SEISMIC QUALIFICATION TEST
OF
LIMIT CONTROL SWITCHES
June 1977

Prepared for

NAMCO Controls
An Acme-Cleveland Company
Jefferson, Ohio

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

1. PURPOSE

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

2. IDENTIFICATION OF SWITCHES

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

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

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

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

Switch No. 33 — Same as Switch No. 32

Switch No. 45 — Same as Switch No. 32

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

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

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

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

3. TEST EQUIPMENT

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

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

4. SEISMIC TEST PROCEDURE

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

Part I - Resonance Search

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

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

Part II - Fragility Test

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

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

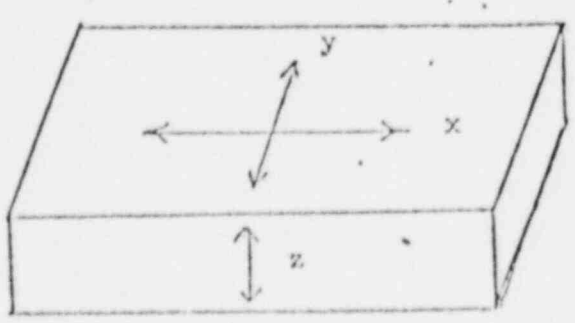
The trip angle of each switch was also monitored during the vibration test. This was done by monitoring the switch angle position on the oscilliscope. The variation in the trip angle position should not exceed 0.060 inches while being subjected to the vibration test.

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

Dwell Points

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

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



5. TEST RESULTS

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

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

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

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

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

*See page 14(B)

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

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

6. CONCLUSIONS

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

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

No resonance frequencies were noted during the test.

7. CERTIFICATION

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

Edward J. Walter, Ph.D.

Edward J. Walter, Jr.

James DiSiena

EQUIPMENT USED

Calidyne Electrodynamic Shaker, Model B44

Mechanical Shake Table

Tektronix Storage Oscilloscope Type 564

Shure Brothers Accelerometer Model 62CP, calibrated August, 1977

Brush-Clevite Recorder Mark II

Dr. Edward J. Walter & Associates
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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 oscilliscope 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 oscilliscope would be used (by Dr. Edward J. Walter & Associates' personnel) to determine if there was a contact opening of more than 2 milliseconds or not.

Edward Solem 7/13/77

E. Solem Date
Metallurgical Engineer

APPENDIX C

CROSS COUPLING ANALYSIS

APPENDIX C

ANALYSIS OF CROSS COUPLING

Abstract

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

APPENDIX C

SEISMIC TESTING/CROSS COUPLING

All of the parts and assemblies of which the switch is comprised may be classified into three categories depending upon the geometric constraints upon their movement within the unit. The first category is components free to revolve about an axis but which have balanced angular masses about the axis. The second category is components which are free to rotate about an axis within a range the limits of which are 9^{o} 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^{o} 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^{o} of the Y axis. Therefore, a vibration with a deviation of 9^{o} 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^{o}) in order to compensate for possible effects due to multi-axis vibration.

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

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

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

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

ELS:cr

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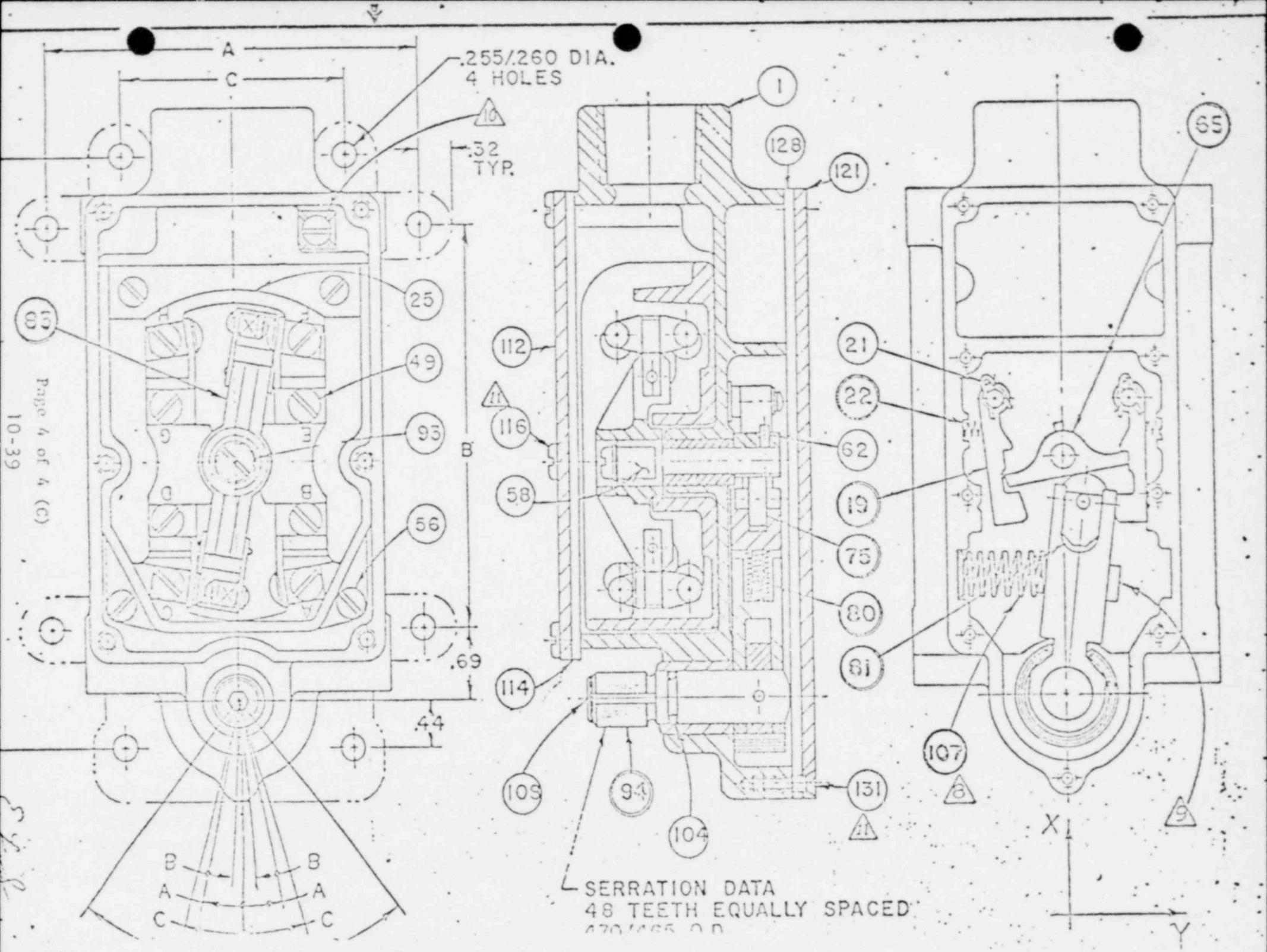
[1] Blueprint specified minimum.

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

[3] See Page 12(B).


A
C
.255/.260 DIA.
4 HOLES
10
.32
TYP.
B
.69
.44
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83
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Page 4 of 4 (C)
10-39
B
A
C
1
128
121
112
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58
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19
75
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81
114
108
94
104
131
11
SERRATION DATA
48 TEETH EQUALLY SPACED
65
21
22
107
8
9
X
Y

APPENDIX D

DATA SHEETS

INITIAL INSPECTION

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

SWITCH NUMBER: 138-90

SHIPPING DAMAGE: None

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

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

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

SIGNED: J.P.

DATE: 10/3/79

HEAT AGING

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

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

ELECTRICAL MEASUREMENTS

LOAD: .086 amps at 100 volts DC

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

COMMENTS

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

SIGNED:

*Meter measured between 1000 M and infinity. DATE: 10/22/79

WEAR CYCLING

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

NO. OF CYCLES: 100,200

CYCLE RATE: 70 RPM

METHOD: CAM

ELECTRICAL LOAD: 0.5 amps at 100 volts DC

ELECTRICAL MEASUREMENTS

LOAD: .086 amps at 100 volts DC

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

COMMENTS

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

SIGNED: [signature]

DATE: 10/24/79

IRRADIATION

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

IRRADIATED

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

ELECTRICAL MEASUREMENTS

LOAD: .086 amps at 100 volts DC

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

COMMENTS

SIGNED: JP
DATE: 12/5/79

SEISMIC TEST

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

TESTED BY: ACDC

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

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

COMMENTS:

ELECTRICAL MEASUREMENTS

LOAD: .0.5 amps at 125 volts DC

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

SIGNED: [signature]

DATE: 1/4/80

SEI[illegible]C TEST

CODES

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

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

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

COMMENTS:

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

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

**.5 ms contact bounce.

Signed: [signature]

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

SEISMIC TEST

CODES

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

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

Frequency (Hz)	Period (Sec.$^{-1}$)	Accelerometer Output (mV-pp)	Displacement (Inches)	Max. g (g's)	Normally Open			Normally Closed			Pre-Travel Angle	Reset Angle
					Mech.	Seismic	Osc.	Mech.	Seismic	Osc.		
1.0	1	33.8 *	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: [signature]

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

SEIS[redacted] TEST

CODES

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

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

Frequency (Hz)	Period (Sec.$^{-1}$)	Accelerometer Output (mV-pp)	Displacement (Inches)	Max. g (g's)	Normally Open Mech.	Normally Open Seismic	Normally Open Osc.	Normally Closed Mech.	Normally Closed Seismic	Normally Closed Osc.	Pre-Travel Angle	Reset 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: [redacted]

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

DB[illegible]EST
(Summary of Transients)

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

PROFILE REF.: IEEE Standard 382

CAUSTIC SPRAY: NaOH, Boric Acid, Sodium Thiosulphate

PROFILE (ACTUAL)

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

*Originally 0 PSIG.

SIGNED: [signature]

DATE: 2/7/80

Page 9 of 19 (D)

10-49

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

The closed contact resistance after the test was:

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

ELECTRICAL MEASUREMENTS

*See Page 15 of 19 (D).

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

SIGNED: [signature] DATE: 1/7/80

CAUSTIC SPRAY COMPOSITION
(BY BATCH)

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

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

SIGNED: Dawn R 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: [signature]

DATE: 2/7/80

SWITCH NO. [redacted]138-90 MODEL NO.: EZ-10683-90/[redacted]80-11302 TESTED FROM/TO: 1/7/[redacted]- 2/7/80

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

SIGNED: J.P.

DATE: 1/7/80

DBP TEST

PAGE NO.: 2 of 7

SWITCH NO.: [redacted]38-90 MODEL NO.: EZ-10683-90/EA-180-11302 TESTED FROM/TO: 1/7/80 - 2/7/80

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

SIGNED: J.B.

DATE: 1/7/80

10-54

SWITCH NO.: [redacted]38-90 MODEL NO.: EZ-10683-90/EA-180-11302 TESTED FROM/TO: 1/7/80 - 2/7/80

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

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

SIGNED: [signature]

DATE: 1/7-8/80

DB[illegible]EST

SWITCH NO.: [illegible]8-90 MODEL NO.: EZ-10683-90/EA-180-11302 PAGE NO.: 4 of 7

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

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

SIGNED: [signature]

DATE: 1/8-10/80

10-56

DBE CST

PAGE NO.: 5 of 7

SWITCH NO.: 198-90 MODEL NO.: EZ-10683-90/EA-180-11302 TESTED FROM/TO: 1/7/80 - 2/7/80

DATE	TIME	ELAPSED TIME	TEMPERATURE (°F)	PRESSURE (PSI)	CAUSTIC FLOW (CC'S/MIN.)	WATER LEVEL (IN.)	pH	COMMENTS
1/10/80	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 460 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: [signature]

DATE: 1/10-12/80

10-57

DBE ST

SWITCH NO.: 138-90 MODEL NO.: EZ-10683-90/EA-180-11302 PAGE NO.: 6 of 7

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

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

SIGNED: J B

DATE: 1/12-29/80

85-0

DE[illegible] EST

PAGE NO.: 7 of 7

SWITCH NO.: [illegible]8-90

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

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

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

SIGNED: J.B.

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

APPENDIX E

EQUIPMENT CALIBRATION

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

*Not traceable to NBS.

ELS
2/15/80

10.2 SHORT TRAVEL SUPPLEMENT

10.0 TEST REPORTS (CONT'D).

10.2 Supplementary Testing for Short Travel Switches.

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

A copy of this report is included in this section.

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

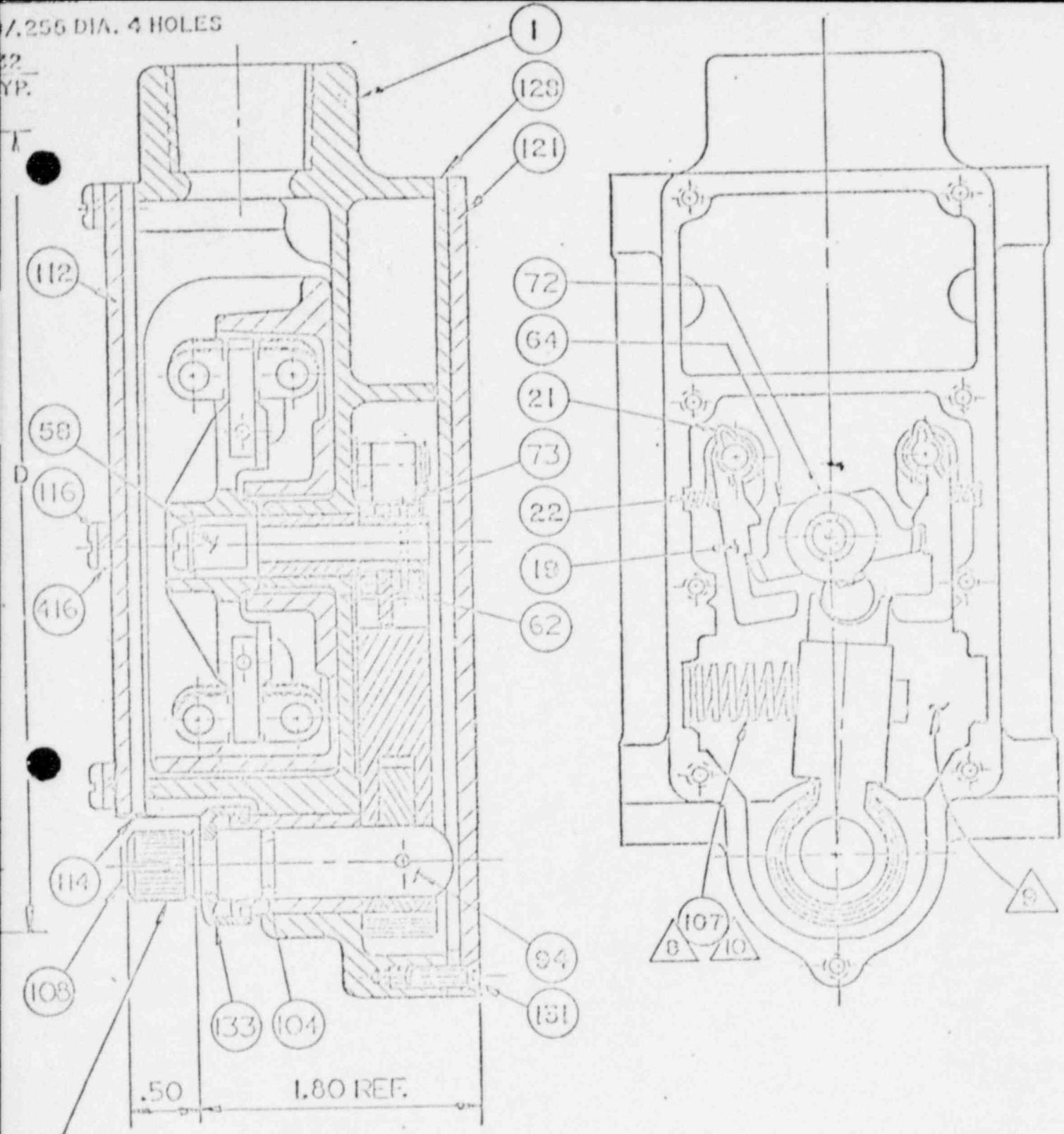
The tests conducted were the same as those conducted on the switch #61 in the body of the report except that the LOCA tests were not performed.

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

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

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

E L L



SERRATION DATA
48 TEETH EQUALLY SPACED
.470/.465 O.D.

REF. NO. ER10607-23		MARMON DOWTY-ROLLS An Acme-Cleveland Company CLEVELAND, OHIO U.S.A.
OTHERWISE SPECIFIED .XX ± .01 .XXX ± .005 ANGULAR ± 0°30' VE ALL SHARP EDGES	DR. SCOTT CK. DATE	TITLE D2400 NUCLEAR SWITCH SHORT TRAVEL 6½° TRIP W/BOOT MATERIAL 10-65 — DO NOT SCALE

March 1, 1978

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

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

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

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

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

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

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

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

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

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

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

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

J. J. Patsey

JP

TE 12/23/77

HEAT AGING

SWITCH # 83

MODEL # EA-180-14302

EZ1060751

PROTOTYPE
PRODUCTION

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

ELECTRICALS LOAD = .086A @ 100 VDC

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

(Continue on back)

INTERIOR EXAMINATION (OPTIONAL)

GASKETS:

CONTACTS:

BLOCK:

O-RING:

GREASE:

E 1-3-78

SWITCH # 83

MODEL # EA180-1430

☐ PROTOTYPE
☐ PRODUCTION

WEAR CYCLING

EZ10607-51

F CYCLES	100,000		LOAD	.5A @ 100 DC						COMMENTS		
LE RATE	70 RPM											
IOD	Cam											
ELECTRICAL MEASUREMENTS; LOAD = .086A @ 100 VDC												
		Meggar			Conductivity (amps)							
	1	3	2	4	1	3	2	4				
TIAL	Inf	Inf	Inf	Inf	.086	.086	.086	.086				
AL	"	"	"	"	"	"	"	"				
EP												
			INTERNAL EXAMINATION (OPTIONAL)						(Continue on back)			
KETS:												
TACTS:												
CK:												
ING:												
ASE:												

10-68

E 1-31-78

SWITCH # 83

MODEL # EA180-14302

EZ10607-51

☐ PROTOTYPE

☐ PRODUCTION

IRRADIATION

ADIATED AT:	Isomedix, Inc.											
FROM 1-12-78			TO 1-31-78			TOTAL IRRADIATION 204 Mrad.						
RGY LEVEL 1.25 Mev.			SOURCE Cobalt 60 gamma					RATE 1.2 Mrad/hi.				
ELECTRIDAL MEASUREMENTS ;			LOAD	= .086A @ 100 DC					COMMENTS			
	Meggar				(Conductivity (amps)							
	1	3	2	4	1	3	2	4				
TIAL	Inf	Inf	Inf	Inf	.086	.086	.086	.086				
FINAL	"	"	"	"	"	"	"	"				
THER												
			INTERIOR EXAMINATION (OPTIONAL)									
ts:												
NTACTS:												
OCK:												
RING:												
EASE:												
NTS (Cont.)												

ISOMEDIX

February 6, 1978

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

Dear Mr. Solem:

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

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

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

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

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

Yours very truly,

Jonathan C. Young
Production Manager

JCY/mr

10-70

DATE 2-13-78

SWITCH # 83

MODEL # EA180-1430

EZ10607-51

☐ PROTOTYPE

☐ PRODUCTION

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

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

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

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

Reference

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

CURRENT SWITCH TEST

1 Switch No. 83, EA 180-14302

VIBRATION TESTS

The switch was subjected to the following tests:

I - Fragility Test

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

II - Plant Induced Vibration Simulation

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

Test Procedure:

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

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

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

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

Changes in Trip Position
which exceeded 1/16 inch

Y-comp.

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

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

The switch was a double throw type and was energized electrically at 125 volts at 1/2 amp. during the test. It was subjected to 51 distinct vibration tests, 48 of these at a minimum of 60 seconds each and three at a minimum of 56 minutes each.

Edward J. Walter

DR. EDWARD J. WALTER AND ASSOCIATES
February, 1978

11.0 TEST PLAN

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

11.1 Test Plan No. LP10767-3

Dated July 26, 1979

Revision 1

NAMCO CONTROLS

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

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

COPY NO.

TEST PLAN NO. LP10767-3

DATE AUG. 29, 1980

REV 3

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

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

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

ORIGINAL TEST PLAN DATED 8/31/77.

REVISIONS

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

TEST PLAN NO. LP10767-3

DATE JULY 26, 1979

John R. Bendokaitis
Project Engineer
Nuclear Switch Coordinator
NAMCO CONTROLS

Joseph Buzogany
Chief Engineer
NAMCO CONTROLS

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FIGURES

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

② 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

② 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	4×10^6 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	180×10^6 Rads, Gamma

Total testexposure to radiation 204×10^6 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			
.13	Seismic Qual.	6.6	X				125VDC.5A
.14							
.15	Performance Test	6.2.2	X	X		X	
.16	Accident Envir .	6.7	X	X		X	
.17							
.18	Long Term Envir .	6.8					
.19							
.20	Performance Test	6.2.2	X	X		X	
.21	Inspection	6.9					

5. QUALIFICATION TEST SEQUENCE

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

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

* Qualification by similarity analysis.

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES

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

6.1 Inspection and Preparation

6.1.1 Check and record the identity per section 3.

6.1.2 Mark the switch as required per 3.4.4.

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

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

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

6.2 Performance Testing

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

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

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.2 Performance Testing - Cont.

6.2.1 Baseline Data Test

6.2.1.1 Electrical load test (close circuit)

Calibrate the test circuit

Voltage 100VDC

Current .086A

Resistive load

Connect switch leads per Figure 2 A

Test each circuit (close condition)

Record resulting currents

6.2.1.2 Insulation Resistance

(open circuit resistance)

Connect switch leads per Figure 2 B

Measure and record circuit resistance

of each circuit in the open condition.

6.2.1.3 Functional Test

Connect switch leads per Figure 2 C

Measure and record the following:

pertravel angle in degrees, differential

travel in degrees, maximum torque during

pretravel, inch pounds.

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.2 Performance Testing - Cont.

6.2.2 Performance Test

6.2.2.1 Electrical load test (close circuit)

Calibrate the test circuit

Voltage 100 VDC

Current .036 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.

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

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.4 Mechanical Wear Aging

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

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

6.4.2 The lead wires will be connected per Figure 5.

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

6.4.4 Electrical Load

Voltage_____ 100VDC

Current_____ 0.5 Amps

Resistive Load

6.4.5 Service life simulation

100,000 cycles minimum

6.4.6 See Section 4 for operating lever requirements

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

6. QUALIFICATION TEST CONDITIONS AND PROCEDURES - Cont.

6.5 Radiation Simulation

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

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

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

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

6.5.4 Temperature, pressure and humidity - ambient.

6.5.5 Radiation exposure

Accident environment	180×10^6 Rads
Margin (+10%)	20×10^6 Rads
Normal environment (40 yrs inside containment)	4×10^6 Rads
Total exposure (this test)	204×10^6 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 III, Table 1 and IEEE 323-1974 Appendix A, Table A1.

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

6. 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

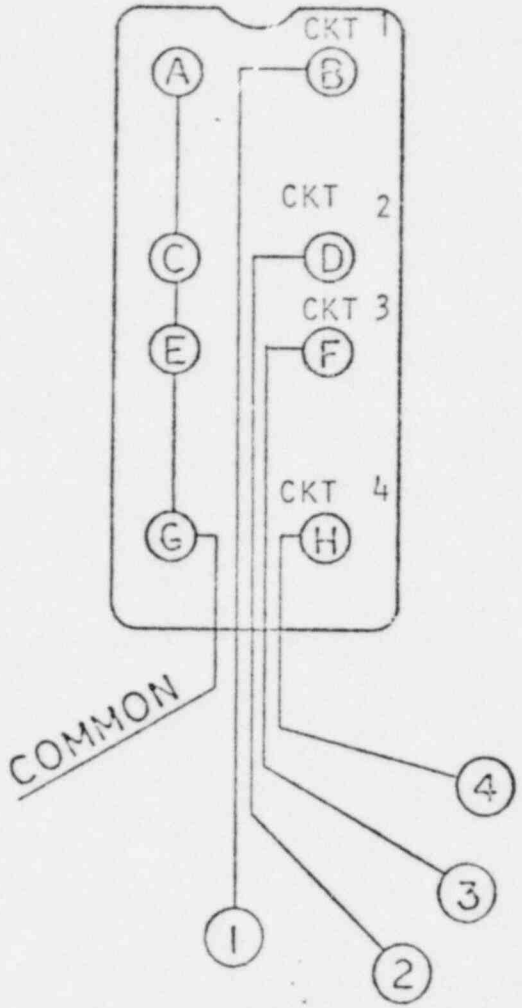
Pretravel . . . . . 10°

Differential Travel . . . . . 8°

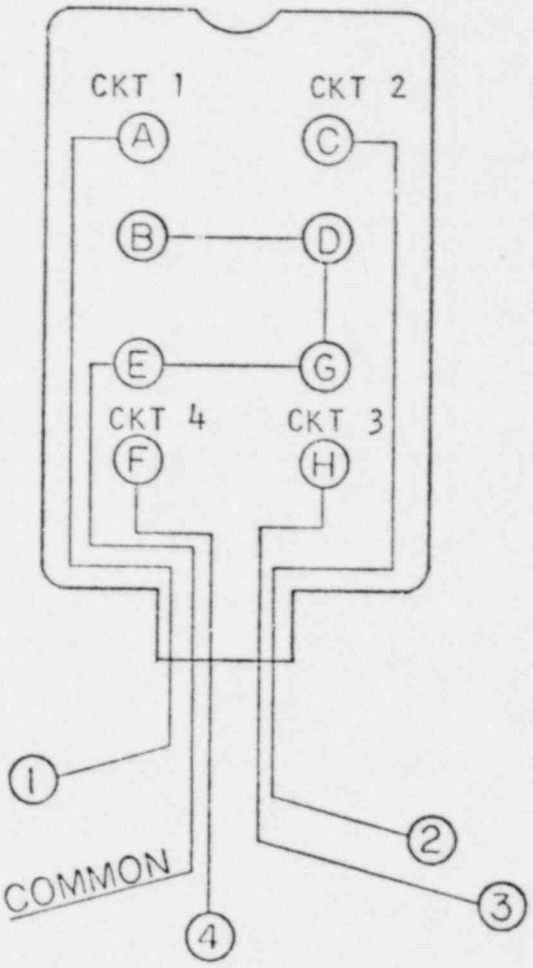
Recommended Travel . . . . . 13°

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

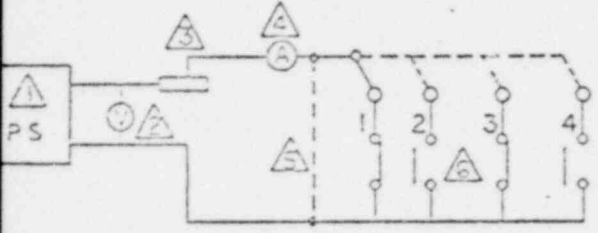
TOP VIEW
EA740 LIMIT SWITCH
WIRE CONNECTIONS
FIG. 1A



TOP VIEW
EA180 LIMIT SWITCH
WIRE CONNECTIONS
FIG. 1B



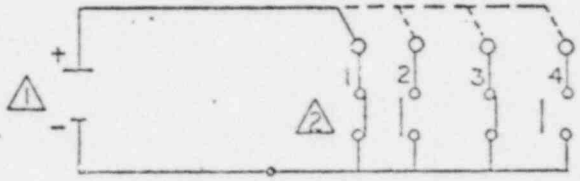
LEAD WIRE HOOK-UP
FOR EA180 & EA740 SWITCHES
FIGURE 1



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

Electrical Load Test

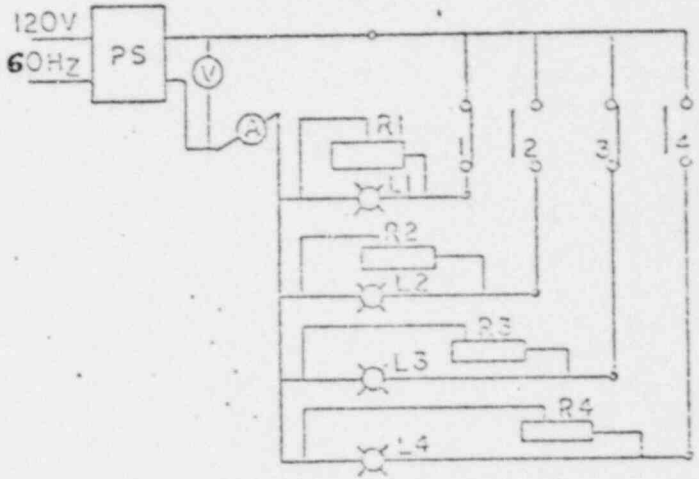
FIG. 2A



1. 500 VDC Meggar Insulation tester, James G. Biddle Company #1111784
2. Limit switch contacts, the Meggar Instrument measures across the open contacts (N.O.)

Insulation Resistance Test
(Open Circuit Resistance)

FIG 2B



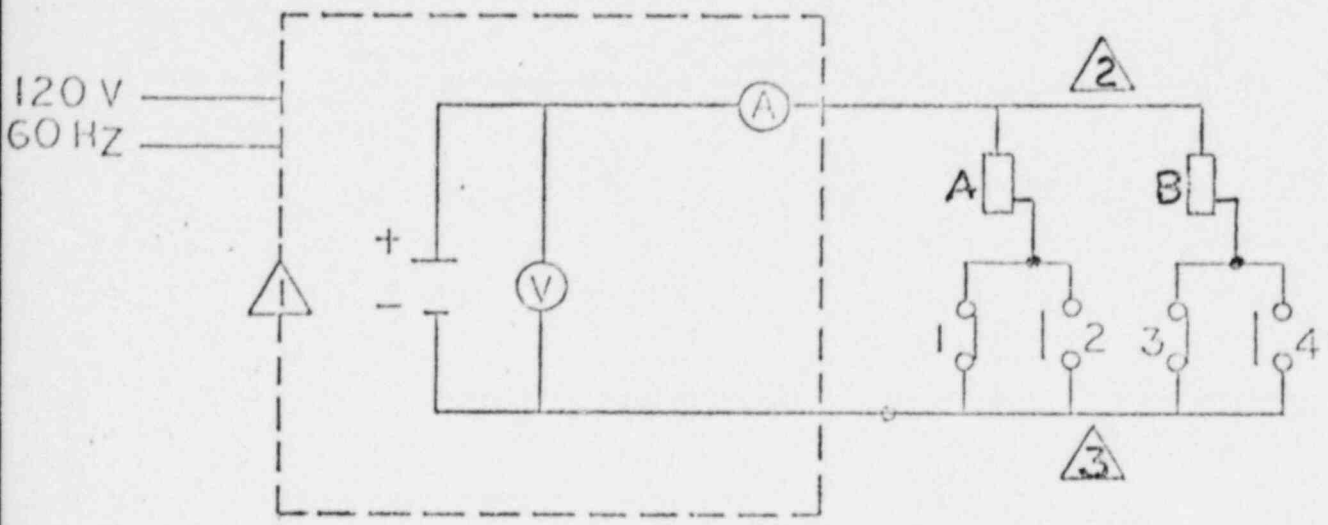
PS — DC Power Supply
A — Ammeter (DC)
V — Voltmeter
L_1, L_2, L_3, L_4 — Pilot Lights
R_1, R_2, R_3, R_4 — Variable Resistor

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

FIG 2C

FIG 2

CONNECTION DIAGRAMS



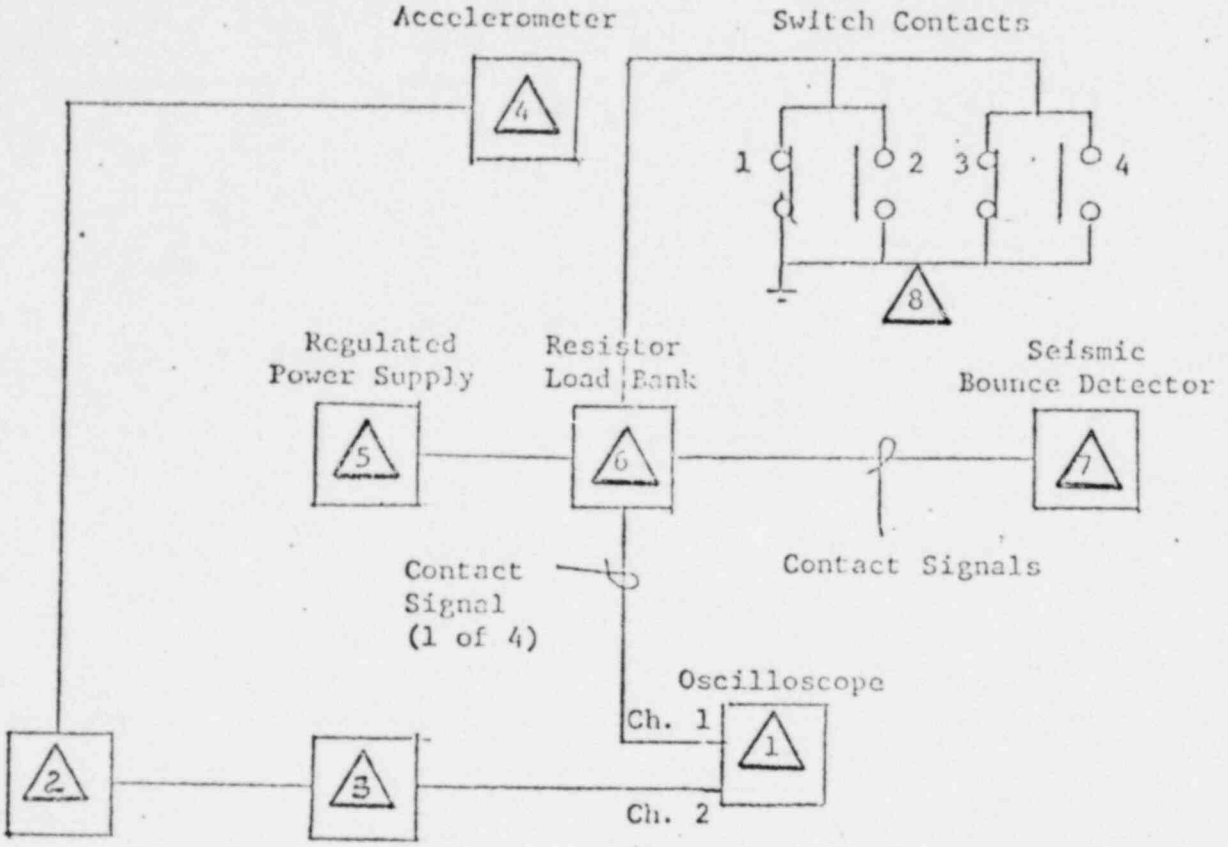
1. Sorenson Power Supply with built-in voltmeter and ammeter

2. Variable Resistors A & B

3. Limit Switch Contacts

CONNECTION DIAGRAM FOR
MECHANICAL AGING LOAD

FIGURE 5



1. Tektronix Type 564 Oscilloscope
2. EBN Model P16 amplifier modified for 1 Hz operation
3. Low pass filter, Krohn-Hite #3202
4. BBN 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

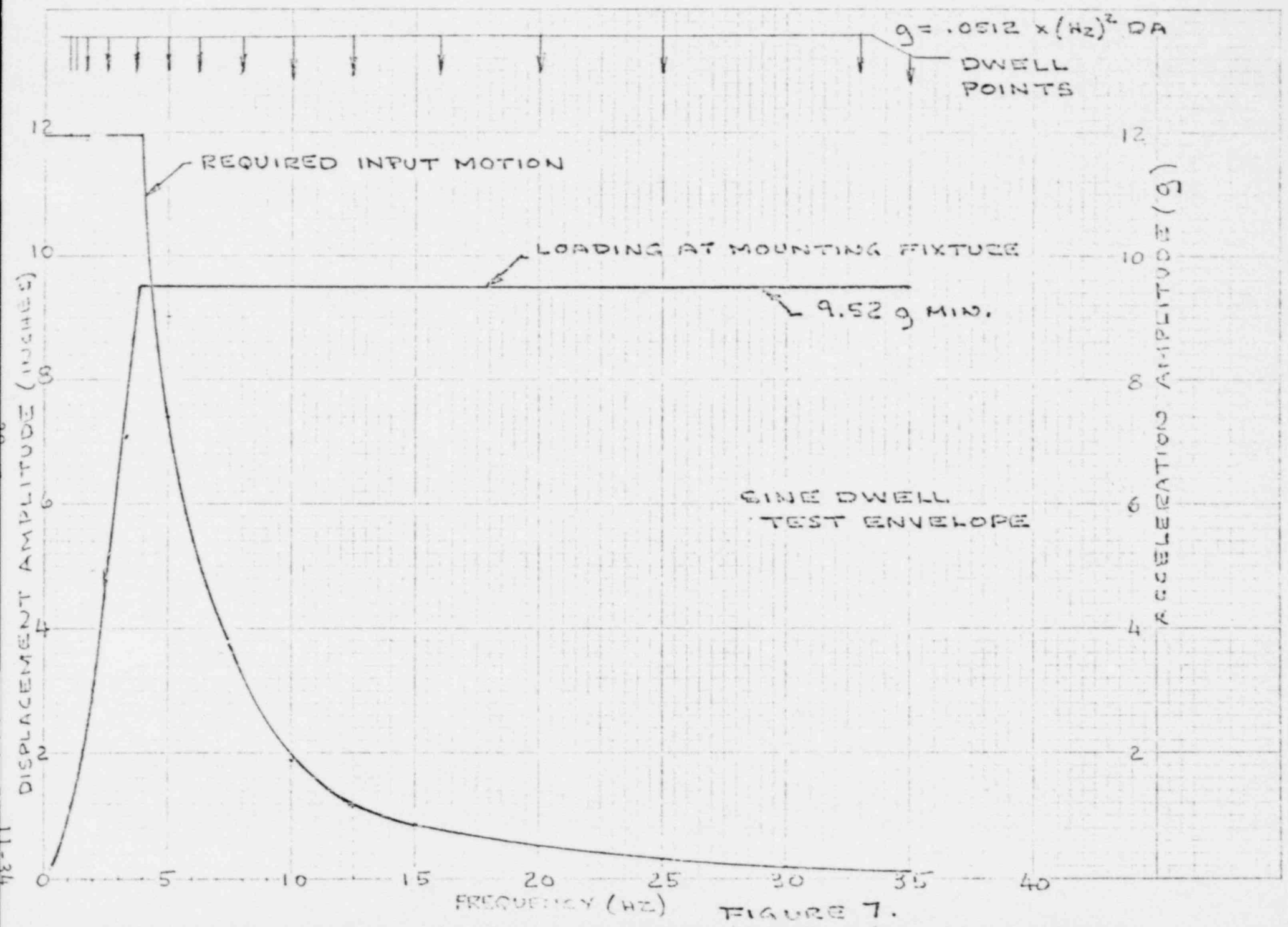

g = .0512 x (Hz)² DA
DWELL POINTS
REQUIRED INPUT MOTION
LOADING AT MOUNTING FIXTURE
9.52 g MIN.
SINE DWELL TEST ENVELOPE
DISPLACEMENT AMPLITUDE (INCHES)
ACCELERATION AMPLITUDE (g)
FREQUENCY (Hz)
0
5
10
15
20
25
30
35
40
2
4
6
8
10
12

FIGURE 7.

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

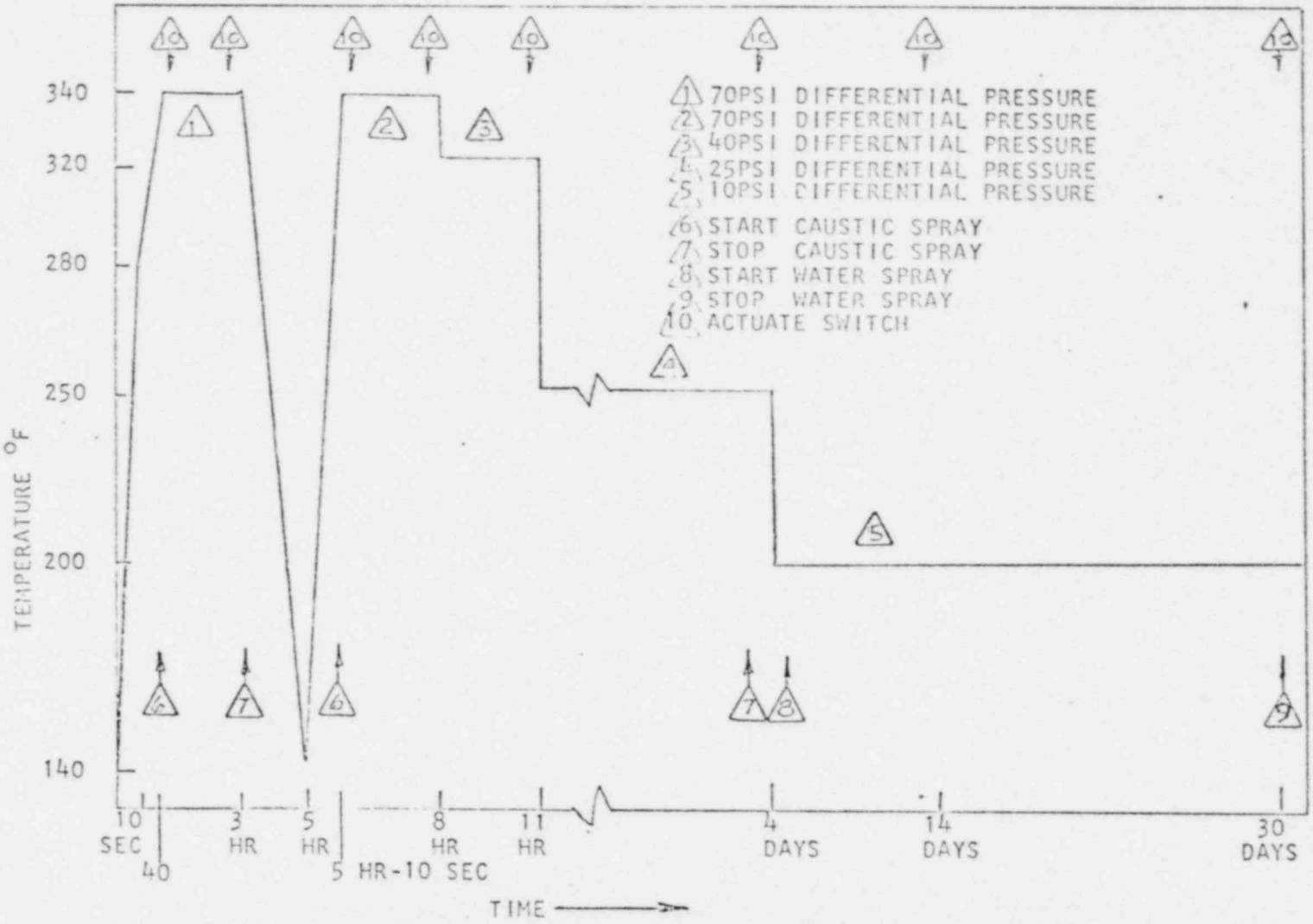


FIGURE 8

10. ATTACHMENTS

See Section 9.0 of Qualification Test Report for attachments.