (infinity). Before and after the seismic test the closed contacts passed a current of .086 amps at 100 V.D.C.

The test program for switch #83 was completed on 2/13/78. The data is attached.

J. J. Patsey

DATE 12/23/77

HEAT AGING

SWITCH # 83-51

J-71

MODEL # EA-180-14302

EZ1060751

☐ PROTOTYPE
☐ PRODUCTION

FROM 12-23-77		TO 1-1-78	COMMENTS
TIME	DATE	TEMP.	Latching mechanism = short travel. The top cover screws were torqued to 10 lb.in. The gasket bulged .016" from the plate. The bottom gasket had a .044" bulge from the plate.
12:30 PM	12-23-77	200°F	
	12-26-77	"	
	12-28-77	"	
	12-31-77	"	
9:35 AM	1-3-78	"	
	Removed switch		

ELECTRICALS LOAD = .086A @ 100 VDC

	Meggar				Conductivity (amps)			
	1	3	2	4	1	3	2	4
INITIAL	Inf	Inf	Inf	Inf	.086	.086	.086	.085
FINAL	"	"	"	"	"	"	"	"
OTHER								

(Continue on back)

INTERIOR EXAMINATION (OPTIONAL)

GASKETS:

CONTACTS:

BLOCK:

O-RING:

GREASE:

DATE 1-3-78

SWITCH # 80-51

MODEL # EA180-1430

EZ10607-51

1-71 ☐ PROTOTYPE
☐ PRODUCTION

WEAR CYCLING

# OF CYCLES	100,000		LOAD	.5A @ 100 DC						COMMENTS			
CYCLE RATE	70 RPM												
METHOD	Cam												
ELECTRICAL MEASUREMENTS; LOAD = .086A @ 100 VDC													
		Meggar			Conductivity (amps)								
	1	3	2	4	1	3	2	4					
INITIAL	Inf	Inf	Inf	Inf	.086	.086	.086	086					
FINAL	"	"	"	"	"	"	"	"					
OTHER													
			INTERNAL EXAMINATION (OPTIONAL)						(Continue on back)				
GASKETS:													
CONTACTS:													
BLOCK:													
O-RING:													
GREASE:													

JR-

DATE 1-31-78

SWITCH # 83-51

1-71 ☐ PROTOTYPE
☐ PRODUCTION

MODEL # EA180-14302
EZ10607-51

IRRADIATION

IRRADIATED AT: Isomedix, Inc.

FROM 1-12-78 TO 1-31-78 TOTAL IRRADIATION 204 Mrad.

ENERGY LEVEL 1.25 Mev. SOURCE Cobalt 60 gamma RATE 1.2 Mrad/hr.

ELECTRIDAL MEASUREMENTS ; LOAD .086A @ 100 DC COMMENTS

	Meggar				Conductivity (amps)				
	1	3	2	4	1	3	2	4	
INITIAL	Inf	Inf	Inf	Inf	.086	.086	.086	.086	
FINAL	"	"	"	"	"	"	"	"	
OTHER									

INTERIOR EXAMINATION (OPTIONAL)

Gaskets:

CONTACTS:

BLOCK:

O-RING:

GREASE:

COMMENTS (Cont.)

ISOMEDIX

February 6, 1978

Mr. Edward L. Solem
Metallurgy Engineer
Acme-Cleveland Development Co.
625 Alpha Drive
Highland Heights, Ohio 44143

Dear Mr. Solem:

This will summarize parameters pertinent to the irradiation of three switches per your purchase order no. DC-97214, dated January 12, 1978. The units were identified as switches 81A, 82A, and 83.

The switches were placed in a cobalt-60 gamma field at a dose rate of 1.2 Mrad per hour. The switches were exposed for 170.0 hours, yielding a minimum dose of 204 megarads.

Dosimetry was performed using an Atomic Energy of Canada Limited (AECL) Red Perspex system with Type BC-2 readout. Calibration of the Perspex is made by AECL using Ceric dosimetry traceable to the U.S. National Bureau of Standards. Isomedix regularly cross-calibrates its AECL system with an inhouse Harwell Perspex system, and makes semi-annual calibrations directly with NBS, using the NBS Radiochromic Dye system. A copy of the dosimetry correlation report is available upon request.

Irradiation was conducted in air at ambient temperature and pressure. Radiant heat from the source heated the samples somewhat, but the temperature did not exceed 100°F, as indicated by previous measurements on an oil solution in the same relative position.

Irradiation was initiated on January 15, 1978, and was completed on January 26, 1978.

Yours very truly,

Jonathan C. Young
Production Manager

JCY/mr

DATE 2-13-78

SWITCH # 83-51

1-71
☐ PROTOTYPE
☐ PRODUCTION

MODEL # EA180-1430
EZ10607-51

SEISMIC TESTING

SPECIAL PARTS:

TESTED BY: Dr. Edward Walter & Associates

REPORT REF.: IEEE Standard 323, 344 and 382

INTERNAL EXAMINATION (OPTIONAL)

GASKETS

CONTACTS

BLOCK

O-RING

GREASE

COMMENTS

Electricals

	Meggar					Conductivity (amps)			
	1	3	2	4		1	3	2	4
Before seismic 2-1-78	Inf	Inf	Inf	Inf		.086	.086	.086	.086
After seismic 2-13-78	"	"	"	"		"	"	"	"

JF

Page 8 of 11 (F)

Dr. Edward J. Walter & Associates
Vibration and Sound Consultants
P.O. BOX 171 • CHESTERLAND, OHIO 44026 • TELEPHONE: (216) 729-7415

Vibration Test of Limit Control Switch
NAMCO Controls
An Acme-Cleveland Company
January, 1978

Reference

A detailed description of the vibration testing equipment and test procedures is given in our report of June, 1977, Seismic Qualification Test of Limit Control Switches, prepared for NAMCO Controls.

CURRENT SWITCH TEST

1 Switch No. 83, EA 180-14302

VIBRATION TESTS

The switch was subjected to the following tests:

I - Fragility Test

Frequency Hz	Vibration Specification
1.0	Displacement - 12.1 inches pp
1.25	giving 9.52 g's acceleration
1.6	at 4 Hz.
2.0	
2.5	
3.15	
4.0	
	Acceleration 9.52 or greater
5.0	Displacement - 8.0 inches pp
6.3	Displacement - 5.0 inches pp
8.0	Displacement - 3.0 inches pp
10.0	Displacement - 2.0 inches pp
12.5	Displacement - 0.45 inches pp
16.0	as above
20.0	as above
25.0	Displacement - 0.40 inches pp
32.0	giving acceleration 9.52 g's or greater.

II - Plant Induced Vibration Simulation

The switch was vibrated at a non-resonant frequency, 100 Hz at an acceleration 1.3 g for a total of 10^6 cycles, one third of the total cycles in each component, X, Y, and Z.

Test Procedure:

The switch was tested in each of three mutually perpendicular directions, designated X, Y, and Z, parallel to the major axes of the switch. In each orientation, the fragility dwell test and the plant induced vibration simulation test were made.

In the Fragility Dwell test the switch contacts were monitored. Both the Normally Open (NO) contacts and the Normally Closed (NC) contacts were monitored for seismic failure by means of a light indicator circuit. No seismic failure occurred during the tests.

The trip angle of the switch was also monitored during the test at both the normally Open (NO) contacts and the Normally Closed (NC) contacts. The Normally Open (NO) contacts were monitored first. The switch was actuated and subjected to vibration for a minimum of 30 seconds. Next, the Normally Closed (NC) contacts were monitored with the switch unactuated and subjected to vibration for a minimum of 30 seconds. Total vibration time was a minimum of 60 seconds. This procedure was repeated for each frequency of the fragility dwell test.

The trip position remained within 1/16 inch throughout the test procedure with the following three exceptions:

Changes in Trip Position
which exceeded 1/16 inch

Y-comp.

Frequency Hz	Total Change in inches
16	.107 early
25	.080 early
32	.107 early

In the Plant Induced Vibration Simulation test, the switch was vibrated at a non-resonant frequency, 100 Hz, at an acceleration of 1.3 G, for a minimum of 10^6 cycles. Each component, X, Y, and Z was subjected to one third of the total number of cycles, e.g. $1/3 \times 10^6$ cycles.

The switch was a double throw type and was energized electrically at 125 volts at 1/2 amp. during the test. It was subjected to 51 distinct vibration tests, 48 of these at a minimum of 60 seconds each and three at a minimum of 96 minutes each.

Edward J. Walter

DR. EDWARD J. WALTER AND ASSOCIATES
February, 1978

11.0 TEST PLAN

This section contains a copy of the test plan and amendments used for this qualification test.

11.1 Test Plan No. LP10767-3

Dated July 26, 1979

Revision 1

NAMCO CONTROLS

170 EAST 131ST STREET • CLEVELAND, OHIO 44108 • (216) 268-4200 • TELEX 98-5499

REPLY TO: 149 CUCUMBER STREET · JEFFERSON, OHIO 44047 · (216) 576-4070

COPY NO.

TEST PLAN NO. LP10767-3

DATE AUG. 29, 1980

REV 3

TEST PLAN FOR THE QUALIFICATION OF SERIES EA180 AND EA740 SWITCHES FOR USE IN NUCLEAR POWER PLANTS IN COMPLIANCE WITH IEEE STANDARDS 323-74, 382-72 AND 344-75.

EXTENSION OF EA180 QUALIFICATION REPORTS DATED SEPT. 5, 1978 AND MARCH 3, 1978.

EXTENSION OF EA740 QUALIFICATION REPORTS DATED FEB. 20, 1978 AND FEB. 22, 1979.

ORIGINAL TEST PLAN DATED 8/31/77.

TEST PLAN NO. LP10767-3

DATED JULY 16, 1979

REVISIONS

REV	DESCRIPTION OF CHANGE	DATE
0	Draft	7-16-79
1	Released	7-26-79
2	Delete Reference to Qnty. of Test Switches	8-29-79
3	Add test sequence 5.2 Revise Section 9 Add EA180 14302 & 13302 type.	8-29-80

John R. Bendokaitis
Project Engineer
Nuclear Switch Coordinator
NAMCO CONTROLS

Joseph Buzogany
Chief Engineer
NAMCO CONTROLS

INDEX

SECTION		PAGE
1.	Purpose of Test Plan	1
2.	Applicable Specifications and Drawings	2
3.	Number and Types of Switches to be Tested	3
4.	Service Conditions, Mounting and Connection Requirements	4
5.	Qualification Test Sequence	7
6.	Qualification Test Conditions and Procedures	8
7.	Performance Limits	20
8.	Documentation	21
9.	Generic Group Qual. and Minor Design Mod. Justification	22
10.	Attachments	31

FIGURES

FIGURES		PAGE
1.	Lead Wire Hook-Up for EA180 & EA740 Switches	23
2.	Connection Diagrams for Baseline Data Test	24
3.		
4.		
5.	Connection Diagram for Mechanical Aging _ ad	27
6.	Connection Diagram for Seismic Qualification Test	28
7.	Sine Dwell Test Envelope	29
8.	Environmental Chamber Conditions	30

1. PURPOSES OF TEST PLAN

1.1 The purpose of this test plan is to provide a step by step procedure for type qualification of a series of NAMCO CONTROLS Limit Switches to IEEE Std. 323-1974, 382-1972 and 344-1975.

1.2 The further purpose of this test plan is to extend the qualification of the EA180 and EA740 series Limit Switches to include a series of product improvement changes. See Section 9 for description of changes.

1.3 Original EA180 qualification reports dated Sept. 5, 1978 and March 3, 1978.
Original EA740 qualification reports dated Feb. 20, 1978 and Feb. 22, 1979.

1.4 This test plan supersedes the original test plan dated August 31, 1977.

1.5 This test plan will envelope the environmental test conditions as set forth in Section 4, Service Conditions.

1.6 This test plan includes testing of Limit Switch performance, aging simulation, seismic qualification and accident and special environment simulation.

1.7 Only the pressurize water reactor and boiling water reactor portions of IEEE 382-1972 will be applied in this test plan.

✓

2. APPLICABLE SPECIFICATIONS AND DRAWINGS

2.1 The listed documents are a part of this test plan and will be referred to as required, where differences exist between the documents and this plan, the plan will prevail.

2.2 IEEE Std 323-1974 - Std for Qualifying Class IE Equipment for Nuclear Power Generating Stations.

2.3 IEEE Std 382-1972/ANSI N41.6 IEEE Trial-Use Guide for Type Test of Class I Electric Valve Operators for Nuclear Power Generating Station.

2.4 IEEE Std 344-1975 - Recommended Practices for Seismic Qualification of Class IE Equipment for Nuclear Power Generating Stations.

2.5

2.6 NAMCO CONTROLS drawings

2.6.1 EA180 11302 (type) Limit Switch Assy

2.6.2 EA740 20000 (type) Limit Switch Assy

3. TYPES OF SWITCHES TO BE TESTED

3.1 Test several versions of switch P/No. EA180 11302

3.1.1 Nameplate Rating:
125VAC-20A, 250VAC-15A, 480VAC-10A,
600VAC-5A, 125VDC-5A, 250VDC-1.5A
75-100% Power Factor

3.1.2 Operating Data
Pretravel - - - - - - - - - - - - - 10°
Differential Travel - - - - - - - - 8°
Recommended Travel - - - - - - - - 13°
Maximum Torque During Pretravel - 23 inch lbs

3.2 Test several versions of switch P/No. EA740 20000

3.2.1 Nameplate Rating
125VAC-20A, 250VAC-15A, 480VAC-10A,
600VAC-5A, 125VDC-5A, 250VDC-1.5A
75-100% Power Factor

3.2.2 Operating Data
Pretravel - - - - - - - - - - - - - 18°
Differential Travel - - - - - - - - 14°
Recommended Travel - - - - - - - - 30°
Maximum Torque to Trip - - - - - - 27 inch lbs

3.3 Manufacturer and Type

The switches are manufactured by NAMCO CONTROLS, an Acme Cleveland Company, and are heavy duty, double pole, double throw, butt contact, quick break and quick make type.

3.4 Identification

Test switches will be identified for test purposes with the following:

3.4.1 Part Number

3.4.2 Revision letter and/or EZ number

3.4.3 Date of manufacture

3.4.4 Test switch reference number (optional)

4. SERVICE CONDITIONS, MOUNTING AND CONNECTION REQUIREMENTS

4.1 Service Conditions

This test plan envelopes the rated ambient, operational and electrical service conditions of the limit switch. Test conditions were chosen to simulate the most severe (or conservative) limits of these parameters. Where multi-electrical conditions exist, e.g. AC and DC ratings, a single voltage condition was chosen (based upon past experience) as most severe (or conservative).

4.1.1 Environmental Conditions

Normal Ambient Conditions

Temperature	see 4.1.5
Pressure	ambient
Humidity	0 to 100% RH
Radiation	4 X 10^6 Rads, Gamma

Design basis event conditions (see Fig. 8)

Temperature	up to 325° F (163° C)
Pressure	up to 70 psig
Humidity	saturated steam @ 100% RH
Chemical Spray	see section 6.7.6
Radiation	180 X 10^6 Rads, Gamma

Total testexposure to radiation 204 X 10^6 Rads.

4.1.2 Enclosure Type

The switch enclosure meets the requirements of NEMA types 1, 4 & 13.

4.1.3 Electrical Conditions

Rated - see section 3

4.1.4 Operational Life

Mechanical - 100,000 operations min.

Electrical - 100,000 operations min.

4. SERVICE CONDITIONS, MOUNTING AND CONNECTION REQUIREMENTS - Cont.

4.1 Service Conditions - Cont.

4.1.5 Service Life

Service life is dependant upon the ambient condition of the switch installation, see section 6.3 for estimated qualified life.

4.1.6 Earthquake Environment

Safe shutdown earthquake requirements of IEEE Std 344, acceleration loads of 9.52 g's minimum at frequencies of 1 to 35 Hz (see Fig. 7). Plant induced vibrations of 10^6 vibratory cycles at low acceleration loads and up to 100 Hz.

4.2 Mounting and Connections

The test mountings and connections predicate the following service and installation conditions:

4.2.1 Mount the switch with proper size and length of fasteners.

4.2.2 Wire passage through switch conduit entrance must be sealed in such a way as to maintain the switch integrity under service and DBE conditions.

4.2.3 Wire terminals should not be of zinc or zinc plate material.

4.2.4 Top and bottom covers, gaskets and screws to be properly assembled and torqued per Installation Instructions.

4. SERVICE CONDITIONS, MOUNTING AND CONNECTION REQUIREMENTS - Cont.

4.3 Operating Lever Assembly

One of the listed lever assemblies shall be used as part of the test fixture to operate the switch. Removal or replacement shall not be considered in the test results.

4.3.1 EL060 53301 Lever Assembly

1.5 inch bronze lever, stainless steel pin

.74 dia X .24 wide Nitronic steel roller

4.3.2 EL060 53300 Lever Assembly

1.5 inch bronze, lever, stainless steel pin

.74 dia X .24 wide Be Cu roller

5. QUALIFICATION TEST SEQUENCE

5.1 Test Sequence for Standard EA180 11302 and EA740 20000 Limit Switch Types

TEST SEQUENCE	DESCRIPTION	REFERENCE SECTION	FUNCTIONAL TEST	100 VDC .086A	100 VDC 0.5A	INSULATION RESISTANCE (MEGGAR)	REMARKS
.1	Inspect & Assy	6.1					
.2	Baseline Data	6.2.1	X	X		X	
.3							
.4	Thermal Age	6.3					120° C @ 400Hrs.
.5							
.6	Performance Test	6.2.2	X	X		X	
.7	Mechanical Wear Age	6.4			X		
.8							
.9	Performance Test	6.2.2	X	X		X	
.10	Radiation Simulation	6.5					
.11							
.12	Performance Test	6.2.2	X	X		X	
.13	Seismic Qual.	6.6	X				125VDC.5A
.14							
.15	Performance Test	6.2.2	X	X		X	
.16	Accident Envir .	6.7	X	X		X	
.17							
.18	Long Term Envir .	6.8					
.19							
.20	Performance Test	6.2.2	X	X		X	
.21	inspection	6.9					

5. QUALIFICATION TEST SEQUENCE

5.2 Test Sequence for Limit Switch Types within the same generic group: such as short travel, maintained, etc.

TEST SEQUENCE	DESCRIPTION	REFERENCE SECTION	FUNCTIONAL TEST	100 VDC .086A	100 VDC 0.5A	INSULATION RESISTANCE (MEGGAR)	REMARKS
.1	Inspect & Assy	6.1					
.2	Baseline Data	6.2.1	X	X		X	
.3							
.4	Thermal Age	6.3					120° C @ 400 Hrs.
.5							
.6	Performance Test	6.2.2	X	X		X	
.7	Mechanical Wear Age	6.4			X		
.8							
.9	Performance Test	6.2.2	X	X		X	
.10	Radiation Simulation	6.5					
.11							
.12	Performance Test	6.2.2	X	X		X	
.13	Seismic Qual.	6.6	X				125VDC.5A
.14							
.15							
* .16	Accident Envir .						
.17							
* .18	Long Term Envir .						
.19							
.20	Performance Test	6.2.2	X	X		X	
.21	Inspection	6.9					

* Qualification by similarity analysis.

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES

The following paragraphs detail the test conditions and procedures for performing each test. The sequence of testing will be in the order listed in section 5. Notice that some tests are repeated in the sequence.

6.1 Inspection and Preparation

6.1.1 Check and record the identity per section 3.

6.1.2 Mark the switch as required per 3.4.4.

6.1.3 Inspect the switch for any signs of damage. Remove top cover and gasket.

6.1.4 Wire per Figure 1 using stranded No. 18 AWG wire with radiation resistant insulation.

6.1.5 Assemble top cover and gaskets per assembly procedure provided with switch.

6.2 Performance Testing

Throughout the qualification test sequence a series of functional tests will be conducted to obtain two types of data; base line data & performance data.

The base line data test will determine performance characteristics of the test switch prior to the environmental test sequence and provide a basis for comparison during the qualification test. The performance data tests will be conducted to determine acceptability of the switch, see Performance Limits in section 7.

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.2 Performance Testing - Cont.

6.2.1 Baseline Data Test

6.2.1.1 Electrical load test (close circuit)

Calibrate the test circuit

Voltage 100VDC

Current .086A

Resistive load

Connect switch leads per Figure 2 A

Test each circuit (close condition)

Record resulting currents

6.2.1.2 Insulation Resistance

(open circuit resistance)

Connect switch leads per Figure 2 B

Measure and record circuit resistance of each circuit in the open condition.

6.2.1.3 Functional Test

Connect switch leads per Figure 2 C

Measure and record the following: pertravel angle in degrees, differential travel in degrees, maximum torque during pretravel, inch pounds.

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.2 Performance Testing - Cont.

6.2.2 Performance Test

6.2.2.1 Electrical load test (close circuit)

Calibrate the test circuit

Voltage 100 VDC

Current .086 Amps

Resistive load

Connect switch leads per Figure 2 A

Test each circuit (close condition)

Record resulting currents

6.2.2.2 Insulation Resistance

(open circuit resistance)

Connect switch leads per Figure 2 B

Measure and record circuit resistance of each circuit in the open condition.

6.2.2.3 Functional Test

During the above test record whether contacts transferred when switch was operated.

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.3 Thermal Aging

Thermal aging is conducted by placing a prepared switch in a chamber in which the temperature can be maintained.

6.3.1 The switch conduit entrance will be sealed with a stainless steel pipe nipple and cap.

6.3.2 The lead wires will be enclosed in the nipple during exposure to these environments. The circuits will not be energized.

6.3.3 Temperature
120° C

6.3.4 Relative Humidity
Uncontrolled

6.3.5 Pressure
Ambient

6.3.6 Duration
400 hours

6.3.7 Switch Operation

NONE REQUIRED

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.3 Thermal Aging - Cont.

6.3.8 Service Life Simulation

The above thermal aging simulates normal service conditicns, which can vary with the Limit Switch application.

Estimated qualified life is predicated upon the service temperature. The following chart of estimated qualified life has been derived thru the use of the Arrhenius Equation, as referenced in IEEE 382, using an activation energy of 0.8eV.

SERVICE TEMP		EST. QUALIFIED LIFE
°F	°C	Years
105	40.6	18.1
110	43.3	13.9
115	46.1	10.8
120	48.9	8.4
125	51.7	6.6
130	54.4	5.1

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.4 Mechanical Wear Aging

The mechanical wear aging test consists of mounting the switch with an operating lever on a fixture with a cam designed to operate the switch at 70 (ON-OFF) actuations per minute with an electrical load applied to the contacts.

6.4.1 The switch conduit entrance will be open during this test.

6.4.2 The lead wires will be connected per Figure 5.

6.4.3 The switch will be attached to the fixture with screws, using the threaded side mounting holes on one side of the switch.

6.4.4 Electrical Load

Voltage_____ 100VDC

Current_____ 0.5 Amps

Resistive Load

6.4.5 Service life simulation

100,000 cycles minimum

6.4.6 See Section 4 for operating lever requirements

6.4.7 Set up switch per EZ10567-80 or -81 (see attachments). Lever travel to be set at recommended travel angle (see Section 3).

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.5 Radiation Simulation

This test is designed to expose the switch to the total radiation dosage expected over the service life of the switch plus accident conditions and margins.

6.5.1 The switch conduit entrance will be sealed with a stainless steel pipe nipple and cap.

6.5.2 The lead wires will be enclosed in the nipple during exposure to these environments. The circuits will not be energized.

6.5.3 The test will be performed by an approved vender. The vendor shall provide a certified test report and statement of instrumentation calibration.

6.5.4 Temperature, pressure and humidity - ambient.

6.5.5 Radiation exposure

Accident environment	180 X 10^6 Rads
Margin (+10%)	20 X 10^6 Rads
Normal environment (40 yrs inside containment)	4 X 10^6 Rads
Total exposure (this test)	204 X 10^6 Rads Minimum

6.5.6 Radiation type and rate

Cobalt-60 Gamma field at a rate of .5 to 1 X 10^6 Rads/hr.

6.5.7 Mounting Cautions

The switch shall be placed on a rack to allow free air movement around the switch.

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.6 Seismic Qualification

Seismic qualification will be performed per IEEE Std 344-1975 thru a combination of analysis and test sequences.

. The absence of cross coupling will be established so that single axis testing can be used.

6.6.1 Mounting and connections during seismic qualification.

6.6.1.1 The switch conduit entrance will be open during this test. Note: Lead wires will be protected against abrasion.

6.6.1.2 The lead wires will be connected per Figure 6.

6.6.1.3 The switch will be attached to the fixture with screws, using the threaded side mounting holes on one side of the switch.

6.6.2 Electrical Load

Voltage 125 VDC

Current **0.5** Amps resistive load

Circuits will be monitored to detect interruptions (contact opening) of 2.0 milli-seconds or greater. At least 10.0 milli-seconds will be allowed for contact bounce after switch operation.

6.6.3 Operating lever will be used. See section 4.

6.6.4 The response accelerometer will be attached to the switch mounting table in close proximity to the switch.

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.6.5 All tests will be conducted in each of the three orthogonal axis.

6.6.6 All tests will be conducted with the switch, first in the un-operated condition than in the operated condition.

6.6.7 Pretravel angle and differential travel angle will be measured during each sine dwell point.

6.6.8 Resonance Search

Subject the switch to a continuous sine sweep from 1 to 35 Hz at a rate of one octave per minute as follows:

Frequency Hz	Displacement Inches	Acceleration g
1-10	1.0	.05 - 5.1
10-35	0.01	.05 - .63

Resonant frequencies found during this test will be added as dwell points in the fragility test.

6.6.9 Fragility Test

This test will be conducted per Figure 7 and envelope the conditions of 1 to 35 Hz and up to 9.52 g's minimum. Dwell points - 1/3 octave bands from 1 to 35 Hz.

Dwell time - 60 seconds minimum

(unactuated 30 seconds minimum)

(actuated 30 seconds minimum)

6.6.10 Plant induced vibration simulation.

The switch will be subjected to 10^6 vibratory cycles of sinusoidal motion at a non-resonant frequency near 100 Hz with .75 g acceleration to simulate vibration during normal use.

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.7 Accident Environment Simulation Test

This test will subject the switch to the environmental conditions of temperature, pressure, moisture and chemical solution spray in a cycle described by Figure 8.

6.7.1 The switch will be placed in the test chamber prior to initiating the temperature/pressure cycle.

6.7.2 A pipe nipple will be assembled into the switch conduit entrance. This coupling will be made pressure and liquid tight. This nipple will pass thru the environmental chamber wall and act as a pass thru for the lead wires.

6.7.3 The switch will be supported by the nipple during this portion of the test since no unusual mounting stress are encountered.

6.7.4 A means will be provided to operate the switch during test.

6.7.5 Electrical and Mechanical Performance

The switch will be operated thru one complete ON-OFF cycle at the intervals noted by arrows on Figure 8. Performance test per 6.2.2.

6.7.6 Chamber Environment

Steam and chemical spray, a solution as defined in IEEE 382-1972 Part III, Table 1 and IEEE 323-1974 Appendix A, Table A1.

The chemical spray will be started 40 seconds after start of each transient per Figure 8. Rate of flow will be approximately 200 cubic centimeters (cc) per minute and continue for 91 hours after second transient. Chamber temperature and pressure per Figure 8.

QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.8 Long Term Environment Simulation

At the completion of the major pressure/temperature cycles, at approximately 96 hours, the option to change to a long term environment test chamber shall be provided. The long term environment chamber will maintain the pressure temperature and moisture for the remainder of the profile in Figure 8.

6.8.1 A pipe nipple will be assembled into the switch conduit entrance. This coupling will be made pressure and liquid tight. This nipple will pass thru the chamber wall and act as a pass thru for the lead wires.

6.8.2 Lead wires will not be connected for this test.

6.8.3 The switch will be supported by the nipple during this test.

6.8.4 The switch need not be operated during this portion of the test.

6.8.5 Chamber Environment

Distilled water SPRAY

Chamber temperature and pressure per Figure 8.

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.9 Inspection

NAMCO CONTROLS Engineering shall be notified of completion of test prior to removal from test chamber and opening of top and bottom covers. Remove top and bottom covers, observe and record the condition of components of switch.

7. PERFORMANCE LIMITS

The switch performance limits (see 6.2.2) for this qualification test are as follows:

7.1 Close Circuit Current

The closed circuit current change when tested with 100 VDC, .086 Amps, will be recorded and supplied for customer evaluation.

7.2 Open Circuit Resistance (insulation resistance)

50,000 Ohms Minimum

7.3 Closed circuit shall not open for more than 2 milli-seconds during seismic testing. Contact bounce after switch operation (10 milli-seconds) shall not be considered.

7.4 During performance test, contacts must transfer during each switch operation.

7.5 The pretravel, differential travel and torque data shall be recorded for reference information only.

8. DOCUMENTATION

The type test documentation will be sufficient to verify that the switch meets the performance limits. Baseline data and Engineering data will be provided for comparison purposes. The test report will include the following:

8.1 Description of switches.

8.2 Test plan number and date.

8.3 Test specifications and objectives.

8.4 Description of test facilities, equipment and instrumentation.

8.5 Calibration record of instrumentation.

8.6 Test procedure.

8.7 Test results and accuracy.

8.8 Inspection results.

8.9 Supporting data such as similarity analysis, seismic analysis, qualified life predictions, etc.

8.10 Description and justification for adjustments, disassembly or alteration, other than those specified in the test plan.

8.11 Conclusions.

8.12 Approved signature and date. The test report will be certified as a true account of the test.

8.13 All documentation (log data, reports, calculations, etc) will be arranged and maintained in an auditable form.

9. GENERIC GROUP QUALIFICATION AND MINOR DESIGN MODIFICATION JUSTIFICATION

This section of the test plan and qualification report will be reserved for future analysis and/or test reports to justify generic group qualification and design changes.

9.1 Qualify the EA180 14302 limit switch, the short travel version of the standard EA180 type.

Test per sequence 5.1, LOCA environment qualification will be by similarity to standard switch.

Operating Data

Pretravel . . . . . 6° 30'

Differential Travel . . . . . 4°

Recommended Travel . . . . . 7°

Max. Torque During Pretravel. . . . . 38 In. Lbs.

9.2 Qualify the EA180 13302 limit switch, the maintained contact version of the standard EA180 type.

Seismic test per 6.6, all other qualification will be by similarity to standard switch.

Operating Data

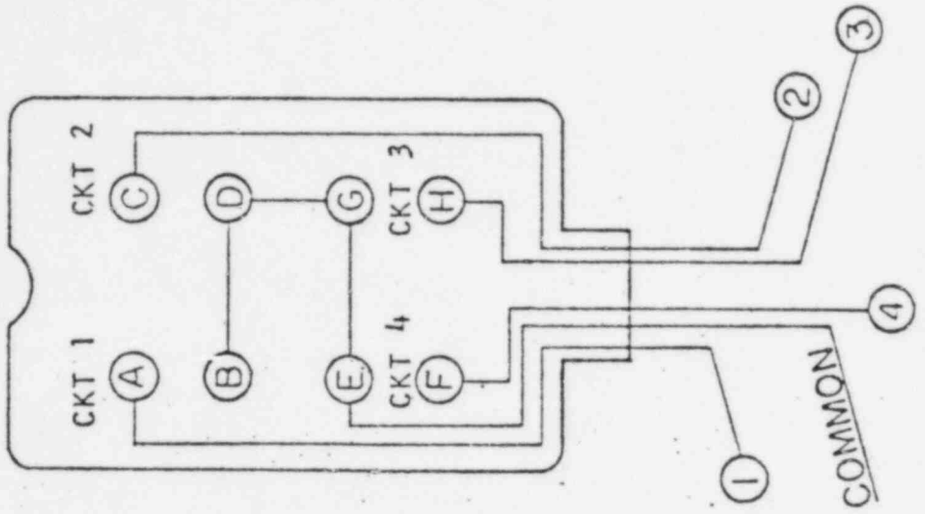
Pretravel . . . . . 10°

Differential Travel . . . . . 8°

Recommended Travel . . . . . 13°

Max. Torque During Pretravel. . . . . 10 In. Lbs.

TOP VIEW
EA180 LIMIT SWITCH
WIRE CONNECTIONS
FIG. 1B

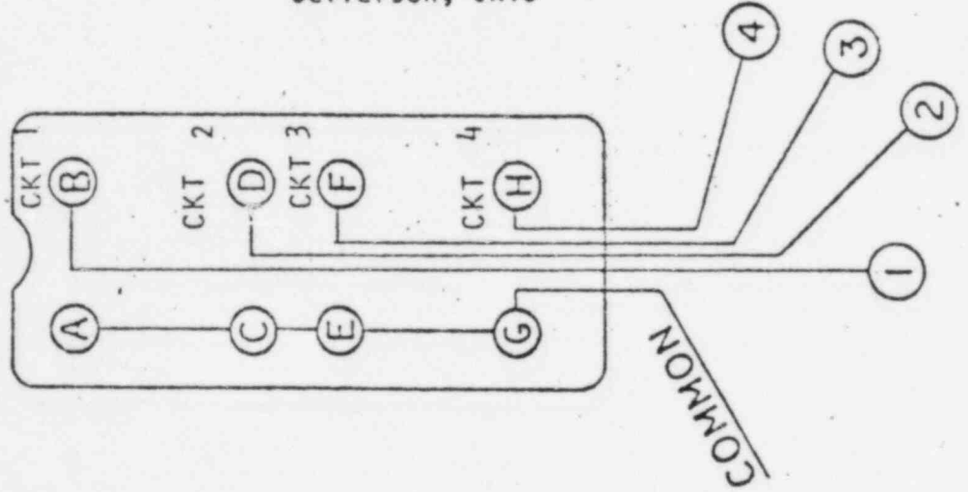


LEAD WIRE HOOK-UP
FOR EA180 & EA740 SWITCHES
FIGURE 1

SEISMIC QUALIFICATION TEST
OF
LIMIT CONTROL SWITCHES
June 1977

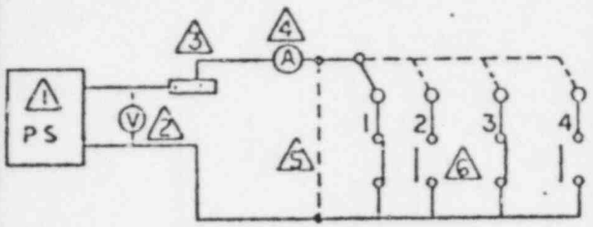
Prepared for
NAMCO Controls
An Acme-Cleveland Company
Jefferson, Ohio

TOP VIEW
EA740 LIMIT SWITCH
WIRE CONNECTIONS
FIG. 1A



10-21

Dr. Edward J. Walter & Associates
Vibration and Sound Consultants
P.O. BOX 321 • CHESTERLAND, OHIO 44026 • (216) 729-7415



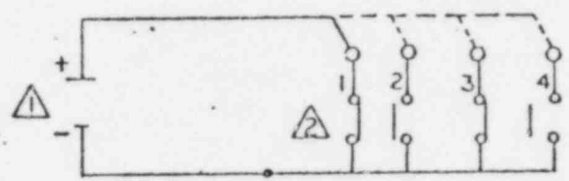
1. Regulated DC power supply
2. Voltmeter
3. Variable power resistor
4. DC Ammeter
5. Calibration circuit
6. Limit switch contacts 1, 2, 3 and 4 electrical load applied to one circuit at a time, N.C. condition

Electrical Load Test

24

11-31

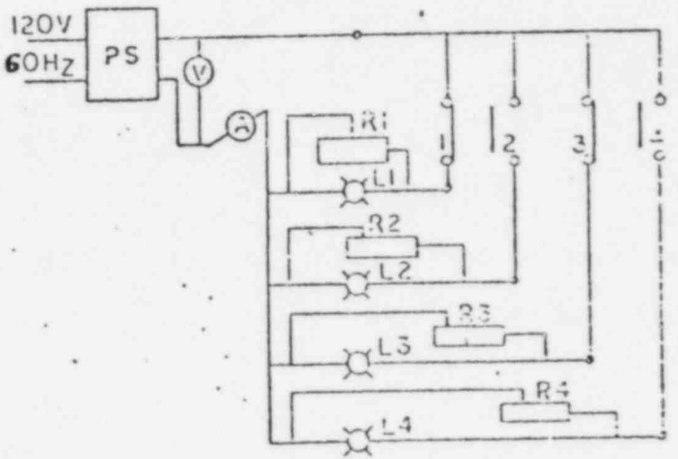
FIG. 2A



1. 500 VDC Meggar Insulation tester, James G. Biddle Company #1113794
2. Limit switch contacts, the Meggar instrument measures across the open contacts (N.O.)

Insulation Resistance Test
(Open Circuit Resistance)

FIG 2B



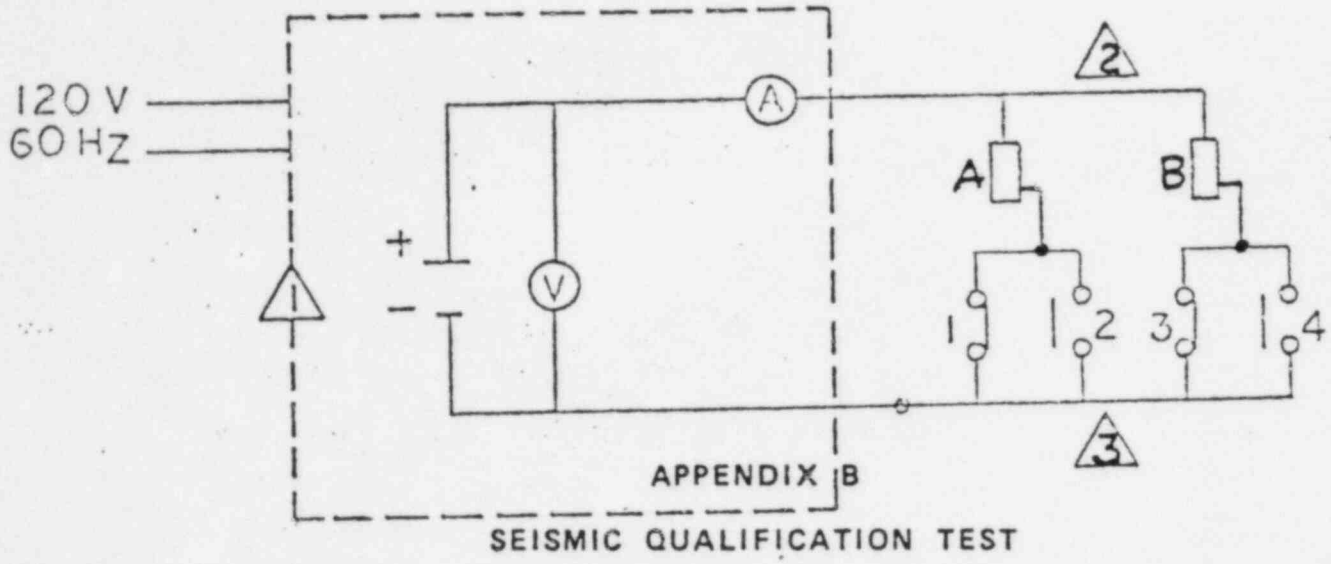
PS — DC Power Supply
A — Ammeter (DC)
V — Voltmeter
L_1, L_2, L_3, L_4 — Pilot Lights
R_1, R_2, R_3, R_4 — Variable Resistor

Circuit for indication of contact closure during pretravel and differential travel test

FIG 2C

FIG 2

CONNECTION DIAGRAMS



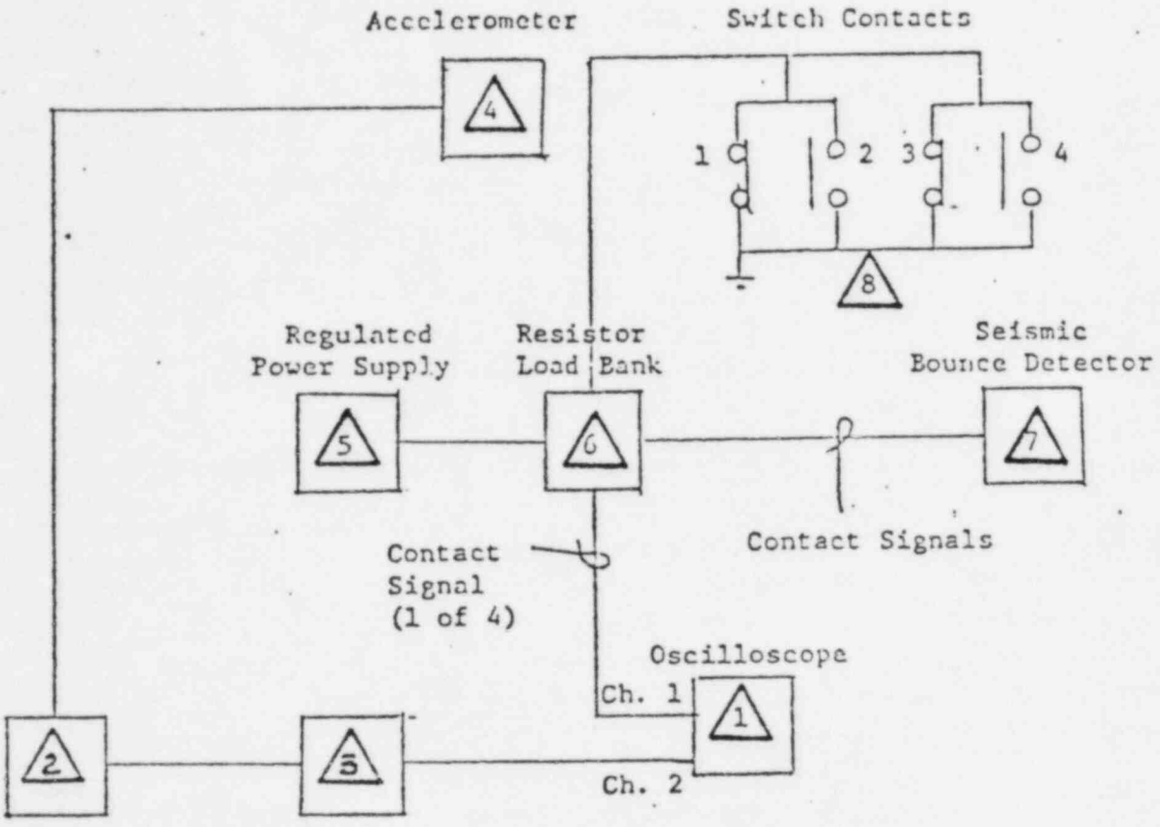
1 Sorenson Power Supply with built-in voltmeter and ammeter

2 Variable Resistors A & B

3 Limit Switch Contacts

CONNECTION DIAGRAM FOR
MECHANICAL AGING LOAD

FIGURE 5



1. Tektronix Type 564 Oscilloscope
2. EBN Model P16 amplifier modified for 1 Hz operation
3. Low pass filter, Krohn-Hite #3202
4. EBN accelerometer pickup Model 507, sensitivity 28.87 mv/g
5. Lambda regulated power supply #LCS-A-100
6. Resistor load banks
7. Seismic bounce detector receives contact signals and discriminates contact open and closure in milliseconds
8. Limit Switch Contacts 1, 3 and 2, 4 (N.C.)

Connection Diagram for Seismic Qualification Test

Figure 6

IRR. REP. Number 79629

Irr. Ref. Number 629

Account Number

Sponsor/Address

Job Description:

Scheduled Start:

Budget:

P.S. br. @

M&S

Hot Cell @

Gamma Pool @

Other

Total Contract

Actual Start 11-5-79 1655 (4:55 pm) Step 5 10 A.M. 11/16/79

Completion 11-16-79 (1130 - 5:30 pm) 24 Step 11-19-79 10:30 AM

Removed from Shield 2.64 x 10^9 n/cm^2 at 12:25 (noon) — Step 11-20-79 1445 pm

Restart 11-19-79 at 12:25 (noon)

Smearable contamination on specimn after test < 100 dpm / 100 cm^2

Radiological Safety Officer

Irradiation of specimen(s) performed by

Page 3 of 4 (A)

REQUIRED LOADING FUNCTION

DISPLACEMENT AMPLITUDE (INCHES)

ACCELERATION AMPLITUDE (g)

FREQUENCY (HZ)

0.05 in (Hz)^2 DYNAMIC TESTS

0.5 in (Hz)^2 DYNAMIC TESTS

1.0 in (Hz)^2 DYNAMIC TESTS

2.0 in (Hz)^2 DYNAMIC TESTS

46 0703

TEST CHAMBER PROFILE FOR ACCIDENT ENVIRONMENT SIMULATION
(TAKEN FROM IEEE STD 382-1972)

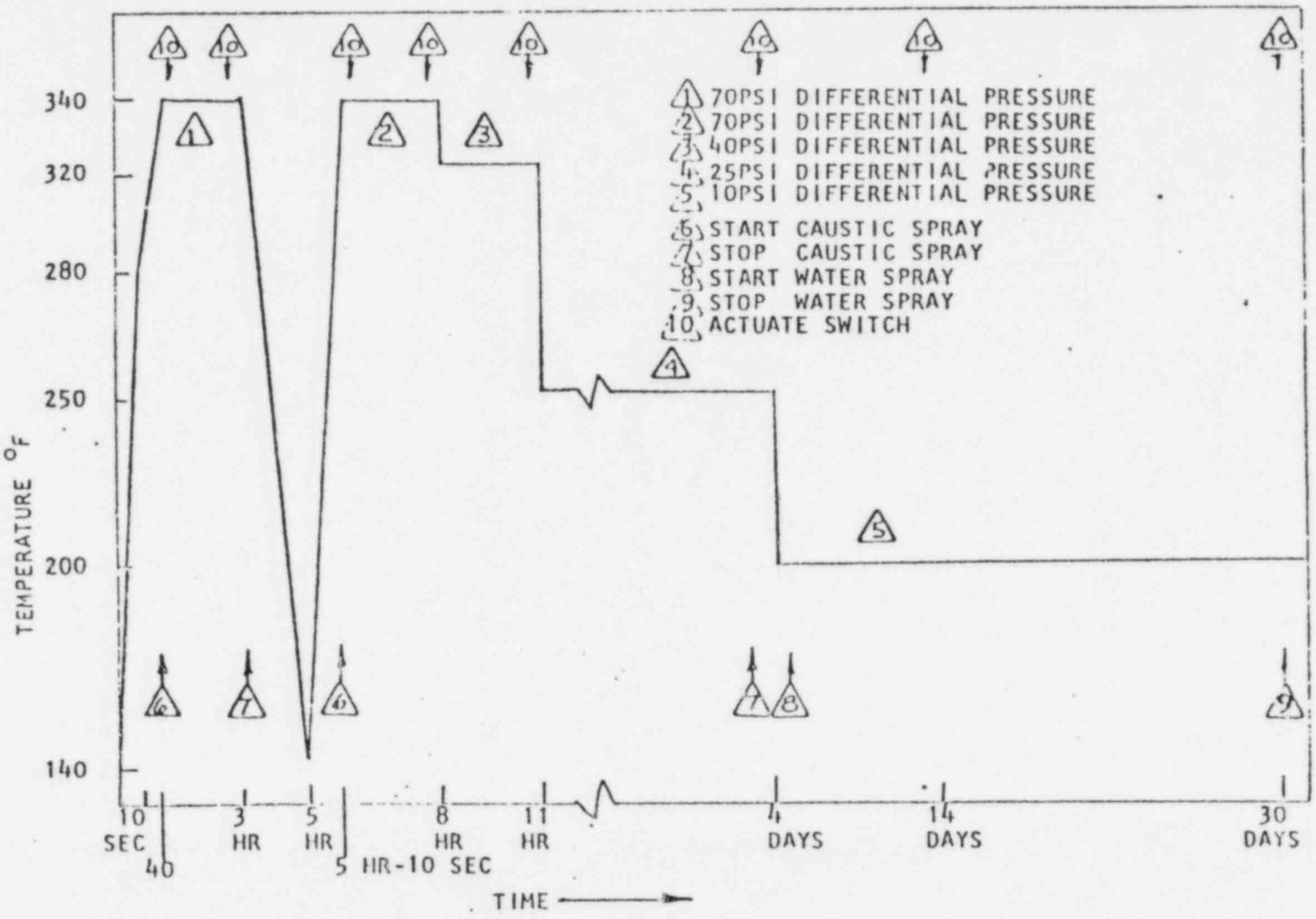


FIGURE 8

NAMCO CONTROLS

LP10767-3 AUGUST 28, 1980

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF NUCLEAR ENGINEERING
ATLANTA, GEORGIA 30332

10. ATTACHMENTS See Section 9.0 of Qualification Test Report for attachments.

FRANK H. NEELY
NUCLEAR RESEARCH CENTER
TELEPHONE: (404) 894-3600

November 20, 1979

Mr. E.L. Solem
Development Engineer
Acme-Cleveland Development Co.
625 Alpha Drive
Highland Heights, Ohio 44143

Dear Mr. Solem:

Pursuant to your instructions seven limit switches and nine small items were irradiated in our hot cell facility using Cobalt 60 (gamma energies 1.173 Mev; 1.332 MeV) to a total dose of 2.04 X 10^8 rads (air) or 2.3 X 10^8 rads (air) as indicated below.

We certify the specific parameters of this irradiation to be:

Test I - 204 Megarads

Irradiation Period:	Total of 9 days, 8 hours and 15 minutes P-1 November 5-November 12, 6 days 15 hours and 15 minutes P-2 November 16 - November 19, 2 days 17 hours and 0 minutes
Dose Rate:	9.1 X 10^5 rad/hour
Total Dose:	2.04 X 10^8 rads (air)
Specimen Id:	(Switch) 134-63 (Switch) 136-90 (Switch) 131-2 (Switch) 138-90 (Switch) 137-67 (Switch) 97 (Switch) 96

Hexseal APM
346
0
308
100
400
NPC-80
11-16 unlabeled items

31

. . . TEST CHAMBER PROFILE FOR ACCIDENT ENVIRONMENT SIMULATION
(TAKEN FROM IEEE STD 382-1972)

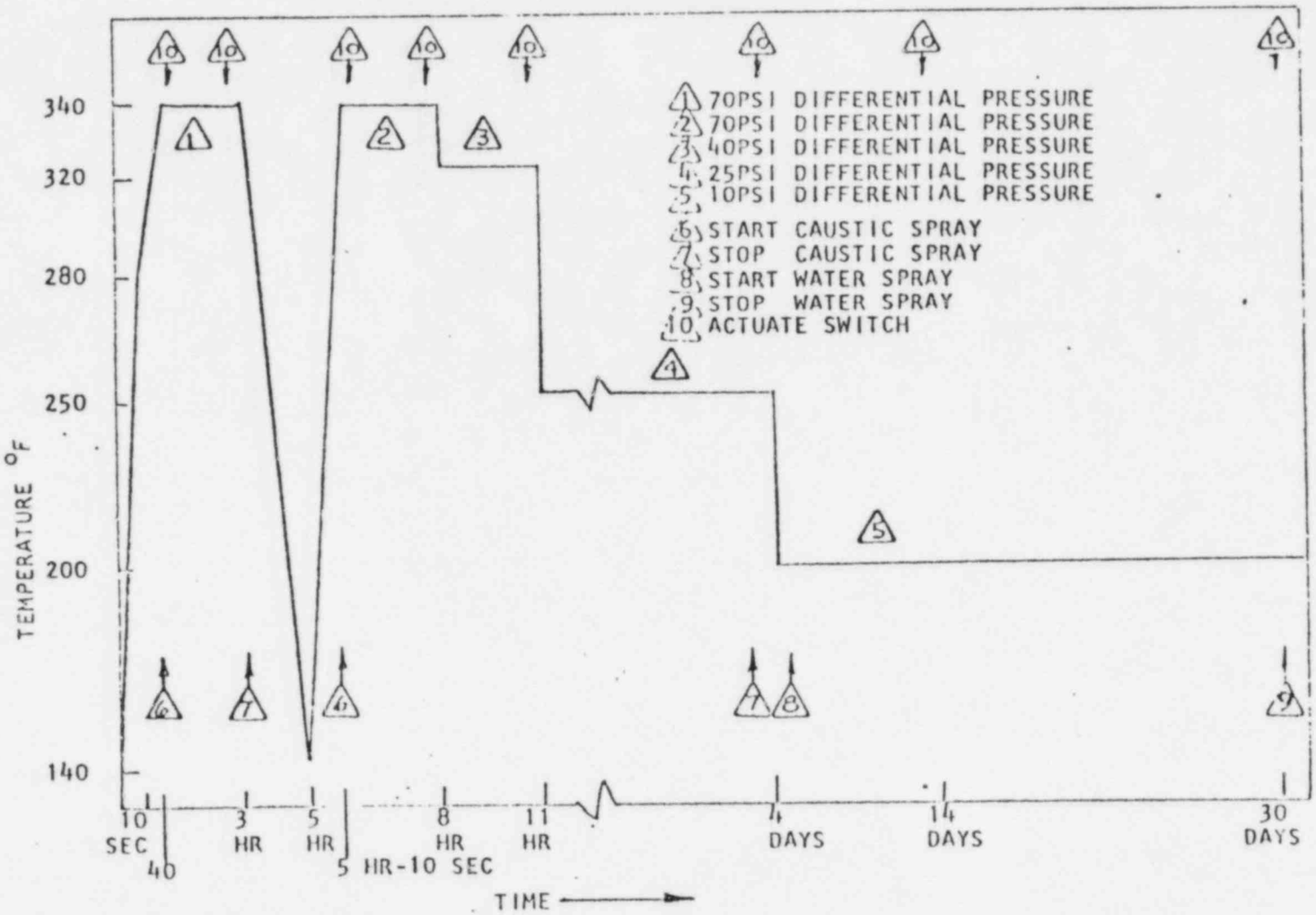


FIGURE 8

10. ATTACHMENTS

See Section 9.0 of Qualification Test Report for attachments.