

REFERENCE 9

NAMCO CONTROLS

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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 QUALIFI-  
CATION REPORTS DATED SEPTEMBER 5, 1978 AND  
MARCH 3, 1978.

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April 3, 1980

REVISION RECORD

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\*Not available, tests in process.

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## 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 6.2 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

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### 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

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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:

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### 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.

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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.

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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 comparative 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.

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## 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

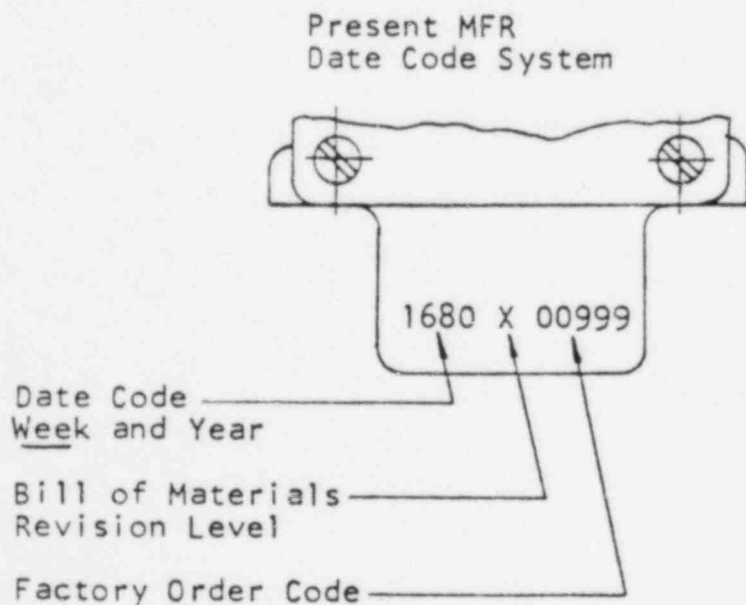
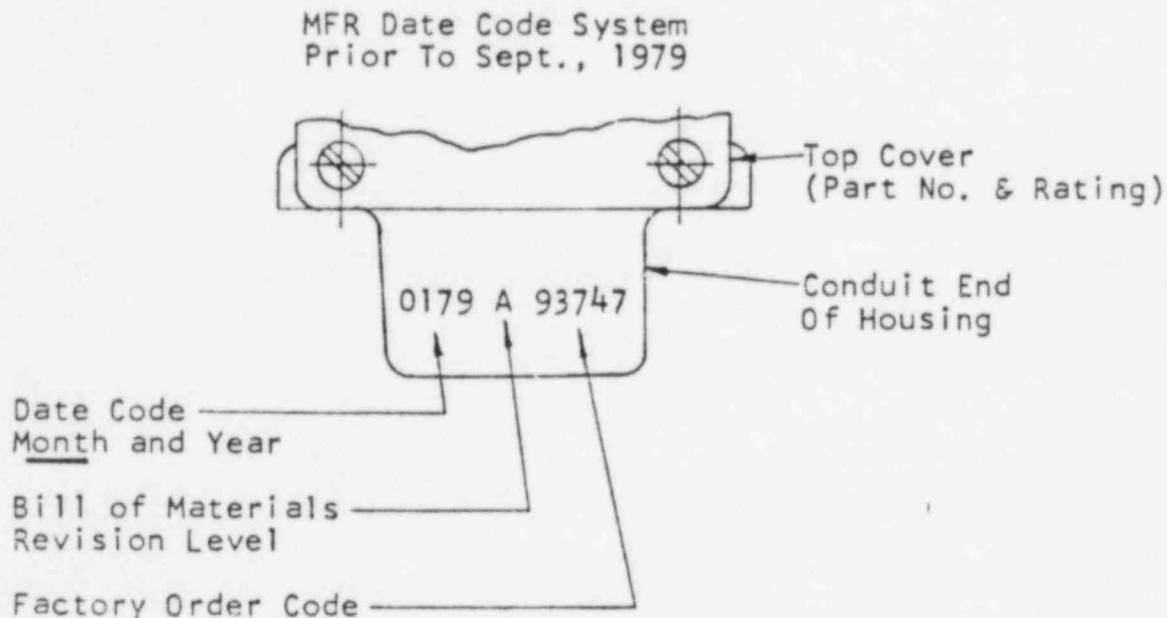
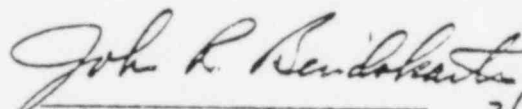


FIGURE 11

CERTIFICATION

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

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

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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.

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										<b>NAMCO CONTROLS</b> An Acme-Cleveland Company CLEVELAND, OHIO U.S.A.																																																																																									
																				UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS .XX ± .01 .XXX ± .005 ANGULAR ± 0°30' REMOVE ALL SHARP EDGES ALL MACHINED SURFACES <sup>12</sup> V										DR NLN CR <i>[Signature]</i>										TITLE INSTALLATION INSTRUCTIONS																																																																															
																				DATE 1-23-80										MATERIAL P.M-										DO NOT SCALE																																																																															
																				SUPERSEDES SCALE										STOCK SIZE EA189-90006																																																																																									
M										11										Y										J										C										F										E										D										C										E										A										N									

9469E 1-07 24096

4-2

FIGURE 5

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JULY 30, 1980

EA189 90051  
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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

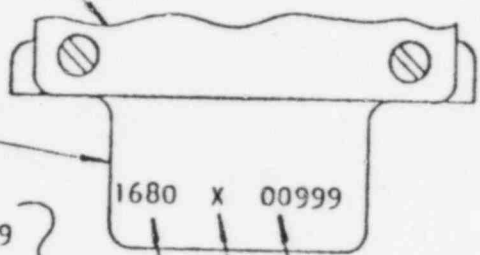
THESE INSTRUCTIONS ARE TO BE USED FOR THE FOLLOWING SWITCH PART NUMBERS AND CORRESPONDING REVISION LEVELS.

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

TOP COVER  
(PART NO. & RATING)

CONDUIT END  
OF HOUSING

DATE CODE SYSTEM  
PRIOR TO SEPT., 1979  
MONTH AND YEAR  
AFTER SEPT., 1979  
WEEK AND YEAR



BILL OF MATERIALS  
REVISION LEVEL

FACTORY ORDER

4-3

FIGURE 6

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CUST PART NO		ASSY NO		REF NO		<b>NAMCO CONTROLS</b> An Acme Cleveland Company CLEVELAND, OHIO U.S.A.					
M	L	K	I	O	F					E	D
		A5557 TU 7/16/80		UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS		DR TW		TITLE		DO NOT SCALE	
		CHANGE DATE		XX ± 01 XXX ± 005 ANGULAR ± 0°30'		CK MK		MAINTENANCE INSTRUCTIONS			
				REMOVE ALL SHARP EDGES ALL MACHINED SURFACES $\sqrt{V}$		DATE 9/16/80		MATERIAL			
				NOTICE THE INFORMATION CONTAINED HEREIN IS THE PROPERTY OF THE NAMCO CONTROLS A DIVISION OF THE ACME CLEVELAND CORP. AND IS SUPPLIED IN CONFIDENCE WITH OUR AGREEMENT NOT BE COPIED OR USED IN ANY MANNER THAT WOULD BE DETRIMENTAL TO OUR INTERESTS.		SUPERSEDES 6/5/80		RM-		EA189 90051 PAGE 1 OF 3	
						SCALE		STOCK SIZE			

9968E 17 7P 9MINUMUN



EA189 90051  
PAGE 3 OF 3

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)

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SEPTEMBER 17, 1980

FIGURE 6 CONT'D.  
4-3.2

CUST. PART NO										ASS'Y NO										REF NO										<b>NAMCO CONTROLS</b>  An Acme Cleveland Company CLEVELAND, OHIO U.S.A.																													
																				UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS										DR TW CR H.K. DATE 9/16/80 DATE 9/16/80 SUPERSEDES 6-5-80 SCALE										TITLE										DO NOT SCALE									
																				REMOVE ALL SHARP EDGES ALL MACHINED SURFACES $\sqrt{}$										MAINTENANCE INSTRUCTIONS										EA189 90051 PAGE 3 OF 3																			
																				NOTICE THE INFORMATION CONTAINED HEREIN IS THE PROPERTY OF THE NAMCO CONTROLS A DIVISION OF THE ACME CLEVELAND CORP. AND IS SUPPLIED IN CONNECTION WITH OUR WORK. IT MAY NOT BE COPIED OR USED IN ANY MANNER THAT WOULD BE DETRIMENTAL TO OUR INTERESTS.										MATERIAL										STOCK SIZE																			
M	L	K	I	G	F	E	D	C	B	A	DATE 9/16/80 CHANGE 45557 T.M.																																																

BRUNING 40-21 34966

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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  $204 \times 10^6$  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:

$204 \times 10^6$  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

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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 debilitating 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 silicone 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

<u>Material</u>	<u>Where Used</u>
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

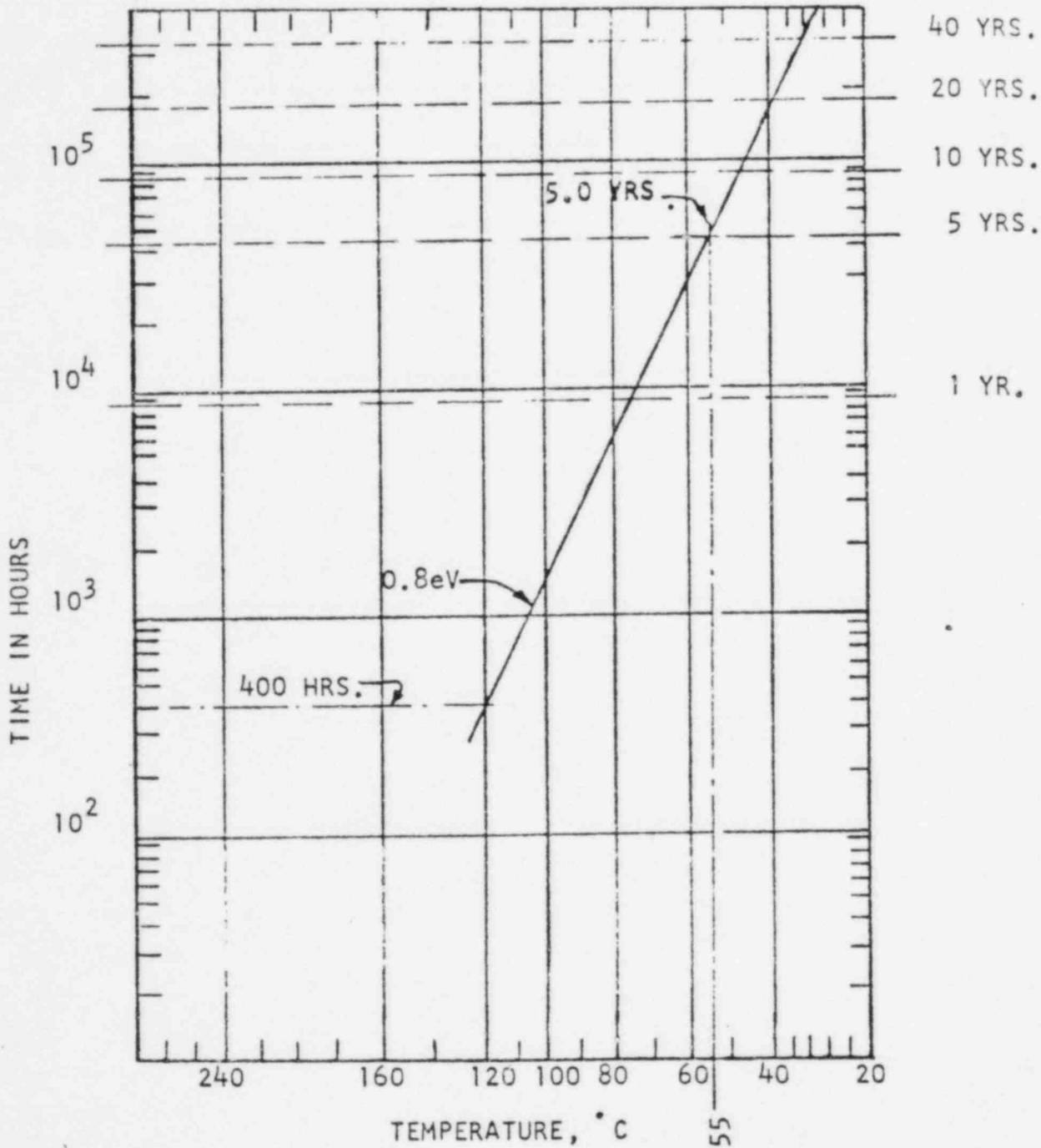


FIGURE 8

## 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  $204 \times 10^6$  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)

QTR 105

AUGUST 28, 1980

## 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.

QTR 105

AUGUST 28, 1980

## 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.

# 7 NAMCO CONTROLS

QTR 105

April 3, 1980  
DATE: FEBRUARY 29, 1980

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



QTR 105

April 3, 1980

## 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 ( $204 \times 10^6$  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.

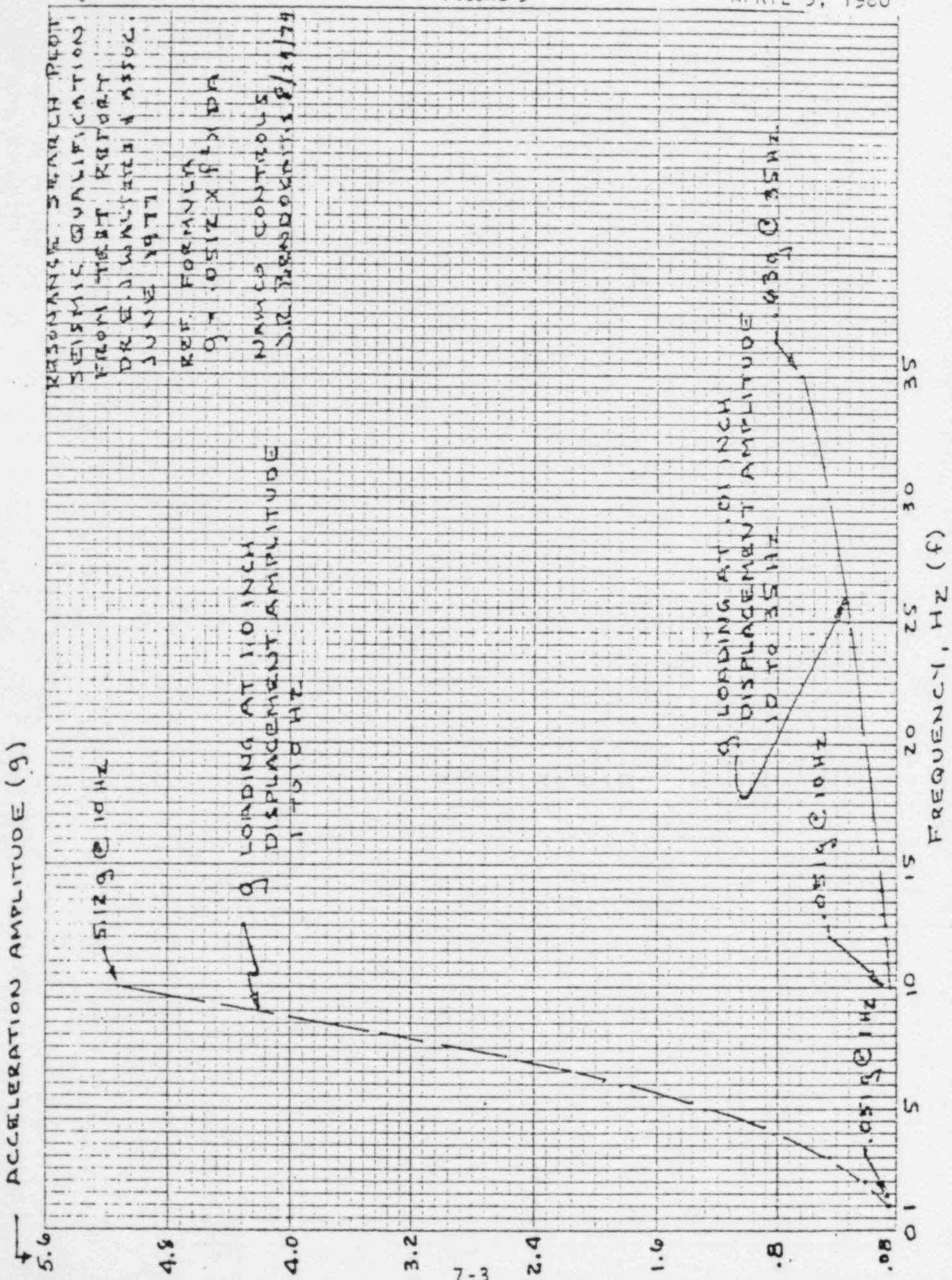
Note: All curves represent test limits because no contact openings (exceeding 2 msec) were encountered.

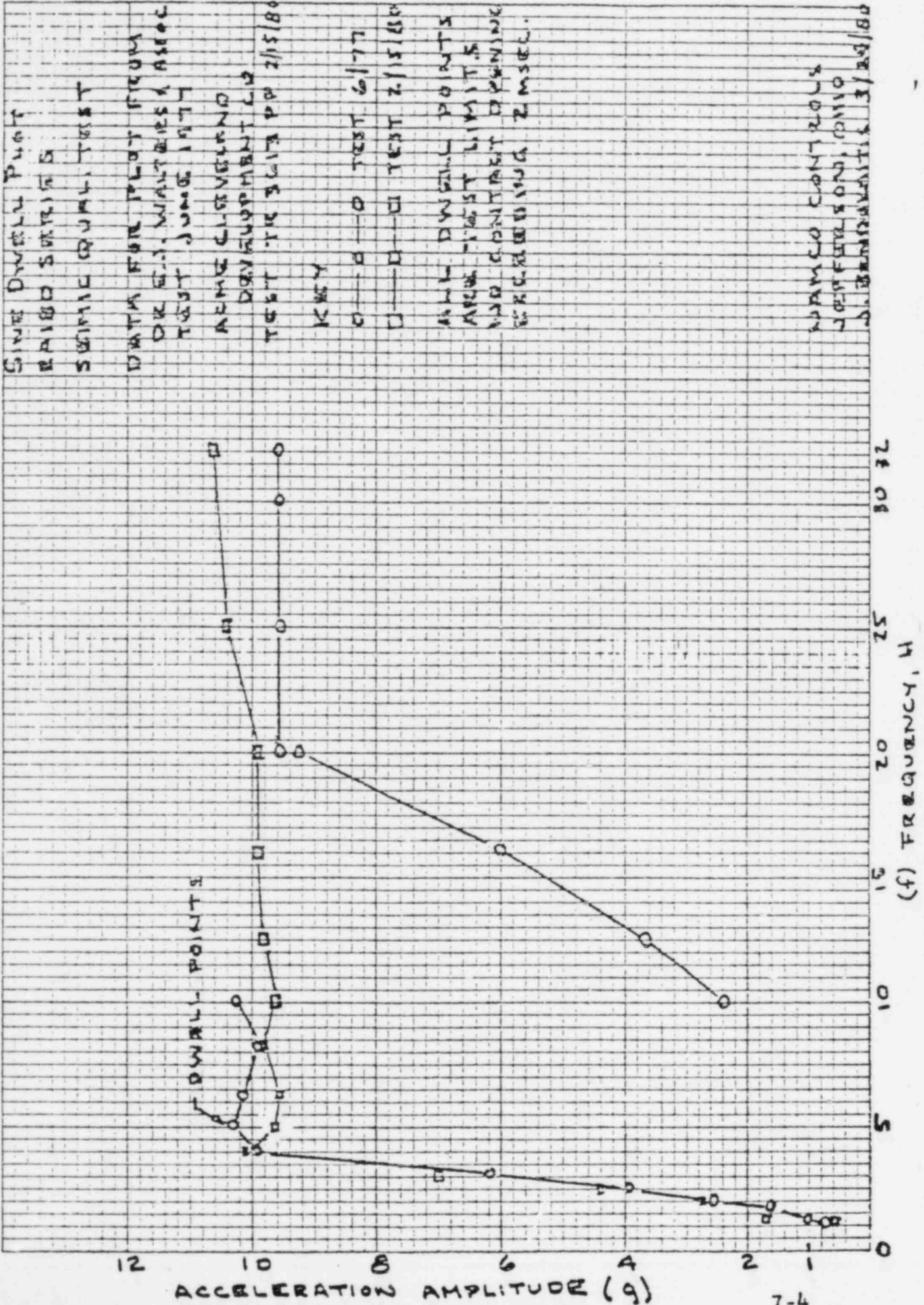
7.3.5 Switch mounting, standard switch mounting (side of housing) was used for all tests.

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.





K&E 10 X 10 TO THE INCH 45 0703  
7 X 10 INCHES  
MADE IN U.S.A.  
KEUPPEL & FROEN CO.

QTR 105

April 3, 1980

## 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.

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AUGUST 28, 1980

## 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.

QTR 105

April 3, 1980

## 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.

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April 3, 1980

## 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 Lock-washer.

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.

QTR 105

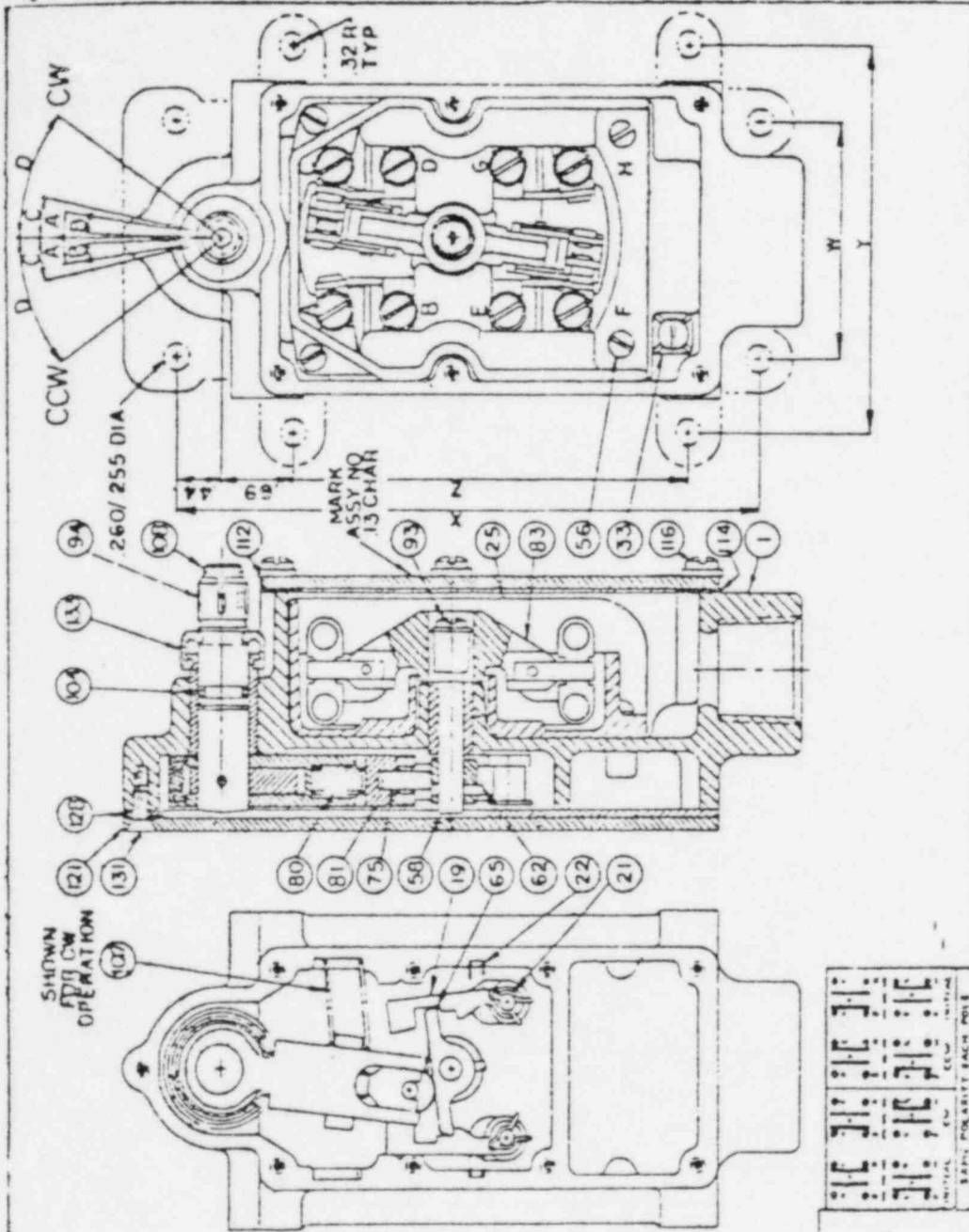
AUGUST 28, 1980

9.0 ATTACHMENTS

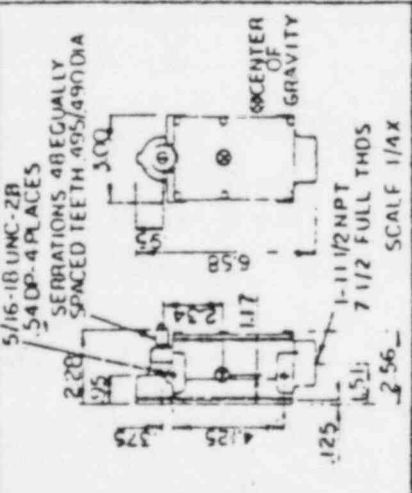
9.2 FA180 11302 Limit Switch Assembly

9.3 EA180 14302 Limit Switch Assembly

9.4 E1060 53300 Operating Lever Assembly



EA180 11302	QTY	DIM X	DIM Y	DIM Z
EA180 11302	1	3.687	3.812	
EA180 11302	1	2.250	5.625	
EA180 11302	1	3.687	3.812	
EA180 11302	1	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

- 1 HEAVY DUTY CONTACT ARRANGEMENT IS DOUBLE POLE (X OF 1-A B C D POLE 2 E F G H) DOUBLE THROW BUTT CONTACTS, QUICK MAKE - QUICK BREAK WITH FIGHT 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" INCHMENTS THRU 17.7"
- 4 ADEQUATE WIRING SPACE FOR NINE NO 12 AWG CONDUCTORS
- 5 AS5Y JPEC
- 6 LUNE JPEC
- 7 INSTALLATION IN THICKNESS PER 10 +90 °C
- 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

**NAMCO CONTROLS**  
 An Army Company  
 CLEVELAND, OHIO U.S.A.

**D2400 NUKLEAR SWITCH**

ASSY NO: 11302

INITIAL: JEC

DATE: 1-23-80

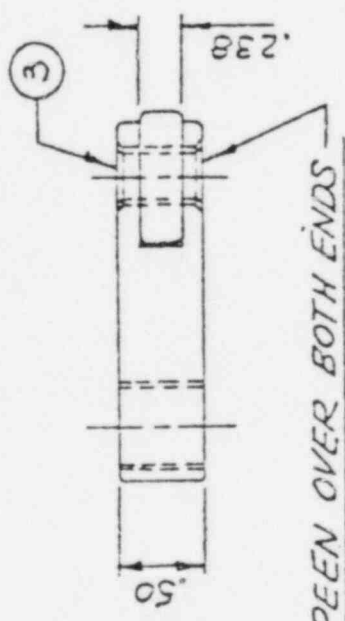
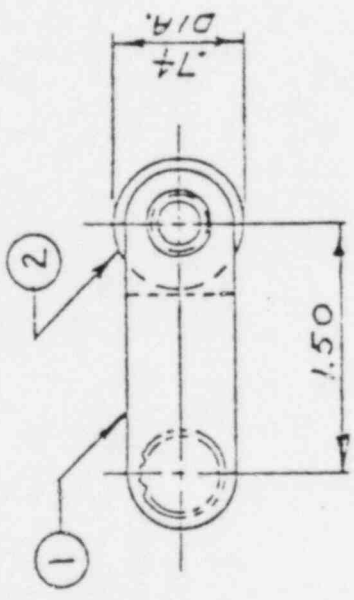
SCALE: FULL

RM

EA180 11302



ELO60 53300 ©	PART NO.	REF. NO.	ITEM 2	REMARKS	OPERATION	QTY
	ELO60 53300	D1260-RU	ELO21 33014	B <sub>ECU</sub> ROLLER	1	
	ELO60 53301	Z10619-5,	ELO21 33017	NITRONIC 60 ROLLER	2	
					3	
					4	
					5	
					6	
					7	
					8	
					9	
					10	



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.	
181 SERIAL		NO. REQ'D.		STOCK SIZE		THE NATIONAL ACME CO. CLEVELAND, OHIO	
LAST SERIAL		DR. DECOOPER		OPERATING LEVER ASSEM.		ELO60 53300	
SUPERSEDES		TR.		SCALE FULL		DATE 4-13-59	
SUPERSEDED BY		CK.		MATERIAL			
REVISIONS		REMARKS					
AT	DATE						
1	9-2-59						
2	10-2-59						
3	11-2-59						
4	12-2-59						
5	1-2-60						
6	2-2-60						
7	3-2-60						
8	4-2-60						
9	5-2-60						
10	6-2-60						

QTR 105

April 3, 1980

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**

625 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

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ACME-CLEVELAND DEVELOPMENT COMPANY

CERTIFICATION

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

James J. Patsey  
J. J. Patsey  
R & D Technician

2/19/80  
Date

Edward L. Solem  
E. L. Solem  
Development Engineer

2/18/80  
Date

APPROVED BY:

Thomas Skingle  
T. J. Skingle, P. E.  
Corporate Manager  
Materials R & D

Feb-18, 1980  
Date

Robert L. Nekola  
R. L. Nekola, P. E.  
General Manager  
Acme-Cleveland Development Company

Feb 17, 1980  
Date

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.

*ELS*

Throughout the testing the following equipment was used to determine the performance level of the units.<sup>1</sup> 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-

---

<sup>1</sup> Calibration dates are contained in Appendix F.

EYS

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 test-int 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-

*E.L.S.*

oscope 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)

<u>Frequency</u>	<u>Peak Acceleration</u>	<u>Peak to Peak Displacement</u>
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.<sup>1</sup>

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.<sup>2</sup>

<sup>1</sup>The switch circuits were energized and the switch exercised in this test as it would have been in full testing.

<sup>2</sup>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.

*EJL*

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/JJP:cr

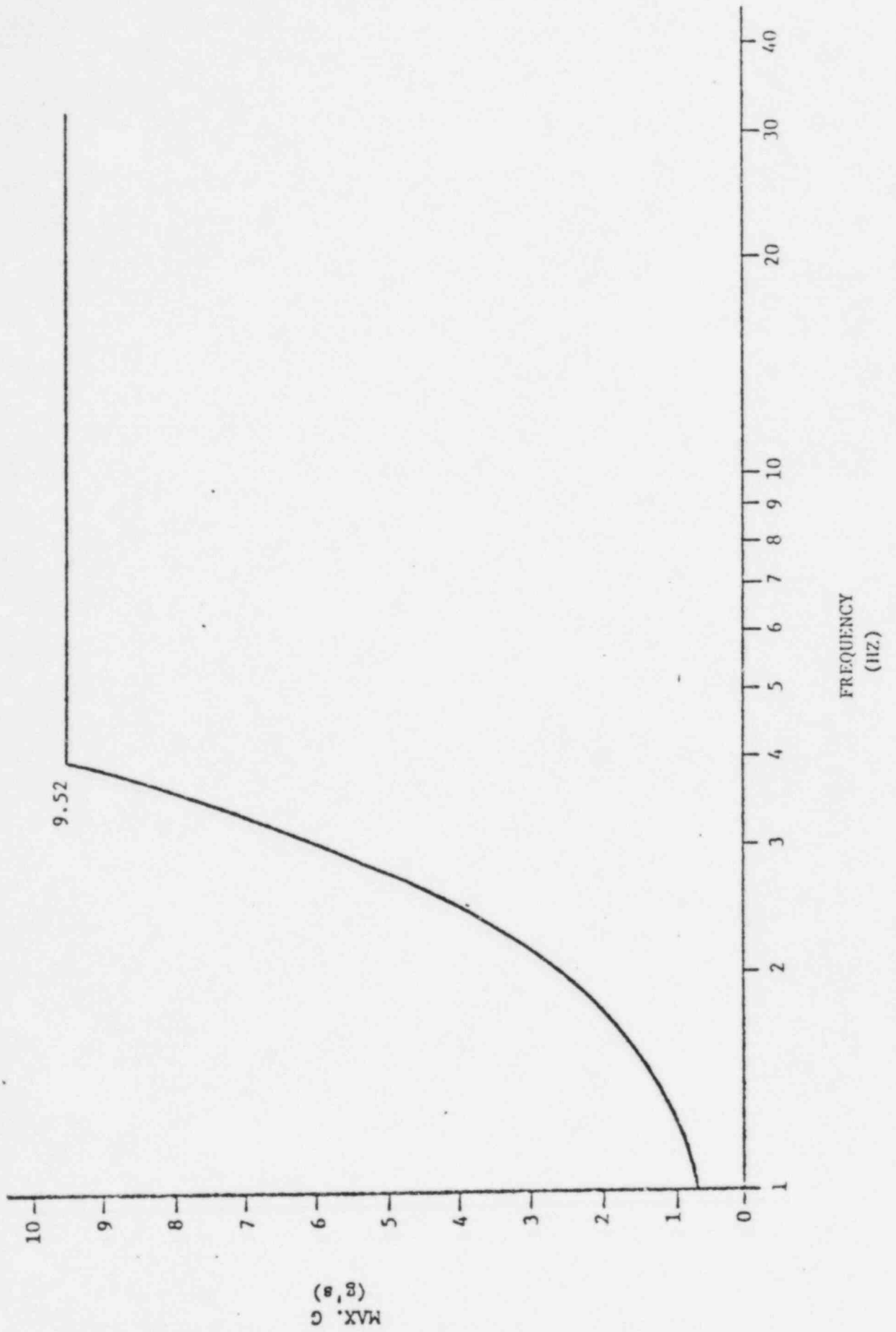
Enclosures

*ELS*

FIGURES

FIGURE 1

SEISMIC INPUT MOTION



MAX. C  
(g's)

FREQUENCY  
(HZ)

FIGURE 2

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

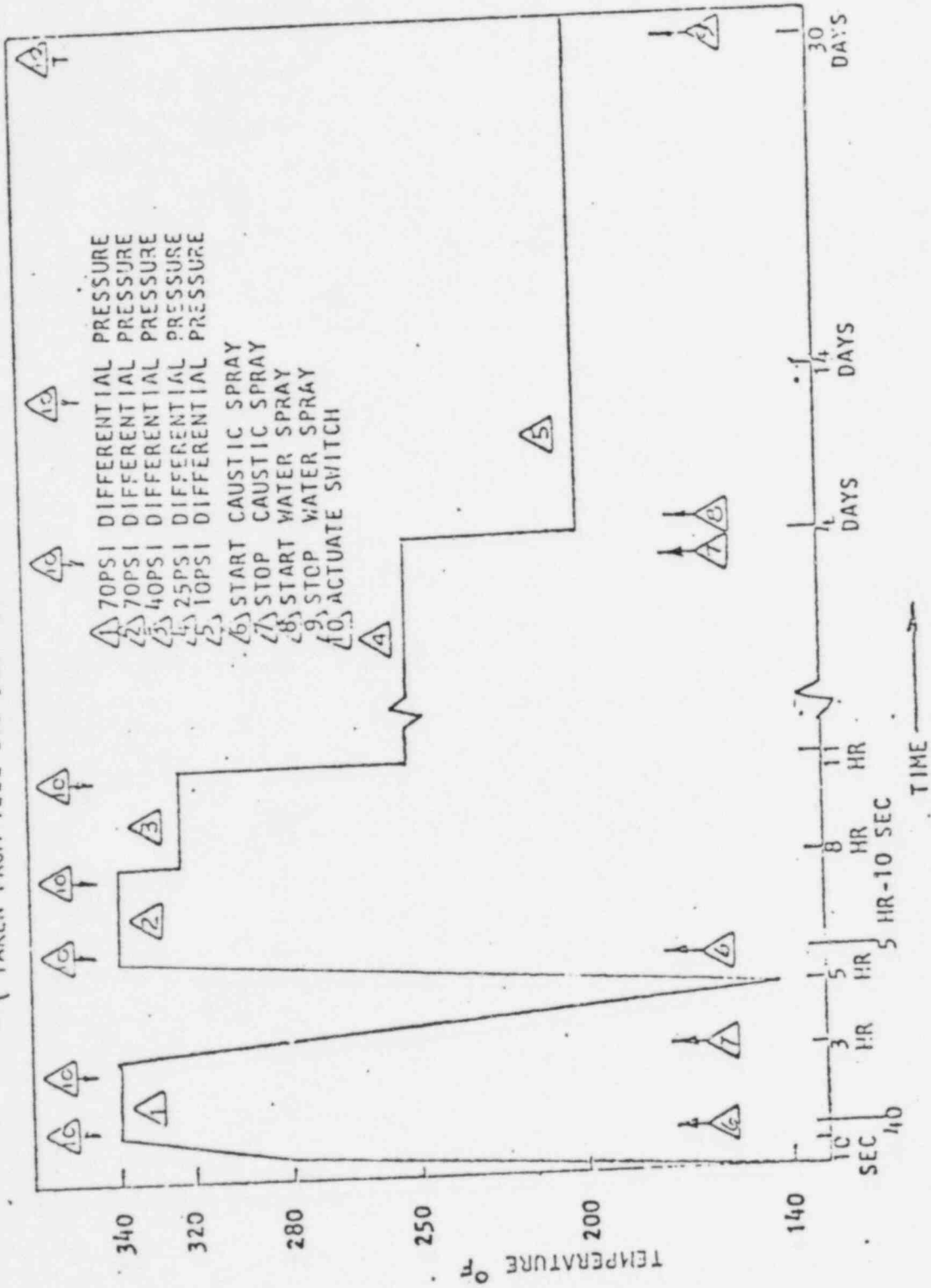
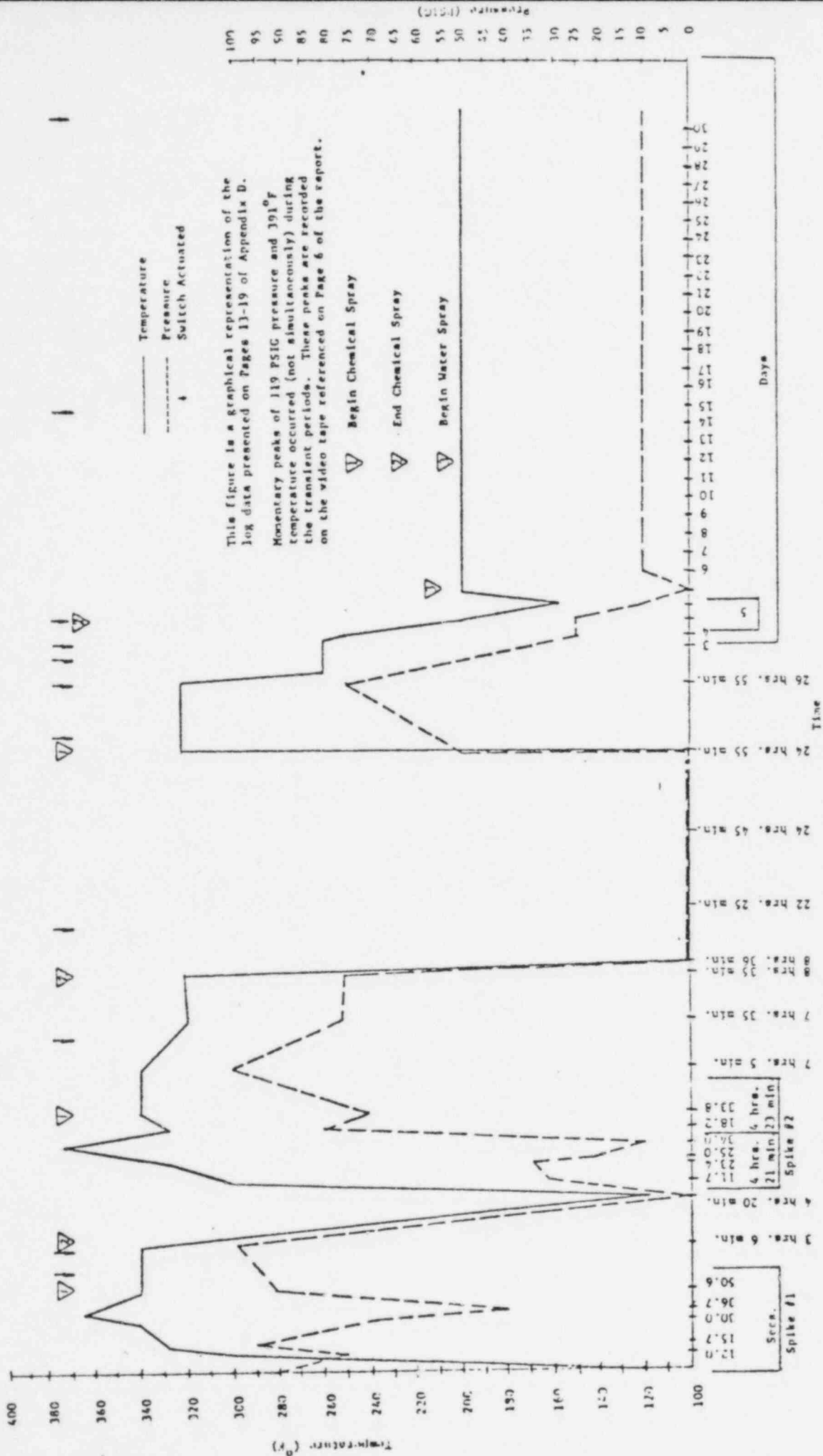


FIGURE 3  
 TEST CHAMBER PROFILE FOR FCC (INLET ENVIRONMENT SIMULATION)  
 (As Recorded)



APPENDIX A  
RADIATION EXPOSURE

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

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

November 20, 1979

Mr. E.L. Solem  
Development Engineer  
Acre-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  $2.04 \times 10^8$  rads (air) or  $2.3 \times 10^8$  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:	$9.1 \times 10^5$ rad/hour
Total Dose:	$2.04 \times 10^8$ 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

Mr. E.L. Solcin  
Page 2  
November 20, 1979

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:  $9.1 \times 10^5$  rad/hour

Total Dose:  $2.3 \times 10^8$  rads (air)

Specimen Id: (Switch) 134-63  
(Switch) 136-90  
2 unlabes 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 G 29

Account Number \_\_\_\_\_

Sponsor/Address Amoco Controls / Ac Ho - Cleveland

Job Description: (7) limit switches (9) small pieces

2011 M Rank 131-2, 138-90, 137-67,  
97, 96 and NRC-90

Scheduled Start: \_\_\_\_\_

Budget:

P.S. \_\_\_\_\_ hr. @ \_\_\_\_\_

M&S \_\_\_\_\_

Hot Cell \_\_\_\_\_ @ \_\_\_\_\_

Gamma Pool \_\_\_\_\_ @ \_\_\_\_\_

Other \_\_\_\_\_

Total Contract \_\_\_\_\_

*2 days  
11:50 am + 1 hour  
+ Radio  
2 days  
17 hrs  
1 day 4 hrs 30 min*

Actual Start 11-5-79 1655 (4:55 pm) Stop 5:10 am 11/12/79

Completion 2nd start 11-16-79 (1730 - 5:30 pm) 2nd Stop 11-19-79 10:30 am

Restart 11-19-79 at 12:25 (12:25 pm) - Stop 11-20-79 1655 pm

Smearable contamination on specimen after test < 100 d/m / 100 c/m

Jim Brey  
Radiological Safety Officer

Irradiation of specimen(s) performed by

[Signature]

Dosimeter Readings

A 1610 nch → 1690 × 199.6  $\frac{\text{rad}(hr)}{\text{hr}}$  ×  $\frac{90017 \text{ rad} \cdot \text{hr}^{-1}}{25(1490)}$  ×  $\frac{60 \text{ min}}{hr} \times \frac{1}{200}$   
 B 1770 --  
 etc.

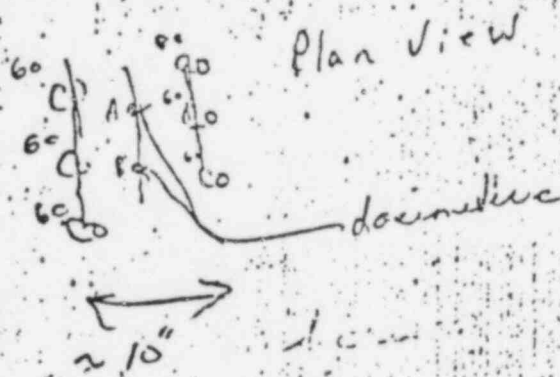
$9.1 \times 10^5 \text{ rad(air)/hr}$

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 bottom



Calculations

$\frac{2.04 \times 10^8}{9.1 \times 10^5} = 224 \text{ hours } 11 \text{ min (9 days 8 hr 11 min)}$   
Actual — 9 days 8 hr 15 min

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

APPENDIX B  
SEISMIC QUALIFICATION TEST

SEISMIC QUALIFICATION TEST  
OF  
LIMIT CONTROL SWITCHES  
June 1977

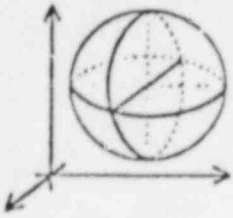
Prepared for  
NAMCO Controls  
An Acme-Cleveland Company  
Jefferson, Ohio

10-21

Page 1 of 14 (B)

*Dr. Edward J. Walter & Associates*  
*Vibration and Sound Consultants*





*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.

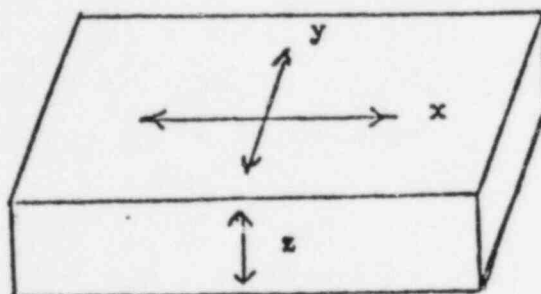
During the vibration test, the switch contacts were monitored for opening by a light indicator circuit. If the light indicator circuit signaled a contact opening, the duration of opening was then monitored on an oscilloscope. The criteria for seismic failure was a contact opening of 2.0 milli-seconds 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 oscilloscope. 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	$1 \leq f \leq 4$ Displacement - 12.0 inches pp. giving 9.52 g's at 4 Hz
1.25	
1.6	
2.0	
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.
	$10 \leq f < 20$
10.0	Displacement - 0.45 inches pp.
12.5	
16.0	
20.0	
	$20 < f < 35$ - acceleration 9.52 g
25.0	Displacement - 0.4 inches pp.
32.0	

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 5/4 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 milliseconds 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	S w i t c h			
	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 milliseconds.

\*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

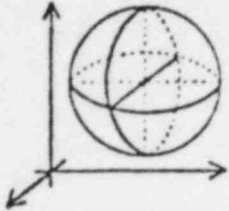
Calidyne Electrodynamic Shaker, Model B44

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

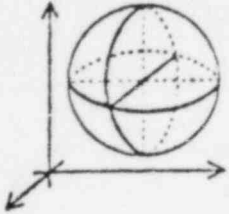
The purpose of the test was to determine whether cross-coupling would cause the switch to trip, and thus fail. The roller and spring were removed and the switch was vibrated in the Y-component. No failures were observed during the test procedure. The displacement, maximum frequency, and g-loading at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

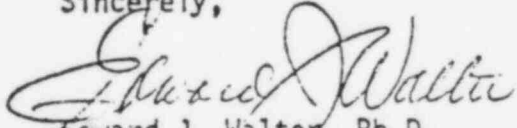
Attn.: Mr. Ed Solem

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, 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 oscilloscope that the circuit was responding not to contact openings but to small changes in voltage due to increases in contact 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 oscilloscope 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 Solen  
E. Solen  
Metallurgical Engineer

7/13/77  
Date

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  $9^{\circ}$  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  $9^{\circ}$  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  $9^{\circ}$  of the Y axis. Therefore, a vibration with a deviation of  $9^{\circ}$  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):

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>
Preload <sup>1</sup> Force (107)	Weight of Non-Cylindrical Parts of (94)	Weight of (81)	Total Off Axis Weight (B + C)	Mechanical Advantage	Effective <sup>2</sup> 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.<sup>3</sup> This conservatively simulates any cross coupling between components (75, 80, and 81) and (65).

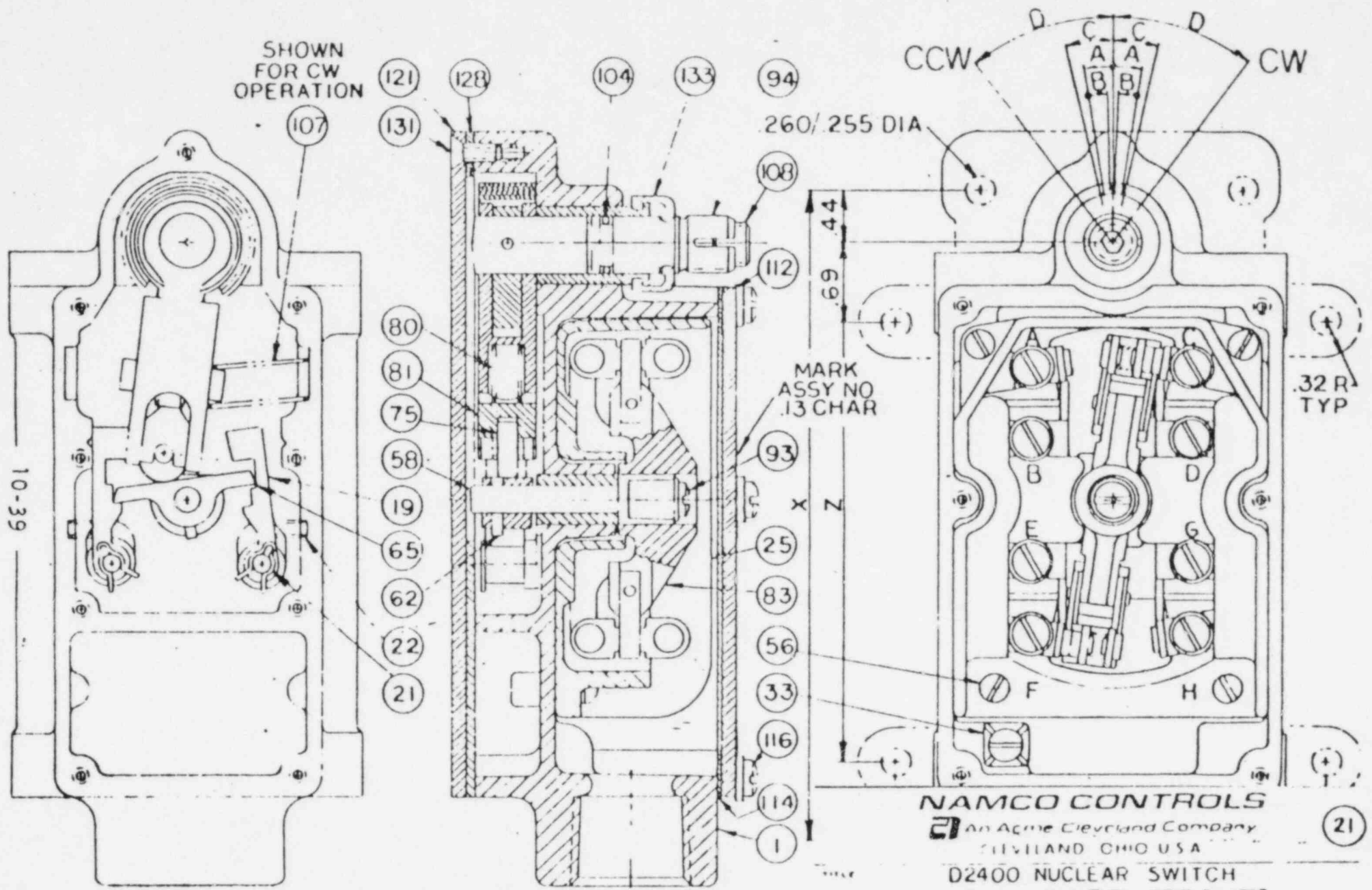
Due to the above considerations, cross coupling is not considered limiting in this unit; and therefore, single axis vibration testing is considered suitable.

ELS:cr

<sup>1</sup>Blueprint specified minimum.

<sup>2</sup>All mass is conservatively assumed to be concentrated at the end of the lever shaft assembly.

<sup>3</sup>See Page 12(B).



10-39

**NAMCO CONTROLS**  
 An Acme Cleveland Company  
 CLEVELAND OHIO USA

D2400 NUCLEAR SWITCH  
 STANDARD TRAVEL

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

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

ELECTRICAL MEASUREMENTS

LOAD: .086 amps at 100 volts DC

	<u>INITIAL</u> ( <u>10/3/79</u> )	<u>FINAL</u> ( <u>10/22/79</u> )	<u>OTHER</u> ( )
<u>MEGGAR</u>			
<u>1</u>	<u>1000 M*</u>	<u>Inf.</u>	
<u>2</u>	<u>1000 M*</u>	<u>Inf.</u>	
<u>3</u>	<u>1000 M*</u>	<u>Inf.</u>	
<u>4</u>	<u>1000 M*</u>	<u>Inf.</u>	

	<u>CONDUCTIVITY (AMPS)</u>		
<u>1</u>	<u>.086</u>	<u>.086</u>	
<u>2</u>	<u>.086</u>	<u>.086</u>	
<u>3</u>	<u>.086</u>	<u>.086</u>	
<u>4</u>	<u>.086</u>	<u>.086</u>	

	<u>CONTACT RESISTANCE</u> (IN OHMS)--BEFORE TEST		
<u>1</u>	<u>.05</u>	<u>::</u>	
<u>2</u>	<u>.05</u>		
<u>3</u>	<u>.06</u>		
<u>4</u>	<u>.05</u>		

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

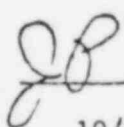
	INITIAL ( )	FINAL ( )	OTHER ( )
<u>MEGGAR</u>			
1	Inf.	Inf.	
2	Inf.	Inf.	
3	Inf.	Inf.	
4	Inf.	Inf.	

	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:   
DATE: 10/24/79

IRRADIATION

SWITCH NO.:  
MODEL NO.:

138-90  
EZ-1C683-90/EA-180-11302

IRRADIATED

AT:  
FROM/TO:  
TOTAL IRRADIATION:  
ENERGY LEVEL:  
SOURCE:  
RATE:

Georgia Tech University  
10/29/79 - 11/20/79  
204 megarads  
1.173 Mev. and 1.332 Mev  
Cobalt 60 gamma  
9.1 x 10<sup>5</sup> rads/hour

ELECTRICAL MEASUREMENTS

LOAD: .086 amps at 100 volts DC

	INITIAL ( 10/29/79 )	FINAL ( 12/5/79 )	OTHER ( )
--	-------------------------	----------------------	--------------

MEGGAR

1	<u>Inf.</u>	<u>Inf.</u>	<u>_____</u>
2	<u>Inf.</u>	<u>Inf.</u>	<u>_____</u>
3	<u>Inf.</u>	<u>Inf.</u>	<u>_____</u>
4	<u>Inf.</u>	<u>Inf.</u>	<u>_____</u>

CONDUCTIVITY (AMPS)

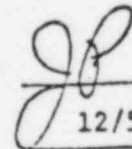
1	<u>.086</u>	<u>.086</u>	<u>_____</u>
2	<u>.086</u>	<u>.086</u>	<u>_____</u>
3	<u>.086</u>	<u>.086</u>	<u>_____</u>
4	<u>.086</u>	<u>.086</u>	<u>_____</u>

COMMENTS

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

SIGNED: \_\_\_\_\_

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

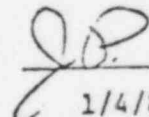
LOAD: .0.5 amps at 125 volts LC  
( 12/12/79 ) ( 1/4/80 )

MEGGAR

1	<u>Inf.</u>	<u>Inf.</u>
2	<u>Inf.</u>	<u>Inf.</u>
3	<u>Inf.</u>	<u>Inf.</u>
4	<u>Inf.</u>	<u>Inf.</u>

CONDUCTIVITY (AMPS)

1	<u>.086</u>	<u>.086</u>
2	<u>.086</u>	<u>.086</u>
3	<u>.086</u>	<u>.086</u>
4	<u>.086</u>	<u>.086</u>

SIGNED:   
DATE: 1/4/80



SEISMIC TEST

CODES

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

- 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. <sup>-1</sup> )	Accelerometer Output (mV/g)	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	57.7*	6	.956								
1.6	.625	101.0*	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: JBF

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

10-47

Page 7 of 19 (D)

SEISMIC TEST

CODES

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

- 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. <sup>-1</sup> )	Accelerometer Output (mV-pp)	Displacement (Inches)	Max. g (g's)	Normally Open			Normally Closed			Pre-Travel Reset	
					Mech.	Seismic	Osc.	Mech.	Seismic	Osc.	Angle	Angle
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. O.  
 Date: 12/21/79 and 1/2/79

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Page 8 of 19 (D)





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 H. Prior*

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:



DATE:

2/7/80


DYE TEST

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

MODEL NO.: EZ-1068J-90/EA-180-11302

SWITCH NO. 1 136-90

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. Drop temperature control to off. Add 60 PSI air for cool down.
1/7/80	9:00 a.m.		250					Set controller to #1.
1/7/80	9:15 a.m.		120	90				
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. Turn on Control #2. (Start spray at 9:20 a.m.)
1/7/80	9:20 a.m.		340	80-100	200-250			Turn Lindberg to 1200°F.
1/7/80	9:30 a.m.		340	80-100	200-250			Turn Lindberg to 1300°F.
1/7/80	9:40 a.m.		340	90-110	200-250			Turn down valve on chamber outlet.
1/7/80	9:48 a.m.		340	95-105	200-250			Turn down steam generator to 160 PSI.
1/7/80	10:00 a.m.		339-342	95-105	200-250			
1/7/80	10:05 a.m.		340-343	93-105	210			Drop pressure on steam generator to 140 PSI.
1/7/80	10:10 a.m.		340-342	93-103	210			

SIGNED:  DATE: 1/7/80


DME TEST

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

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

SWITCH NO.: 138-90

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			Increase steam generator to 160 PSI.
1/7/80	10:45 a.m.		340-343	93-103	210			Tank lost all caustic solution. Turn temperature off.
1/7/80	11:00 a.m.		340-343	93-103	210-230			
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	(air 25 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				Control #2 and spray on.
1/7/80	1:42 p.m.		340	85-115	210-240			Tank temperature 310°F (set).
1/7/80	1:48 p.m.		340	80-106				
1/7/80	2:10 p.m.		340-347	87-110	210			Tank temperature 315°F.
1/7/80	2:50 p.m.		340-345	90-112	230-250			

SIGNED:   
 DATE: 1/7/80

SWITCH NO.: 138-90

MODEL NO.: EZ-10683-90/EA-100-11302

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: 

DATE: 1/7-8/80

DRE TEST

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

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

SWITCH NO.: 138-90

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:  1/8-10/80  
 DATE: 1/8-10/80

DBE TEST


PAGE NO. 1 5 of 7

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

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

SWITCH NO.: 138-90

DATE	TIME	ELAPSED TIME	TEMPERATURE (°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°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:   
 DATE: 1/10-12/80

DNE TEST

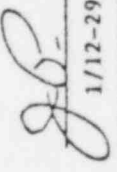
PAGE NO.: 6 of 7

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

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

SWITCH NO.: 138-90

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:  DATE: 1/12-29/80



APPENDIX E  
EQUIPMENT CALIBRATION

<u>Equipment</u>	<u>Calibrated</u>
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

QTR 105

April 3, 1980

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.

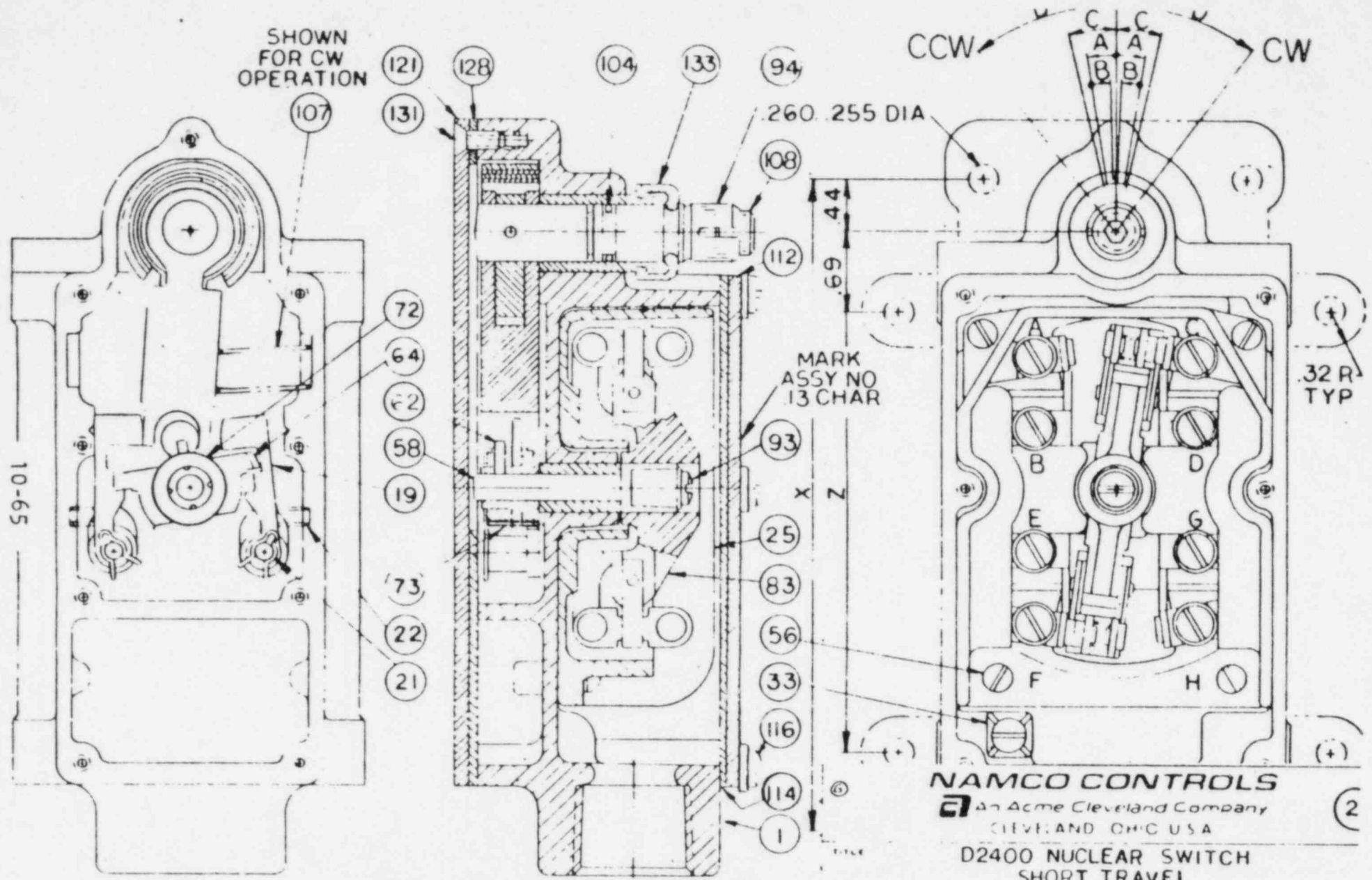
Those switches of the EA-180 series which contain a short travel mechanism differ internally from the standard travel versions in some respects. It was, therefore, felt that it was necessary to test a short travel model up through the seismic portion of the test in order to verify that the internal mechanism 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.



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. Patscy

Page 3 of 11 (F)

*J.P.*

DATE 12/23/77

HEAT AGING

SWITCH # 83-51

1-71

MODEL # EA-180-14302

PROTOTYPE  
 PRODUCTION

EZ1060751

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 .04" 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
INITIAL	Inf	Inf	Inf	Inf
FINAL	"	"	"	"
OTHER				
(Continue on back)				
INTERIOR EXAMINATION (OPTIONAL)				
GASKETS:				
CONTACTS:				
BLOCK:				
O-RING:				
GREASE:				

JP



DATE 1-31-78

SWITCH # 83-51

1-71  PROTOTYPE  
 PRODUCTION

MODEL # EA180-14302  
EZ10607-51

IRRADIATION

IRRADIATED AT: <u>Isomedix, Inc.</u>									
FROM <u>1-12-78</u>		TO <u>1-31-78</u>		TOTAL IRRADIATION <u>204 Mrad.</u>					
ENERGY LEVEL <u>1.25 Mev.</u>		SOURCE <u>Cobalt 60 gamma</u>				RATE <u>1.2 Mrad/ht.</u>			
ELECTRICAL MEASUREMENTS ;				LOAD <u>.086A @ 100 DC</u>				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.)									
J8									



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.

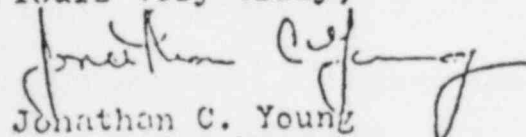
The switches were placed in a cobalt-60 gamma field at a dose rate of 1.2 Mrad per hour. The switches were exposed for 170.0 hours, yielding a minimum dose of 204 megarads.

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

Isomedix Inc. • 25 Eastmans Road, Parsippany, New Jersey (201) 887-4700  
Mailing Address Post Office Box 177, Parsippany, New Jersey 07054

CHICAGO DIVISION • 7828 Maple Ave., Merton Grove, Illinois 60553 (312) 566-1100

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

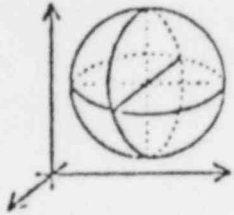
Electricals

Megohm

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	"	"	"	"	"	"	"	"

J.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



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

## 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 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:

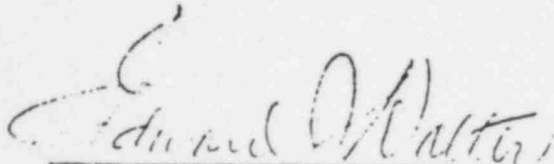
Changes in Trip Position  
which exceeded 1/16 inch

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 56 minutes each.

  
DR. EDWARD J. WALTER AND ASSOCIATES  
February, 1978

QTR 105

AUGUST 28, 1980

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 131<sup>ST</sup> 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

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

TEST PLAN NO. LP10767-3

DATE JULY 26, 1979

*John R. Bendokaitis*

John R. Bendokaitis  
Project Engineer  
Nuclear Switch Coordinator  
NAMCO CONTROLS

*Joseph Buzogany*

Joseph Buzogany  
Chief Engineer  
NAMCO CONTROLS

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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	$4 \times 10^6$ 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	$180 \times 10^6$ Rads, Gamma

Total test exposure to radiation  $204 \times 10^6$  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 ~~and~~ 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 conditions, 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.

<u>SERVICE TEMP</u>		<u>EST. QUALIFIED LIFE</u>
<u>° F</u>	<u>° C</u>	<u>Years</u>
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 vendor. 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	$180 \times 10^6$	Rads
Margin (+10%)	$20 \times 10^6$	Rads
Normal environment (40 yrs inside containment)	$4 \times 10^6$	Rads
Total exposure (this test)	$204 \times 10^6$	Rads Minimum

6.5.6 Radiation type and rate

Cobalt-60 Gamma field at a rate of .5 to  $1 \times 10^6$  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 111, 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.

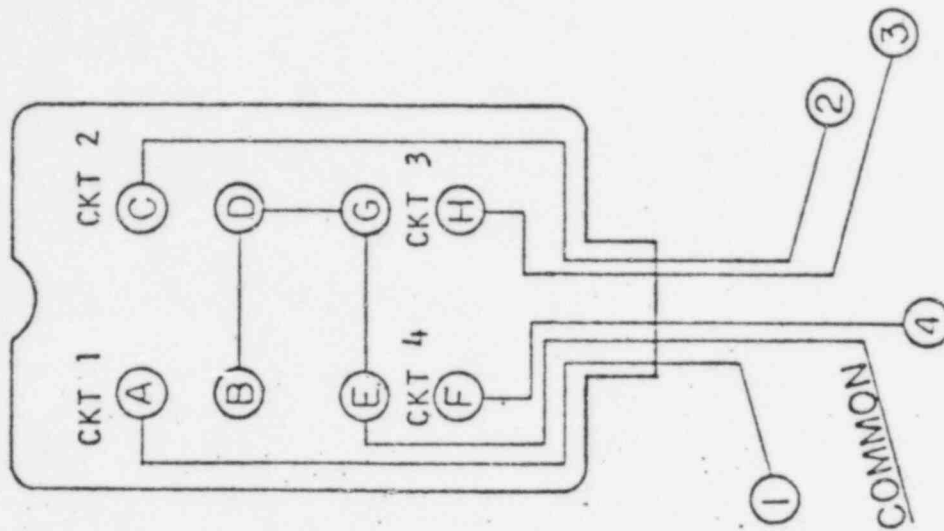
9.2 Qualify the EA180 13302 limit switch, the maintained contact version of the standard EA180 type.

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

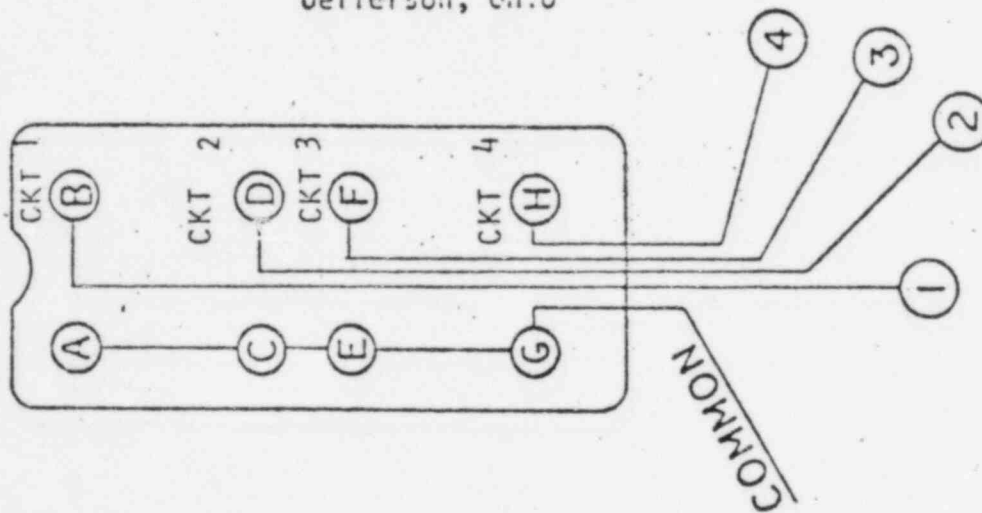


SEISMIC QUALIFICATION TEST  
OF  
LIMIT CONTROL SWITCHES  
June 1977

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

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

TOP VIEW  
EA740 LIMIT SWITCH  
WIRE CONNECTIONS  
FIG. 1A

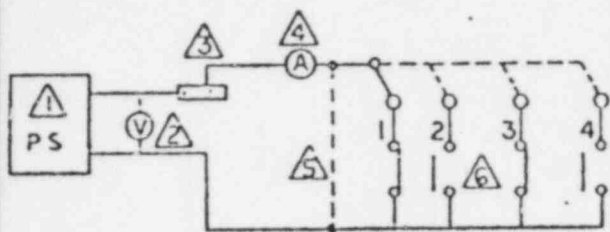


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Page 1 of 14 (B)

Dr. Edward J. Walter & Associates  
Vibration and Sound Consultants





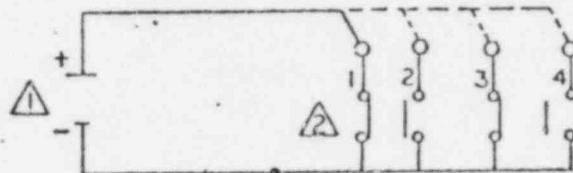
24

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

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Electrical Load Test

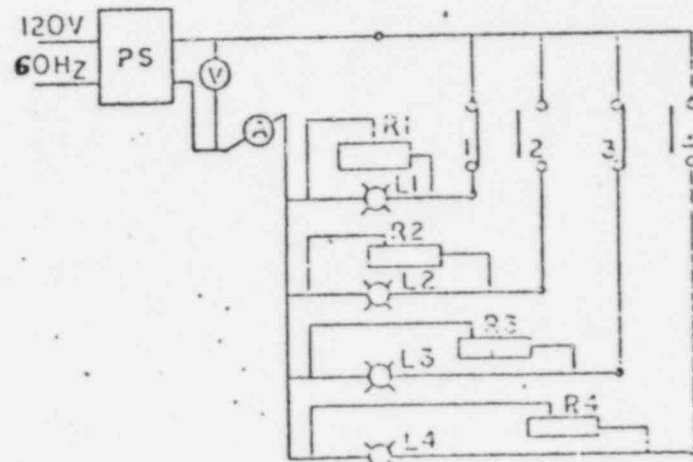
FIG. 2A



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

Insulation Resistance Test  
(Open Circuit Resistance)

FIG 2B

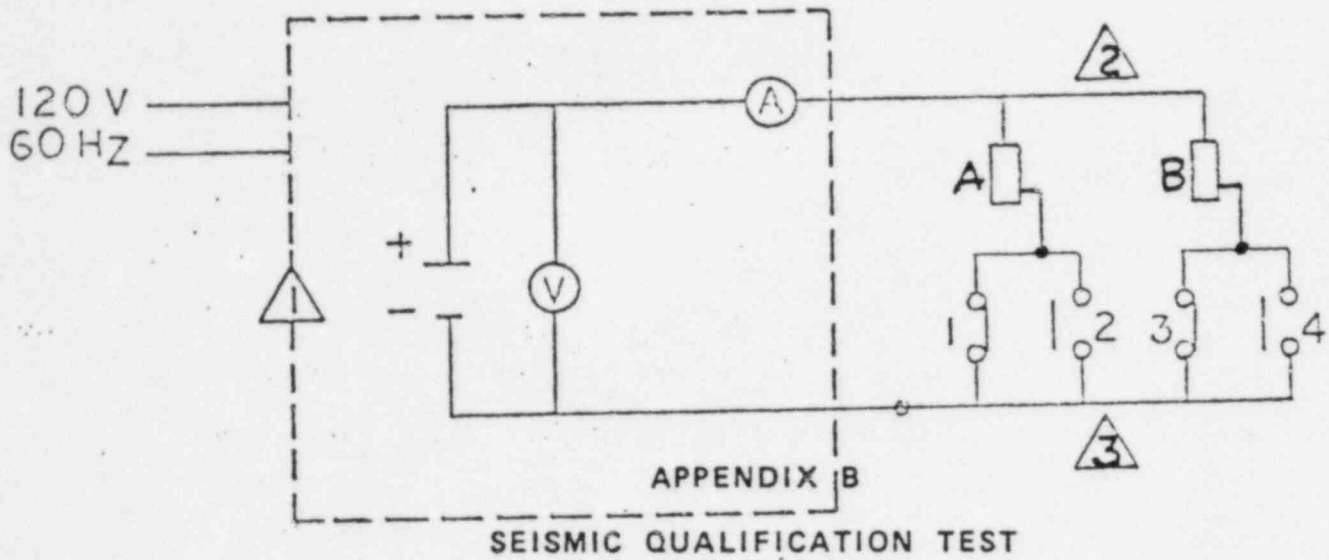


- PS DC Power Supply
  - A Am meter (DC)
  - V Voltmeter
  - L1, L2, L3, L4 Pilot Lights
  - R1, R2, R3, R4 Variable Resistor
- Circuit for indication of contact closure during pretravel and differential travel test

FIG 2C

FIG 2

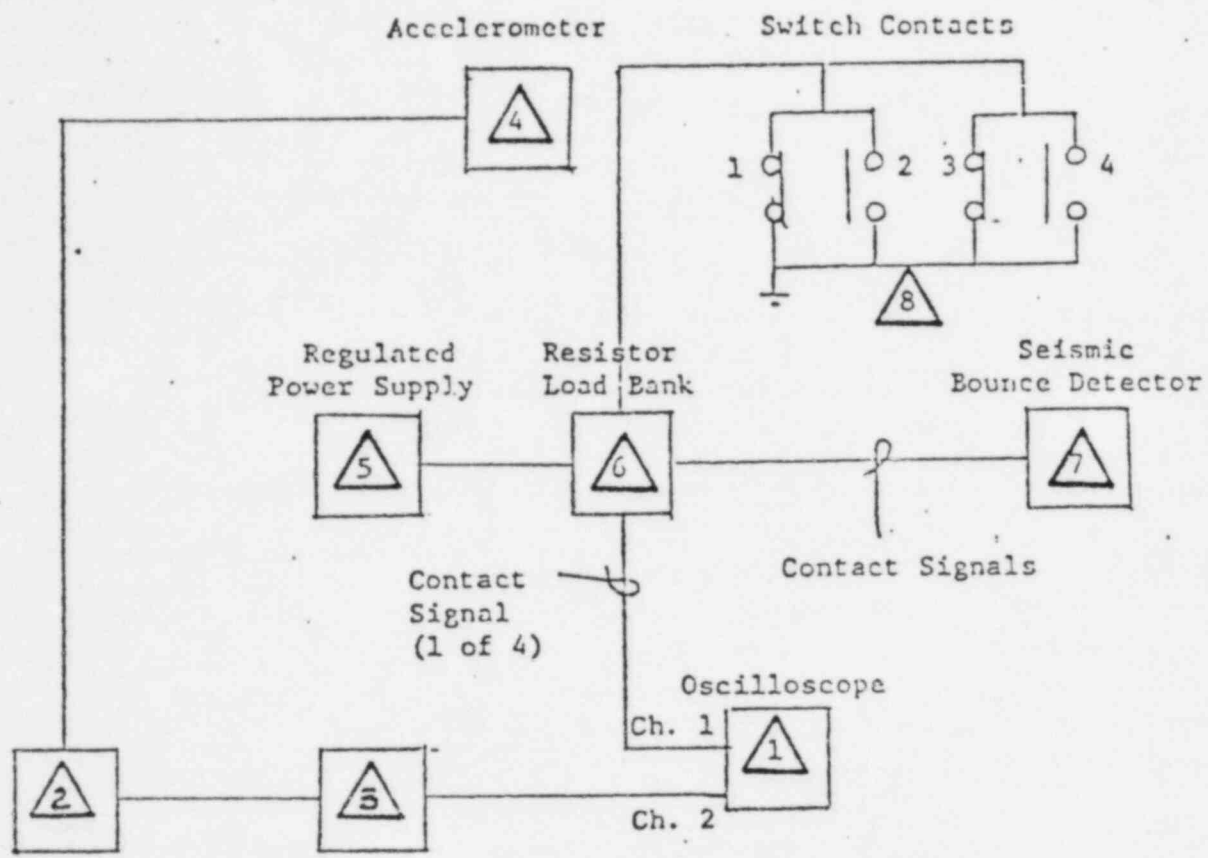
CONNECTION DIAGRAMS



- 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



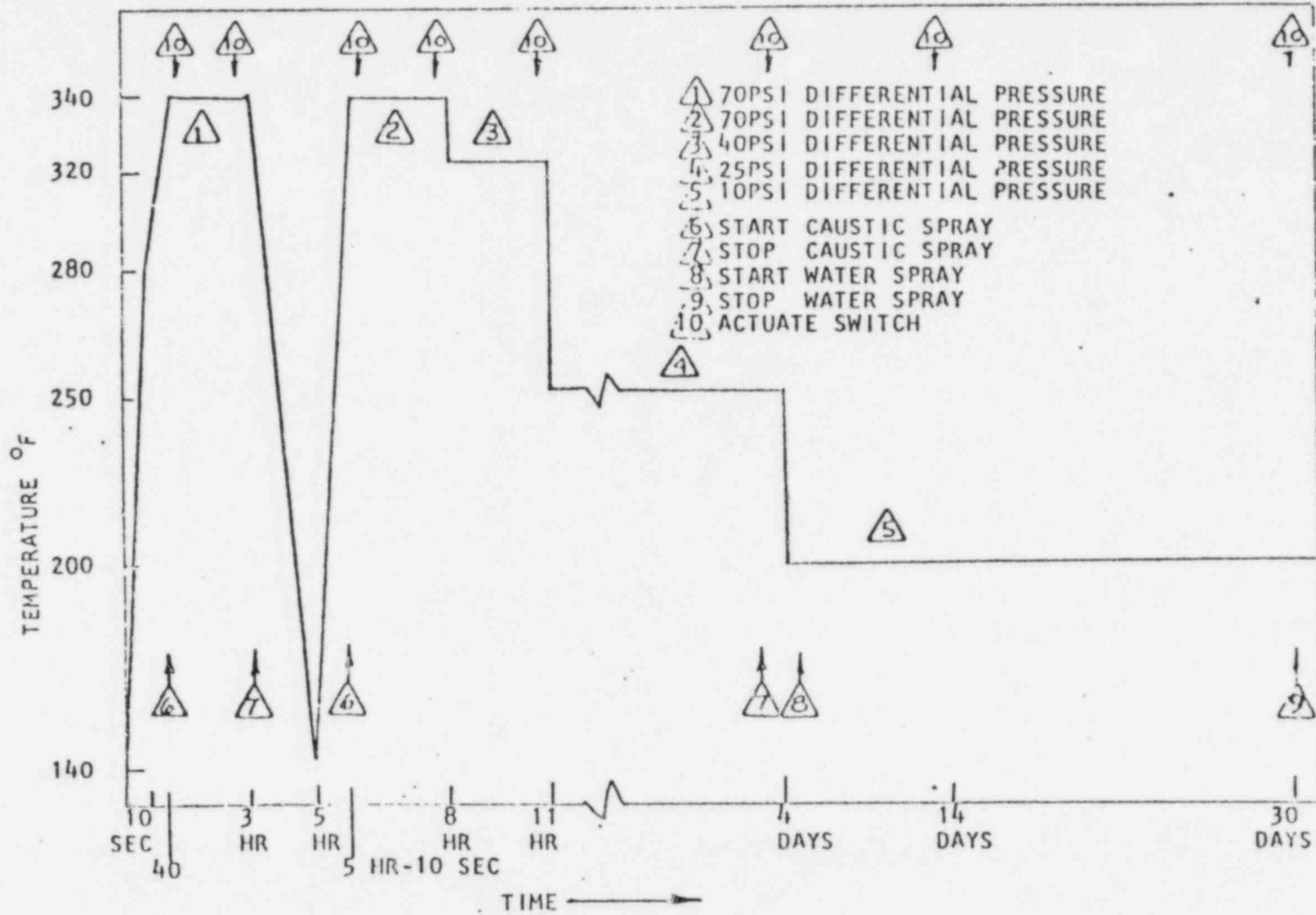
- 1 Tektronix Type 564 Oscilloscope
- 2 EBN Model P16 amplifier modified for 1 Hz operation
- 3 Low pass filter, Krohn-Hite #3202
- 4 EBN accelerometer pickup Model 507, sensitivity 28.87 mv/g
- 5 Lambda regulated power supply #LCS-A-100
- 6 Resistor load banks
- 7 Seismic bounce detector receives contact 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



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



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FIGURE 8

LP10767-3

AUGUST 28, 1980

## GEORGIA INSTITUTE OF TECHNOLOGY

SCHOOL OF NUCLEAR ENGINEERING

10. ATTACHMENTS ATLANTA, GEORGIA 30332

See Section 9.0 of Qualification Test Report for attach-

FRANK H. NEELY  
 NUCLEAR RESEARCH CENTERS.  
 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  $2.04 \times 10^8$  rads (air) or  $2.3 \times 10^8$  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:	$9.1 \times 10^5$ rad/hour
Total Dose:	$2.04 \times 10^8$ 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  
 11-36 unlabeled items

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

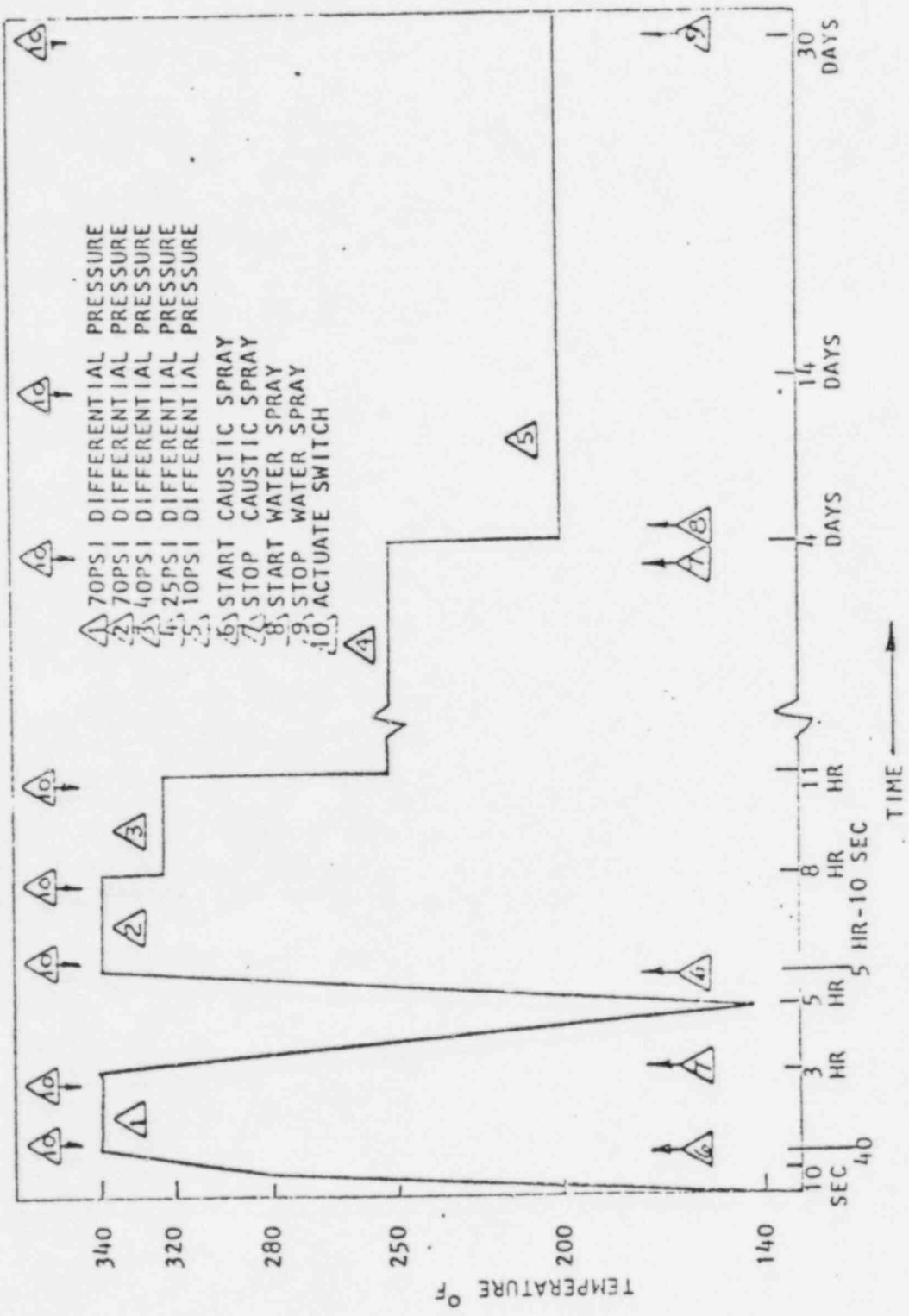


FIGURE 8

LP10767-3

AUGUST 28, 1980

10. ATTACHMENTS

See Section 9.0 of Qualification Test Report for attachments.