B0058

APPENDIX A

LUBRICATION DATA FORM LC8

MAINTENANCE FORM LC9

Stone & Webster Engineering
J.O. No. 12177
Spec. No. ____________

RELEASED FOR:	DIRECTIONS TO SITE:
RETURN TO SUPPLIER ☐	FOR CONSTRUCTION ☐
ENG & DESIGN ☐	NOT FOR CONSTRUCTION ☐
FABRICATION ☐	

☐ APP Approved, Acceptable For Use
☐ AAR Approved As Revised
☐ UNA Unacceptable
☐ BLT As-Built
☐ FIO For Information Only

Date ____________
By ____________

LIMITORQUE CORPORATION

LUBRICATION INSPECTION PROCEDURE & DATA

GENERAL

Proper lubrication is an absolute essential in achieving the design life of all types of power transmission products and Limitorque valve controls are no exception.

The design of the actuator has been specially tailored to absolutely minimize the maintenance and re-lubrication requirements; however, periodic inspection is the only way to guarantee trouble-free service.

Limitorque utilizes a totally sealed gear case factory-packed with grease. The gear case can be mounted in any position (as all penetrations into it are sealed); however, those mounting positions which would cause vulnerable areas of the operator (e.g., motor and limit switch compartment) to be saturated with lubricant should a seal failure occur, should be avoided if possible and are not recommended. Grease is used in normal service instead of oil to minimize the impact of a seal failure (should one occur).

No seal can remain absolutely tight at all times; therefore, it is not unusual to find a very small amount of weeping around shaft seals—especially during long periods of idleness such as storage. The use of grease minimizes this condition as much as possible. Should a small amount of weeping be found in the limit switch compartment on start-up, it should be removed with a clean rag. Once the equipment has begun operating, this phenomenon should disappear.

LUBRICATION INSPECTION

It is recommended that all Limitorque operators be inspected for proper lubrication prior to operating—especially if they had been stored for a long period of time.

FREQUENCY

The frequency of lubrication inspections should be based upon historical data on the installed equipment. Every operator application has its own effect on lubricants and each facility should pattern its inspections around its particular needs. The following schedule of lubrication inspection should be followed until operating experience indicates otherwise.

Main Gear Case: Inspect lubrication on approximate intervals of 18 months or 500 cycles—whichever occurs first. Lubricate the Zerk fitting in the housing cover at the same interval.

Geared Limit Switch: Inspect lubrication on approximate intervals of 36 months or 1000 cycles—whichever occurs first.

The three primary considerations in a lubrication inspection are: (l) Quantity; (2) Quality; (3) Consistency.

Quantity - Limitorque operators are built to operate on the partial immersion principle. The primary concern in the amount of lubricant is whether the "worm" is totally immersed in grease. This can be verified by the use of one or more of the many "fill" and "drain" plugs provided on the operator housing.

Quality - When removing a "fill" or "drain" plug to inspect the lube level, remove a small amount and insure that it is clean and free of any contaminant including water. Should dirt, water, or other foreign matter by found, the units should be flushed with a commercial degreaser/cleaner like Exxon VARSOL #1 or #3 which is non-corrosive and does not affect seal materials such as Buna N or Viton. Repack unit with fresh lubricant.

Consistency - The main gear box lubricant should be slightly fluid approximating a standard NLGI-1 grade consistency or less. Thinners such as Amoco WAYTAC #31 oil may be added provided the volume of thinner does not exceed 20% of the total lubricant.

The geared limit switch lube should be soft to the touch approximating an NLGI-2 consistency or less.

Standard Lubricants
***(−20°F to 150°F)**

United Size	Type	Manufacturer	Color	Base
SMC-04 & 03	Nebula EPO (Rev.1)	Exxon	Dark Tan	Calcium Complex
**SMB/SB/SBD 000,00	Nebula EPO (Rev.1)	Exxon	Dark Tan	Calcium Complex
**SMB/SB/SBD/WB 0 to 4	Nebula EPO (Rev.1)	Exxon	Dark Tan	Calcium Complex
SMB/WB-5	50 EP (XC-421-39)	Sun Oil Co.	Black	Lithium Lead
**All HBC Sizes	Nebula EPO (Rev.1)	Exxon	Dark Tan	Calcium Complex

*Temperature rating based on continuous ambient vs. the time interval for inspection.

**For nuclear containment safety related active units, Nebula EPOis used.

SMB/SB/SBD-000 & 00 lube was changed from Sun 50 EP (XC-421-39) to Nebula EP0 on all unit serial numbers 295810 and higher.
SMB/SB/SBD/WB 0 through 4 lube was changed from Nebula EPI to Nebula EPO on all serial numbers 302262 and higher.
All HBC sizes lube was changed from Nebula EPI to Nebula EPO on all serial numbers 302262 and higher.

GEARED LIMIT SWITCH:

Humble Oil Company - Beacon 325—Light Gray - acceptable substitute Mobil 28.

MOTOR BEARINGS:

Motors furnished with Limitorque valve controls are lubricated for life.

LUBRICANT SUBSTITUTES:

Typical commericially available lubricants other than those used by Limitorque for which manufacturers data indicates compatability with Limitorque operators are shown below with the temperature range recommended by the manufacturer.

Manufacturer	Type	Temperature Range	Base
Exxon	**Humble P290	−40°F to 120°F	Lithium Line
Arco	Litholine HEP1	−10°F to 220°F	Lithium
Gulf Oil	Gulfcrown EPO	−20°F to 220°F	Lithium
Cities Service	City AP	− 0°F to 220°F	Lithium
Mobil Oil Co.	Mobilux EPO	−10°F to 220°F	Lithium 12
Shell Oil	Darina 0	−10°F to 250°F	Hydroxystearate No Soap
Fiske	Lubriplate Low Temp.	−40°F to 150°F	Lithium
Texaco	Marfak 0	+20°F to 200°F	Sodium
	Low Temp. EP	−40°F to 200°F	Lithium
Tidewater Oil	Veedol Alitho 10	−10°F to 150°F	Lithium

** Tested and used by Limitorque for applications at low temperatures (-50°F to -70°F). Consult Limitorque if the temperature range is beyond the limitations shown above.

The standard lubricants used by Limitorque have been proven extremely reliable over many years of service. There are, however, many other lubricants available which may be used *in place of* the standard.

Do not add a different lubricant to a Limitorque operator unless it is of the same soap base as the existing lubricant unless you have received the approval of the lubricant manufacturer.

The minimum lubricant qualities required by Limitorque are:

1. Should contain an "EP" additive.
2. Must be suitable for the temperature range intended.
3. Must be water and heat resistant and non-separating.
4. Must not create more than 8% swell in Buna N or Viton.
5. Must not contain any grit, abrasive, or fillers.
6. Must slump — prefer NLGI grade 0 to 1.
7. Must not be corrosive to steel gears, ball or roller bearings.
8. Dropping point must be above 316°F for temperature ranges of −20°F to 150°F.

8/15/76
Rev. 1 - 12/21/76
Rev. 2 - 9/1/78
Rev. 3 - 6/12/79
Rev. 4 - 10/16/79

LUBRICANT REQUIREMENTS

UNIT SIZE	Amount of Lubricant Approx. Volume Gallons	Approx. Weight Pounds
SMC04	.15	1.0
SMB/SB-000	.50	3.5
SMB/SB/SBD-00	.50	4.0
SMB/SB/SBD/WB-0	1.00	9.5
SMB/SB/SBD/WB-1	1.50	15.0
SMB/SB/SBD/WB-2	1.75	14.5
SMB/SB/SBD/WB-3	5.50	50.0
SMB/SB/SBD/WB-4	8.50	75.0
SMB/WB-4T	8.00	71.0
SMB/WB-5T	7.50*	65.0*

*Add 1 gallon/7 lbs. for thrust bearing assembly in SMB5 thrust-type unit.

H0BC	.20	1.5
H1BC	.35	3.0
H2BC	.50	4.0
H3BC	1.40	12.0
H4BC	3.50	30.0
H5BC	5.20	45.0
H6BC	9.25	80.0
H7BC	14.50	125.0
H10BC	26.00	225.0

LIMITORQUE MAINTENANCE PROCEDURE

MAJOR MAINTENANCE:

The need for major maintenance on Limitorque equipment occurs when some operational deficiency is evident. Care should be taken to evaluate the deficiency in order to determine the extent to which the major maintenance should proceed. Major maintenance should always include the routine maintenance requirements but in addition should proceed as follows:

1. *Disassembly of deficient portion of equipment.

2. Replacement of any damaged or excessively worn component with new factory parts. It is recommended that worm and worm gears be replaced as a set to ensure the greatest benefit from the replacement.

3. Replacement of lubricant if main gear box was involved in the major maintenance.

4. Replacement of all torn gaskets and seals.

5. Inspect stem and stem nut thread carefully for wear and/or damage.

6. Check operability of all electrical control components before reinstallation.

*Complete disassembly and reassembly instructions are available for all equipment.

<u>LIMITORQUE MAINTENANCE PROCEDURE</u>

<u>ROUTINE MAINTENANCE:</u>

A schedule should be made to periodically inspect all Limitorque equipment. The time interval of this inspection should depend upon the frequency of operation and the ambient environmental conditions in which the equipment is stored or installed. A minimum inspection period of eighteen months should be used as a base until experience indicates otherwise. This routine maintenance should include -

1. Remove limit switch compartment and/or control cabinet cover. Should moisture be evident, dry the compartment and components.

2. Inspect and clean all electrical controls and contacts in the limit switch compartment and/or control cabinet. This cleaning should consist of wiping clean of all electrical contacts with electrical type solvent cleaner similar to CRC Lectra Clean and removal of foreign residue.

3. Check all terminal connections for tightness.

4. Clean gasketed surfaces on limit switch compartment and/or control cabinet cover. Replace all damaged gaskets or seals for weatherproof or submersible units. Wipe a coating (approximately 2 mils) of lightweight bearing grease on surfaces of explosion-proof cover flanges for protection.

5. Inspect lubricant per Lubrication Procedure. Visually check shaft penetrations for indications of seal leakage. If abnormal leakage is found, the seal should be replaced. (Slight oil weepage is not cause for seal replacement.) SEE MAJOR MAINTENANCE.

6. Megger the motor. (One MEG-OHM or better is considered normal.)

7. Clean and lubricate the valve stem (obtain valve manufacturer's recommendation for lubricant) for rising stem applications.

CF
6/21/77

APPENDIX B

BWR Containment Qualification

Report 600376A

NUCLEAR POWER STATION

QUALIFICATION TYPE TEST REPORT

LIMITORQUE VALVE ACTUATORS
FOR BWR SERVICE

PROJECT #600376A

Test per IEEE Standard 382-72

Test performed 4/26/72 to 8/30/72

Prepared by Limitorque Corporation

APPROVED: W. J. Denkowski

W. J. Denkowski
Vice President Engineering

DATE: 5/13/76

ACCEPTED: C. D. Formica

C. D. Formica
Quality Assurance Administr.

REISSUED 5/13/76

DATE: 5/13/76

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APPENDICES

BWR Qualifications

1.0 Introduction

A typical Limitorque Valve Actuator, SMB-0 with a 25 ft lb motor was submitted for generic qualification to the type-test specified by IEEE Standard 382-72 for service in a Boiling Water Reactor (BWR) containment chamber in nuclear power station application. The operator is considered acceptable on provision it proves capable of satisfactorily operating against a load simulating a normal valve operating load in both opening and closing directions within a 30-day period following the start of environmental exposure.

2.0 Identification of Sample Valve Actuator

TEST UNIT

A Limitorque SMB-0 Valve Actuator with a 25 ft lb nuclear containment motor (RH insulation) was constructed per standard nuclear bills of material and standard nuclear motor specifications. The following information was taken from the equipment nameplates.

Valve Actuator

Type/Size..........................SMB-0

Manufacturer.......................Limitorque Corporation

Order Number.......................360943A

Serial Number......................144068

Electric Motor Information

Size	25 ft lb stall 5 ft lb run
Manufacturer	Reliance Electric Co.
Identification Number	601962-P
Speed	1700 RPM
Voltage	230/460
Frequency	60 Hz
Duty	15 minute
Insulation Class	RH
Type	P

2.1 The SMB-0-25 Valve Actuator S/N 144068 had originally been subjected to a short term environmental test with motor identification number 601960P. At the conclusion of the test, the valve actuator was refitted with motor identification number 60192-P which had also been subjected to gamma radiation of 204 megarads and to seismic test (Ogden Technology Laboratories, Inc. Report 7192-9).

3.0 Type-Test Procedure and Results

The type-test plan as described in IEEE Standard 382-72, paragraph 4, consists of three basic parts.

1. Aging Simulation
2. Seismic Qualification
3. Accident Environmental Simulation

3.1 Aging Simulation

3.1.1 Thermal Aging

Thermal aging was performed on the motor stators by the motor manufacturer (Reliance Electric Co.).

The motor stator was heat-aged for 100 hours at 180°C. Refer to Appendix C for Certificate of Compliance confirming this aging simulation. Regarding the nuclear valve actuator switches and seals, the aging temperature would not exceed 200°F for 200 hours. The switch and seal materials are rated by the manufacturers for use at 300°F and 450°F respectively. Since Limitorque Corporation has successfully used valve actuators with these materials at continuous temperatures of 300°F, heat-aging these components at lower temperatures was not considered necessary.

3.1.2 Mechanical Aging

Mechanical aging was performed on the test unit by Limitorque Test Laboratory starting 3/13/72 and completing on 3/27/72. The SMB-0-25 Limitorque valve actuator was installed on a test stand with an Acme stem thrusting against a load cell to simulate seating thrust. After calibrating the torque switch to obtain an average thrust of 20,740 lbs (average of ten readings obtained at a torque switch setting of 1-7/8). The unit remained on the test stand and was cycled at room ambient conditions for a total of 500 cycles, each consisting of one opening and one closing stroke.

3.1.2 Mechanical Aging (continued)

At the conclusion of the mechanical aging, the thrust was checked showing an average thrust of 21,058 lbs in a total of ten readings.

3.1.3 Radiation Aging

The test unit was exposed to a cobalt 60 gamma field of one megarad/hour at an air equivalent dosage for a period of four hours by Radiation International, Inc. and then shipped to the test lab for seismic qualification.

After seismic testing, the unit was additionally exposed to the one megarad/hour gamma field for an additional 200 hours.

A copy of Radiation International, Inc. certification of this radiation exposure is included in Appendix D.

3.2 Seismic Qualification

The seismic qualification was performed April 26, 1972 by Ogden Technology Laboratories, Inc. on an Electro-Hydraulic Vibration machine. The test unit with motor was scanned in each of the three major axes over a frequency range of 1 to 35 Hz with a maximum acceleration of 1.0g's to search for resonance. Since no resonance was found, the test sample was then vibrated for a period of ten seconds at each even integer of frequency from 4 to 34 Hz in each axis at an excitation of 3 g's. The unit was operated during each dwell through one cycle from open limit

to torque switch seated position and back to original point. The test sample was then vibrated for a minimum of ten seconds at 35 Hz in each axis at an excitation level of 5 g's with the unit being operated as indicated above.

A report on the seismic qualification was prepared by Ogden Technology Laboratories, Inc. (Report No. 7192-9), a copy being included in Appendix E.

3.3 Accident Simulation

The test was performed at the Franklin Institute Research Laboratory Environmental Facility starting July 31, 1972 and ending August 30, 1972. With the exception of using two temperature transients and limiting the test to thirty days per the combined test profile, the valve actuator was exposed to the profiles indicated on Table 2, page 12 of IEEE382-72.

Due to limitations in the environmental chamber used, the time required to cool the chamber far exceeds that suggested by the combined profile. The temperature transients, however, closely approximated that stipulated by table 2 of IEEE382-72. Since the cooling rate between transients is not specified in table 2, and furthermore, since the second transient is intended to approach a conservative position for further assurance of actuator performance during the LOCA, the cooling rate is not part of the environmental test and is of no consequence.

The Franklin Institute Research Laboratories Test Report F-C3441 attached describes the test detail.

PROPRIETARY INFORMATION

Technical

Final Report
F-C3441

Report

QUALIFICATION TEST OF LIMITORQUE VALVE OPERATORS IN A SIMULATED REACTOR CONTAINMENT POST-ACCIDENT STEAM ENVIRONMENT

September 1972

Prepared for

Limitorque Corporation
(Affiliated with Philadelphia Gear Corporation)
King of Prussia, Pennsylvania

Under Limitorque Shop Order No. 600376-A

PROPRIETARY INFORMATION

THE FRANKLIN INSTITUTE RESEARCH LABORATORIES
BENJAMIN FRANKLIN PARKWAY • PHILADELPHIA, PENNA 19103

1. INTRODUCTION

Two Limitorque SMB-0-25 valve operators were subjected to a qualification test to determine their acceptability for service in a nuclear power plant. The test consisted of a 30-day exposure to a steam environment at temperatures going as high as 340°F during the first day. The performance of the valve operators was monitored by periodic cycling (under simulated valve-seating load) and measurement of insulation resistance on all power and control leads. The test was started on July 31, 1972, and ran through August 30, 1972.

2. IDENTIFICATION OF VALVE OPERATORS

The valve operators were identified by the following information on the name plates.

UNIT NO. 1

LIMITORQUE VALVE OPERATOR

TYPE:	SMB
SIZE:	0
ORDER:	360943A
SERIAL:	144068

MOTOR

MANUFACTURER:	Reliance Electric Co.
IDENTIFICATION NO:	601962-P
START:	25 lb-ft
RUN:	5 lb-ft
TYPE:	P
FRAME:	R56
PHASE:	3
RPM:	1700
HZ:	60
VOLTS:	230/460
AMP:	8.0/4.0
RISE AT RUN TORQUE:	75°C
DUTY:	15 min
INSULATION:	Class HR

UNIT NO. 2

LIMITORQUE VALVE OPERATOR

TYPE:	SMB
SIZE:	0
ORDER:	355696A
SERIAL:	135809A

MOTOR

IDENTIFICATION:	463489-DX
START:	25 lb-ft
RUN:	5 lb-ft
TYPE:	P
FRAME:	R56
PHASE:	3
RPM:	1700
HZ:	60
VOLTS:	230-460
AMPS:	8.0/4.0
AMBIENT:	75°C
INSULATION:	Class HR
DUTY:	15 min

The valve operator on Unit No. 1 had previously been exposed by FIRL to gamma radiation (200 megarads) and a steam/chemical environment (for twelve days), and had been refitted by Limitorque with a motor which had been subjected to a gamma radiation dose of 200 megarads (by FIRL) and a seismic test (by Limitorque). The valve operator had also been subjected to a seismic test by Limitorque. The prior tests conducted by FIRL are documented in Final Report F-C3327.* Unit No. 2 had not been subjected to any prior testing.

During the installation of the units in the test chamber, the melamine switch base of Unit No. 1 was accidentally broken. It was replaced by a new base which was first exposed to 200 megarads of gamma radiation, the same radiation exposure which Unit 1 had received.

**Qualification Test of Limitorque Valve Operator, Motor Brake, and Other Units in a Simulated Reactor Containment Post-Accident Environment*, Final Report F-C3327, Franklin Institute Research Laboratories, July 1972.

3. STEAM ENVIRONMENT TEST

3.1 Test Arrangement

The test was conducted in FIRL's Qualification Test facilities, shown in Figure 1. Unit No. 1 was mounted in the rear, and Unit No. 2 in the front, of the test chamber. Control and power lead connections were made by running teflon insulated wires through sealed (Conax) fittings on the switch compartments of the units and the test chamber wall. A control panel provided with switches and position indicating lights (wired to the geared limit switches) was used to cycle the units during the test. Provision was made for measuring the pressure and temperature inside the test chamber and in the switch compartments of the two units as well as the temperature inside the motor housing of Unit No. 1 and in the steam condensate that collected in the bottom of the test chamber (below the drain level). Instrumentation was provided for measuring electrical parameters when the valve operators were cycled.

To subject the valve operators to a load during cycling, each of them was fitted with a closed-end thrust tube over the screw. At the end of each *close* stroke, seating of the screw against the closed end of the tube simulated the mechanical loading of valve seating.

3.2 Test Procedure

The valve operators were exposed to steam in accordance with the pressure/temperature profile recommended in the proposed IEEE guide for type tests of Class I electric valve operators.* This profile is illus-

Proposed Guide for Type Test of Class I Electric Valve Operators for Nuclear Power Generating Stations, Draft 13, IEEE Project No. 382, JCNPS/SC2.3, June 1972.

trated in Figure 2, which also shows the schedule for cycling the valve operators and measuring the insulation resistance of the power and control leads. During the first four days of the test, the specified temperatures and pressures were maintained by the controlled injection of steam into the test chamber. To achieve the specified temperature drops, the natural cooling of the test chamber (after the steam pressure and flow rate were decreased) was enhanced by blowing air over the exterior of the chamber and circulating water through a coil inside the chamber. During the remainder of the test, the 200°F/10-psig state was maintained by filling the test chamber with air and using external electrical heaters. The atmosphere within the chamber was kept saturated with water vapor by daily injections of steam and by maintaining the steam condensate in the bottom of the chamber at a temperature equal to, or slightly greater than that of the air/vapor mixture.

3.3 Test Results

3.3.1 Pressure/Temperature Profile

Copies of the data log sheets are given in Appendix A.

The actual pressure/temperature profile achieved during the critical first four days is illustrated in Figure 3. During the last twenty-six days of the test, the temperature was maintained within approximately 5% of the specified 200°F. The main difference between the specified and actual temperature profiles is that more than the specified time was required to cool the test chamber after the first dwell at 340°F. (As a consequence of there being two valve operators within the test chamber, the amount of heat that had to be dissipated in two hours exceeded our cooling capacity.) Another difference is that the pressure rises to 105 psig required 19 seconds and 23 seconds at the beginning of the first and second pressure transients, respectively, instead of the specified

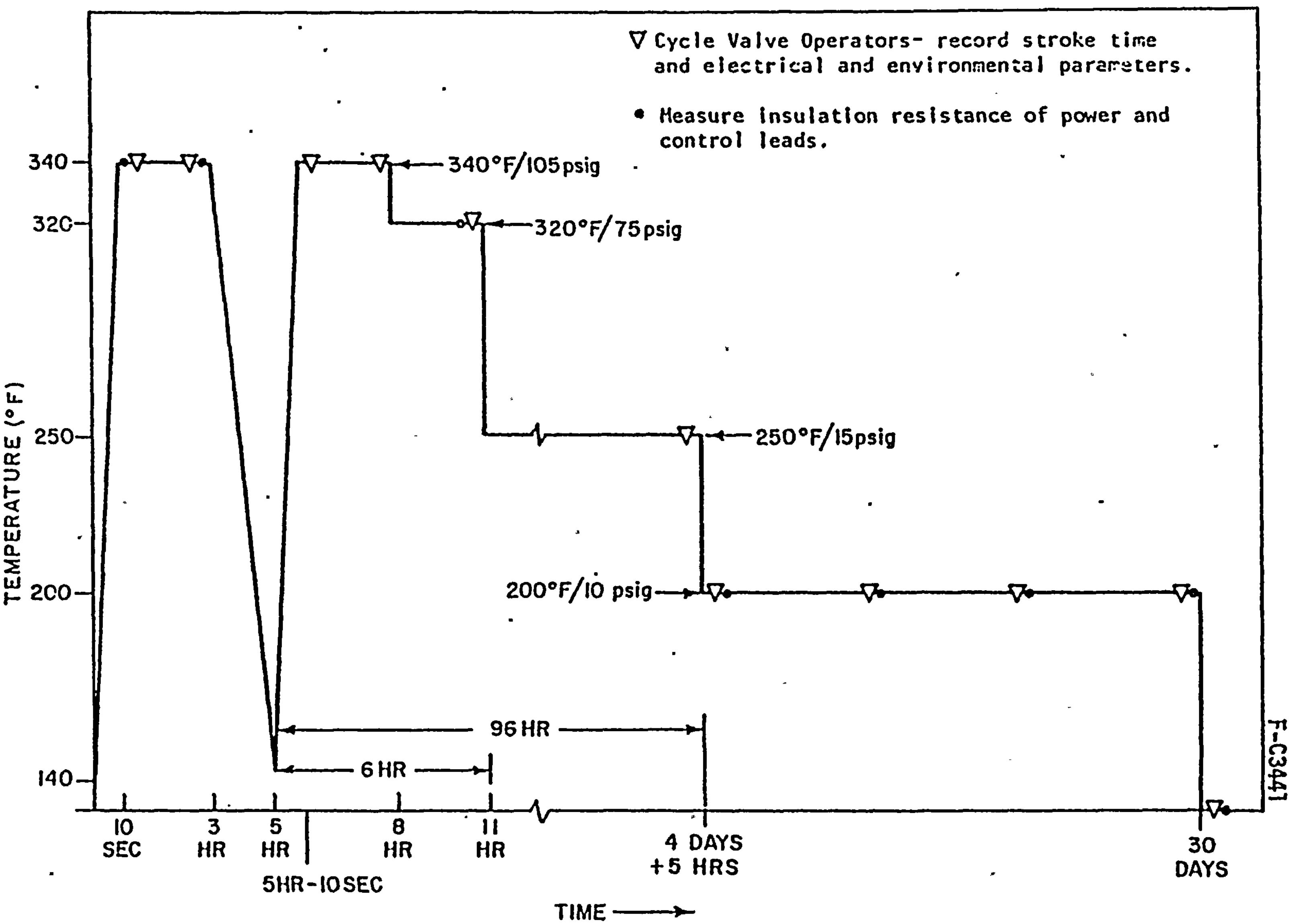
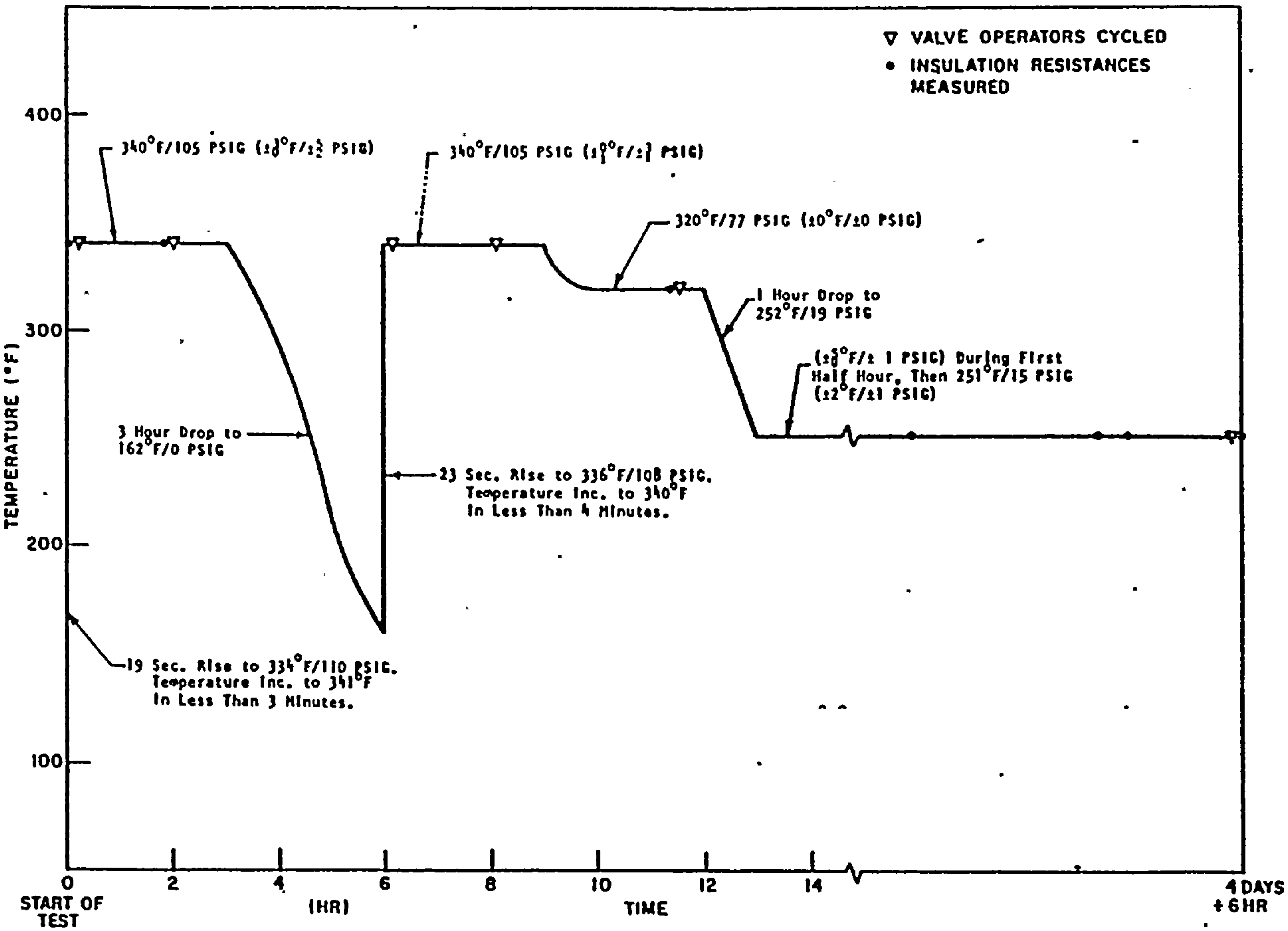


Figure 2. Specified Steam Exposure Profile



F-C3447

Figure 3. Actual Steam Exposure Profile

TABLE 2(b)

INSULATION RESISTANCE OF POWER AND CONTROL LEADS - UNIT NO.2

All Resistances are in Megohms Except Where a K Indicates Kilo-ohms

Time After Start of Test (hr)	Stator Winding Leads			Control Circuit Leads							
	2T-1	2T-2	2T-3	2CL1	241	245	251	255	261	270	271
-238.9*	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
- 65.9*	500	500	500	200	200	200	200	200	200	200	200
- 0.66*	-	-	-	-	-	-	-	-	-	-	-
0.08	90K	80K	80K	60K	60K	60K	60K	60K	60K	60K	60K
1.97	0.13	0.13	0.14	39K	40K	43K	0.24	43K	48K	48K	46K
11.3	0.16	0.15	0.14	0.50	0.50	0.50	1.9	0.50	0.50	0.51	0.51
95.8	1.0K	1.5K	1.5K	1.0K	1.0K	1.0K	4.0K	1.0K	5.0K	5.0K	1.0K
99.3	8.0K	8.0K	8.0K	1.0K	1.0K	1.0K	4.0K	1.0K	5.0K	6.0K	2.0K
99.9	-	-	-	-	-	-	-	-	-	-	-
101.9	25K	25K	25K	40K	40K	40K	90K	40K	40K	50K	50K
167.1	90	90	90	>100	>100	>100	>100	>100	>100	>100	>100
191.0	90	90	90	>100	>100	>100	∞	>100	>100	>100	>100
359.8	8.5	8.5	8.5	50	50	50	100	50	50	50	50
575.2	7.0	7.0	7.0	40	40	40	90	40	40	40	40
724.7	6.5	6.5	6.5	25	25	25	80	25	25	25	25
726.5	<∞	<∞	<∞	<∞	<∞	<∞	<∞	<∞	<∞	<∞	<∞

*Checkout readings taken before start of test.

F-C3441

3.3.5 Final Inspections

A visual inspection of the valve operators and test chamber was conducted at the conclusion of the test. Photographs of the units at this point are shown in Figures 4, 5 and 6. In Figure 4, the grease marks inside the test chamber, at the left, clearly show that the condensate level rose well above the top of the valve operators during the flooding discussed in Section 3.3.2 This means that the motors were completely submerged during the flooding.

The paint had deteriorated over the entire exterior of the units, particularly on Unit No. 1 (which had gone through a steam/chemical exposure prior to the steam exposure reported herein); and corrosion and pitting of the metal surfaces had begun. No damage was apparent inside the switch compartments. On Unit No. 2, a white powdery material that seemed to be a foreign substance covered part of the melamine plate in the limit switch. The lower portions of both switch compartments were covered with a thin layer of grease that had become partially baked and was flaking in some areas. The interior of each switch compartment cover exhibited what seemed to be a water line about 3 to 4 inches from the top; evidently, air trapped inside the covers prevented the water from completely filling the compartments during flooding. However, the height of the water line was such as to indicate that all but the uppermost parts of the switch mechanism had been under water.

After the valve operators were returned to Limitorque, they were disassembled for more detailed inspection. An FIRL engineer viewed the disassembly of Unit No. 1 and participated in inspecting it as well as No. 2.

On Unit No. 1, the gasket between the motor casing and valve-operator housing was in good condition. There was grease mixed with water on the pinion; there also was moisture on the inside of the motor end-caps, mixed with grease at the front end. However, the shaft and bearings turned freely, and lubrication seemed to be unimpaired. The

10 seconds. However, the temperature rose to about 330°F within 15 seconds at the start of the first transient and in 10 seconds at the start of the second transient. This was observed by viewing a thermometer at the top of the test chamber. The further rise to 340°F occurred more gradually.

3.3.2 Flooding of Test Chamber

During the fifth day of the test, when the conditions were being changed from 250°F/15 psig to 200°F/10 psig, it was discovered that the test chamber had become flooded with steam condensate. Investigation revealed that the condensate trap had become clogged with grease that had evidently come out of the pressure relief valve of the valve operators.

Judging by the amount of water which was removed from the chamber (about 225 gal) it was clear that the valve operators had been completely submerged by the condensate. This was confirmed at the conclusion of the test when the water line left inside the test chamber was found to be higher than the top of the valve operators under test. To help clear the interior of the valve operators of water which had entered them as a result of the flooding, air and nitrogen were flushed through the operator switch compartments (by use of the lines running between them and pressure gages outside the test chamber). Aside from this corrective action, the test was carried on without interruption; the test chamber was not opened at any time. The units performed normally when cycled after the period of flooding.

3.3.3 Operator Cycling Data

The electrical parameters (current, potential, and power) and the stroke times are listed in Tables 1(a) and 1(b) for Units 1 and 2, respectively.

The operators functioned normally throughout the test, with the following exception. Beginning with the third cycle, Unit 2 began to require two pushes of the start button to initiate the open cycle, after

Table 1(a) VALVE ACTUATOR CYCLING DATA — UNIT NO. 1

Cycle No.	Time After Start of Test (hr)	OPEN: Potential ϕ_{ab} (V)	OPEN: Potential ϕ_{ac} (V)	OPEN: Potential ϕ_{bc} (V)	OPEN: Running Current ϕ_a (A)	OPEN: Running Current ϕ_b (A)	OPEN: Running Current ϕ_c (A)	OPEN: Power (W)	OPEN: Stroke Time (sec)	CLOSE: Running Current ϕ_a (A)	CLOSE: Running Current ϕ_b (A)	CLOSE: Running Current ϕ_c (A)	CLOSE: Peak Current ϕ_c (A)	CLOSE: Power Running (W)	CLOSE: Power Peak (W)	CLOSE: Stroke Time (sec)
1*	-0.58	480	480	480	3.6	3.3	3.6	250	74.0	3.6	3.5	3.4	3.6	250	2000	74.0
2	0.27	475	475	475	3.5	3.3	3.6	250	74.0	3.5	3.4	3.3	3.6	250	1000	75.0
3	2.0	475	475	475	3.4	3.3	3.5	250	74.0	3.6	3.4	3.3	3.8	250	1000	74.5
4	6.1	475	475	475	3.5	3.4	3.5	250	74.0	3.6	3.5	3.4	4.0	250	1000	74.5
5	8.1	475	475	475	3.6	3.5	3.6	250	74.0	3.7	3.6	3.5	4.0	250	1000	74.5
6	11.6	484	484	484	3.6	3.5	3.7	250	74.0	3.7	3.6	3.5	4.0	250	1000	75.0
7	101.9	478	478	478	3.5	3.3	3.6	250	74.0	3.6	3.4	3.3	3.8	250	1000	75.0
8	167.6	478	476	477	3.5	3.3	3.6	250	74.2	3.6	3.4	3.3	3.8	250	500	75.0
9	191.3	481	481	481	3.5	3.3	3.6	250	74.0	3.6	3.5	3.4	4.0	250	750	75.0
10	360.0	480	480	480	3.5	3.3	3.5	250	74.0	3.6	3.4	3.3	3.8	250	1250	75.0
11	575.6	478	478	478	3.5	3.3	3.6	250	74.0	3.6	3.4	3.3	3.9	250	1250	75.0
12	724.8	478	478	478	3.5	3.3	3.6	250	74.0	3.6	3.4	3.3	3.8	250	1250	75.0
13	726.7	480	479	480	3.6	3.3	3.6	250	74.0	3.6	3.4	3.3	3.8	250	1250	75.0

*Checkout cycle run before start of test.

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Table 1(b) VALVE ACTUATOR CYCLING DATA — UNIT NO. 2

Cycle No.	Time After Start of Test (hr)	OPEN: Potential ϕ_{ab} (V)	OPEN: Potential ϕ_{ac} (V)	OPEN: Potential ϕ_{bc} (V)	OPEN: Running Current ϕ_a (A)	OPEN: Running Current ϕ_b (A)	OPEN: Running Current ϕ_c (A)	OPEN: Power (W)	OPEN: Stroke Time (sec)	CLOSE: Running Current ϕ_a (A)	CLOSE: Running Current ϕ_b (A)	CLOSE: Running Current ϕ_c (A)	CLOSE: Peak Current ϕ_c (A)	CLOSE: Power Running (W)	CLOSE: Power Peak (W)	CLOSE: Stroke Time (sec)
1*	-0.35	480	480	480	3.2	3.4	3.5	250	75.5	3.4	3.6	3.3	3.8	250	1500	76.0
2	0.35	475	475	475	3.2	3.3	3.5	250	76.0	3.3	3.5	3.3	3.5	250	1250	76.5
3	2.2	475	475	475	3.3	3.4	3.5	250	-	3.3	3.5	3.2	3.7	250	1250	77.0
4	6.3	475	475	475	3.3	3.5	3.5	250	79.5	3.4	3.5	3.4	3.9	250	1000	76.5
5	8.2	475	475	475	3.4	3.5	3.6	250	76.5	3.5	3.6	3.4	3.8	250	1000	77.0
6	11.7	484	484	484	3.4	3.5	3.6	250	77.0	3.5	3.7	3.4	3.9	250	1250	77.0
7	101.0	473	473	473	3.2	3.4	3.4	250	76.5	3.4	3.6	3.3	3.8	250	-	76.0
8	167.8	475	475	475	3.2	3.4	3.4	250	75.5	3.4	3.5	3.2	3.6	250	750	76.5
9	191.2	481	481	481	3.3	3.5	3.6	250	75.5	3.4	3.6	3.3	3.9	250	1000	76.5
10	360.2	479	479	479	3.2	3.4	3.5	250	76.5	3.4	3.5	3.3	3.9	250	1250	76.5
11	575.5	478	478	478	3.2	3.4	3.4	250	76.0	3.3	3.5	3.2	3.8	250	1500	77.0
12	724.9	478	478	478	3.3	3.4	3.4	250	76.0	3.4	3.6	3.2	3.7	250	1250	77.0
13	726.6	480	481	480	3.3	3.4	3.5	250	76.0	3.4	3.6	3.2	3.8	250	1250	76.0

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*Checkout cycle run before start of test.

which the cycle was executed normally. An analysis of this effect and checks made after the valve operator was disassembled led to the following explanation.

At the start of the open cycle, the bypass functions to prevent the opening of the torque switch by the torque spring, which is released and bounces back when the *open* pushbutton is actuated. Evidently, although it functioned sstisfactorily at room temperature, the bypass was not remaining active long enough to fulfill its function after the valve operator was heated to 340°F. This may have been due to a change in bypass setting resulting from the fact that the grease lubricating the spring became lighter when heated, and had less dampening effect on the spring bounce than it did at room temperature. Thus, it appears that two pushes of the start button were needed because of an improper initial setting of the gear limit bypass. It must be emphasized that, aside from the need for a second push of the start button, the open cycle was always executed normally.

3.3.4 Insulation Resistance Measurements

The measurements of insulation resistance made periodically on the power and control leads are listed for the two units in Tables 2(a) and 2(b). These measurements were made between each lead and ground (the test chamber), at 500 Vdc. The low values obtained on some of the control leads of Unit No. 1 during the first set of measurements (see first row of Table 2(a) were believed to be caused by chemical deposits left on the switch components by prior testing. In the process of cleaning and reconnecting the affected parts, a switch plate was accidentally broken; and, as mentioned in Section 2, the new part with which it was replaced was first exposed to the same dose of nuclear radiation that Unit No. 1 had received in prior testing.

During the time that the units were flooded with steam condensate (see Section 3.3.2), the insulation resistances decreased significantly on both units; however, there was a recovery to high resistance values when the flooding was corrected.

TABLE 2(a)

INSULATION RESISTANCE OF POWER AND CONTROL LEADS - UNIT NO. 1

All Resistances are in Megohms Except Where a K Indicates Kilo-ohms

Time After Start of Test (hr)	←Stator Winding Leads→			←Control Circuit Leads→							
	T-1	T-2	T-3	CL1	41	45	51	55	61	70	71
-238.9*	>100	>100	>100	∞	0.6	0.6	0.7	0.7	∞	∞	∞
- 65.9*	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
- 0.66*	500	500	500	200	∞	∞	∞	∞	∞	∞	∞
0.08	15K	15K	15K	50K	60K	70K	75K	75K	75K	75K	70K
1.97	70K	65K	65K	35K	35K	38K	40K	45K	42K	45K	42K
11.3	0.13	0.13	0.13	0.48	0.48	0.48	0.49	2.9	0.50	0.51	0.51
95.8	2.0K	3.0K	3.0K	1.0K	1.0K	1.0K	1.0K	2.0K	5.0K	5.0K	1.0K
99.3	5.0K	4.5K	4.5K	1.0K	1.0K	1.0K	1.0K	7.5K	5.0K	5.0K	1.0K
99.9	5.0K	4.5K	4.5K	-	-	-	-	-	-	-	-
101.9	7.5K	7.5K	7.5K	30K	30K	35K	35K	0.14	40K	40K	40K
167.1	∞	∞	∞	>100	>100	>100	>100	∞	>100	>100	>100
191.0	∞	∞	∞	>100	>100	>100	>100	∞	>100	>100	>100
359.8	<∞	<∞	<∞	50	50	50	50	∞	50	50	50
575.2	>100	>100	>100	40	40	40	40	∞	40	40	40
724.7	30	30	30	25	25	25	25	>100	25	25	25
726.5	∞	∞	∞	<∞	<∞	<∞	<∞	<∞	<∞	<∞	<∞

*Checkout readings taken before start of test.

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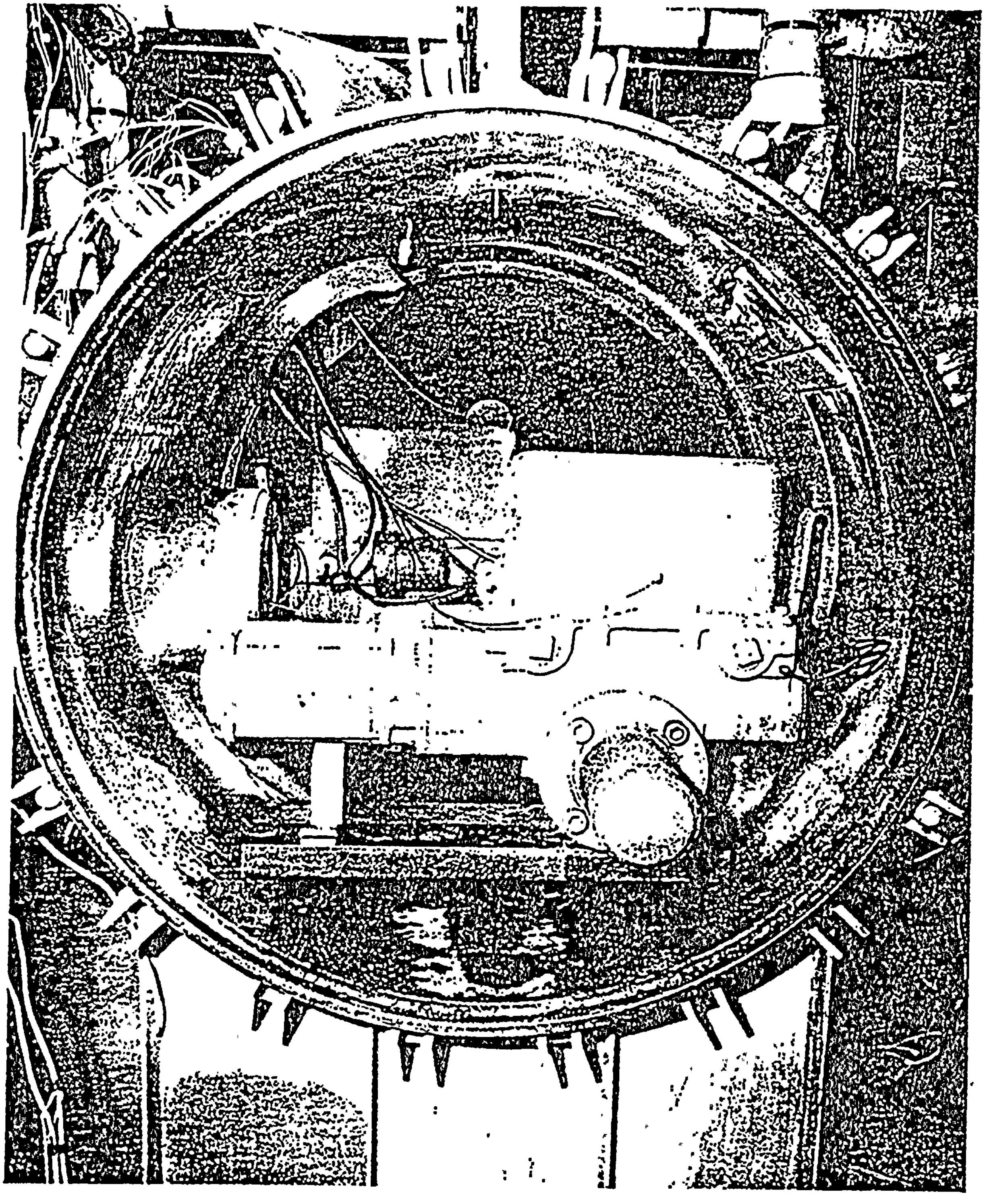

Figure 4. View Inside Test Chamber at Conclusion of Test

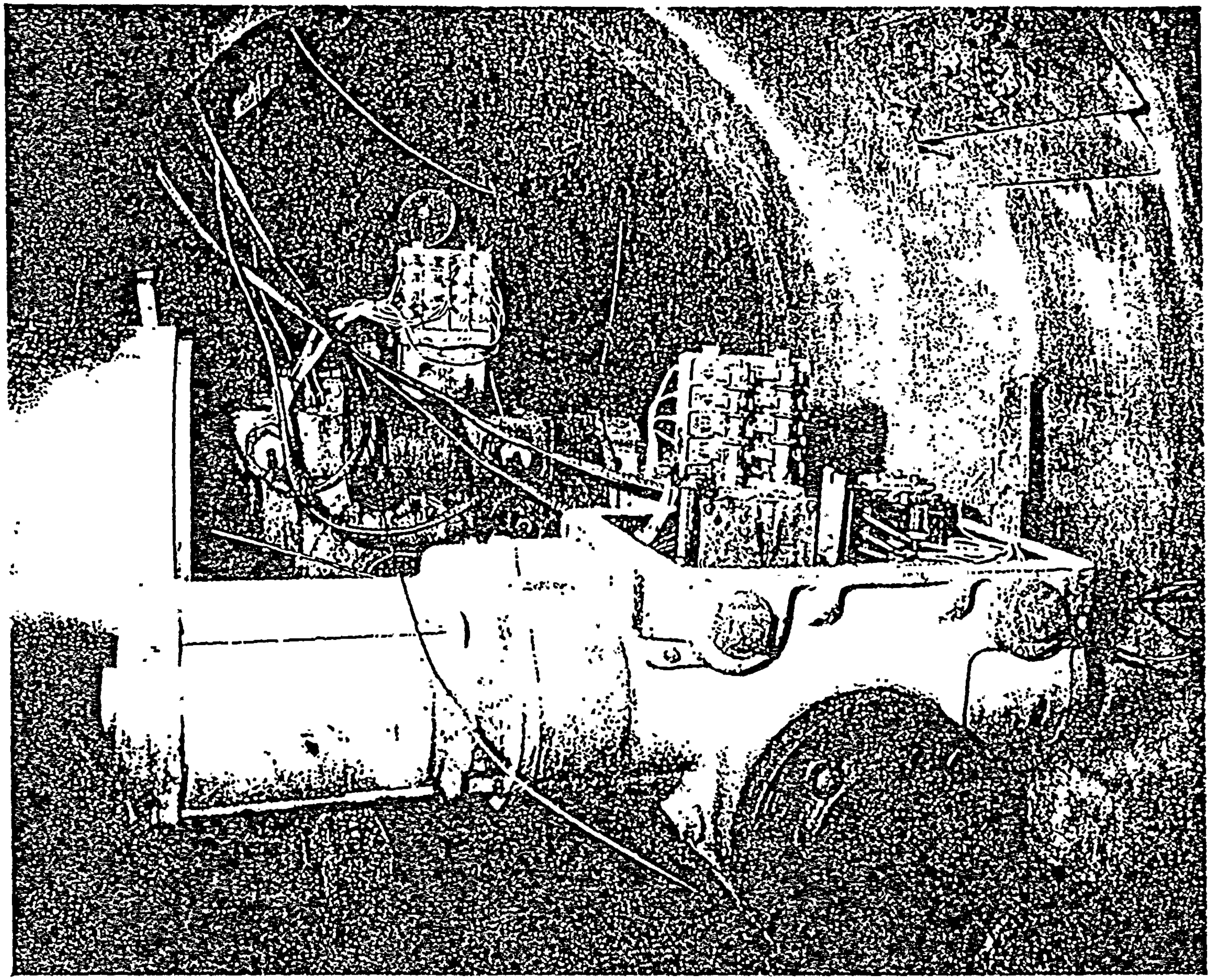

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Figure 5. Closeup View Inside Test Chamber at Conclusion of Test

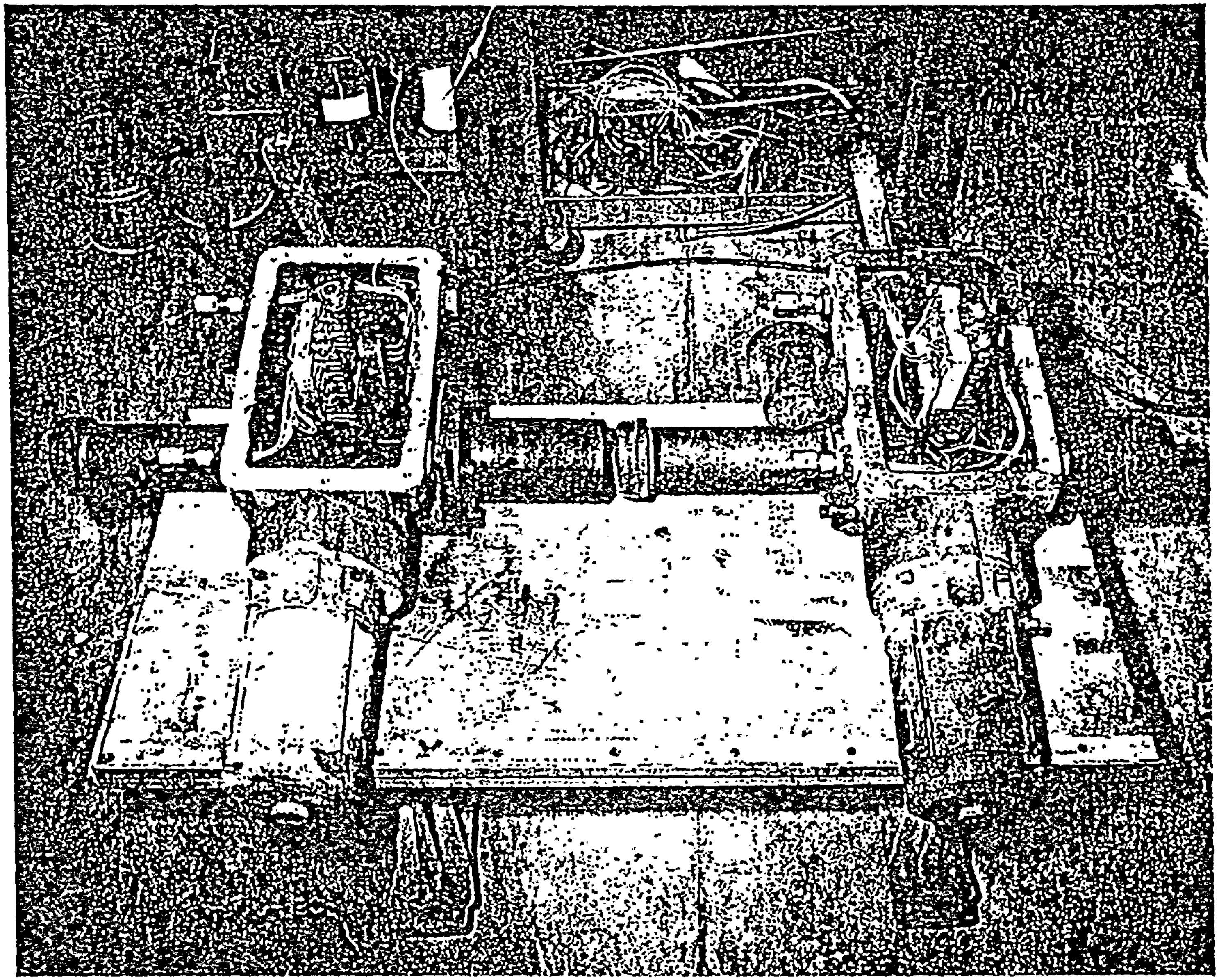

Figure 6. Overall View of Valve Operators After Removal From Test Chamber
Unit No. 1 is at Right, Unit No. 2 is at Left.

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drive gear was removed and found to be covered with grease, with no evidence of water. Water was found in the thrust tube at the valve end of. the stem, but there was no corrosion. The grease at this location appeared to have broken down, possibly as a result of hydrolization or the exposure to nuclear radiation, but it appeared to have maintained lubrication of the stem. The tapered bearing on the drive sleeve was still well lubricated and there was no sign of wear. No moisture was evident on this bearing.

Unit No. 2 had much the same appearance as Unit No. 1, except that there was less evidence that there had been any breakdown of the grease in the thrust tube, possibly because Unit No. 2 had not been exposed to nuclear radiation.

While the observed partial breakdown of grease in the thrust tube is mentioned for completeness, this part of the unit was an attachment to permit simulation of the valve-seating load. In an actual installation, the external part of the stem (within the thrust tube in our setup) might not be lubricated at all.

4. CONCLUSION

Two Limitorque SMB-0-25 valve operators were subjected to a Qualification Test consisting of a 30-day exposure to a steam environment, including two temperature cycles going to 340°F during the first day. Unit No. 1 had previously been exposed to nuclear radiation, a seismic test and a steam/chemical environment, as described in a separate report.* Both units were cycled periodically with a simulated valve-seating load during the test.

The pressure/temperature profile closely followed that recommended by a cognizant IEEE committee.Δ The units were subjected to severe flooding with steam condensate during the first few days of the test; this happened because the condensate trap on the test chamber became clogged with grease that came out of the pressure relief valves of the valve actuators.

The units performed satisfactorily throughout the test in spite of the flooding. Inspection of the units following the test revealed that all parts were in satisfactory condition. It was evident that lubrication had been maintained in spite of the loss of grease. Although water had entered in some places, none of the internal parts were corroded.

*See footnote page 2-2.
ΔSee footnote page 3-1

5. CERTIFICATION

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

S. P. Carfagno
Principal Scientist

Nissen M. Burstein
Sr. Research Engineer

L. E. Witcher
Test Engineer

APPROVED BY:

W. H. Steigelmann, Manager
Energy Systems Laboratory

4.0 Conclusion

Since no detrimental effects during the unit aging were discernible, the unit is considered qualified for a 40-year life as outlined in the aging criteria. Furthermore, the unit operated satisfactorily throughout the environmental LOCA test as previously described and it is therefore concluded this test generically qualifies Limitorque Valve Actuators for use in a BWR containment chamber as depicted in IEEE382-72.

APPENDIX A

Franklin Institute Research Laboratories

Test Data Log Sheets

Appendix

APPENDIX A

COPIES OF TEST DATA LOG SHEETS

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LIMITORQUE

LOG SHEET --- Page 1

OPERATOR	DATE	CLOCK TIME (2400 hr.)	COUNTER TIME (hr.)	TEMPERATURE (of) CHAMBER TC#1	CHAMBER THERM.	COND-ENSAT TC #2	SWITCH COMP #1 TC #5	SWITCH COMP #2 TC #7	LIMITORQUE MOTOR #1 TC #6	LIMITORQUE MOTOR # 2 OMIT	PRESSURE (PSIG) CHAM. GAGE	SWITCH COMP GAGE #1	SWITCH COMP GAGE #2	REMARKS
	7/31/72	0916	0000.0			#2	#5	#7	#6	omit				
GJV	"	0930	Reset Zero 000.0	134	-	134	146	149	153	-	0	0	0	
"	"	0938	RISE TO		105 PSIG	- 19	seconds							
"	"	0939		336	337	314	289	302	110	-	110	> 100	> 100	
"	"	0942		434	341	263	308	313	311	-	110	> 100	> 100	
"	"	0946	0.1	344	342	260	315	320	314	-	109	> 100	> 100	
"	"	0951	0.2	344	343	256	324	330	329	-	109	> 100	> 100	
"	"	0957	0.3	345	343	246	333	337	331	-	109	> 100	> 100	
"	"	1005	0.4	345	343	250	337	340	335	-	109	> 100	> 100	
"	"	1017	0.6	344	342	246	338	340	334	-	105	> 100	> 100	
"	"	1025	0.75	344	342	245	339	340	335	-	105	> 100	> 100	
"	"	1046	1.1	343	341	237	339	341	337	-	105	> 100	> 100	
"	"	1105	1.4	343	341	241	340	341	338	-	104	> 100	> 100	
"	"	1118	1.6	343	340	237	340	341	339	-	104	> 100	> 100	
"	"	1147	2.1	343	341	246	341	341	343	-	105	> 100	> 100	
"	"	1200	2.35	343	341	250	340	342	340	-	103	> 100	> 100	
JEY	"	1215	2.6	343	341	253	341	342	341	-	103	> 100	> 100	
"	"	1230	2.85	343	341	258	341	342	341	-	104	> 100	> 100	
"	"	1248	3.15	338	336	265	339	340	338	-	96	96	99	
GJV	"	1258	3.30	332	330	269	336	336	336	-	88	87	90	
"	"	1326	3.75	308	293	275	327	328	328	-	45	44	47	
JEY	"	1348	4.15	267	265	210	315	317	316	-	0	0	0	
"	"	1537	5.95	164	-	87	217	200	216	-	0	0	0	

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LIMITORQUE

LOG SHEET --- Page 2

OPERATOR	DATE	CLOCK TIME (2400 hr.)	COUNTER TIME (hr.)	TEMPERATURE (of) CHAMBER TC#1	CHAMBER THERM.	COND-ENSATE TC #2	SWITCH COMP #1 TC #5	SWITCH COMP #2 TC #7	LIMITORQUE MOTOR #1 TC #6	LIMITORQUE MOTOR # 2 OMIT	PRESSURE (PSIG) CHAM. GAGE	SWITCH COMP GAGE #1	SWITCH COMP GAGE #2	REMARKS
JEY	7/31/72	1539	6.0	338	335	88	234	250	291	-	108	> 100	> 100	23 sec. rise
"	"	1603	6.4	342	343	146	337	340	332	-	108	> 100	> 100	
"	"	1622	6.7	342	341	154	339	340	330	-	104	> 100	> 100	
"	"	1641	7.0	342	341	164	339	340	328	-	104	> 100	> 100	
"	"	1704	7.4	342	341	171	340	340	329	-	104	> 100	> 100	
"	"	1740	7.7	341	340	177	340	340	329	-	104	> 100	> 100	
"	"	1740	8.0	342	341	181	340	340	328	-	105	> 100	> 100	
"	"	1805	8.4	342	341	186	340	340	330	-	105	> 100	> 100	
"	"	1829	8.8	342	341	188	340	340	328	-	105	> 100	> 100	
"	"	1838	9.0	342	340	190	340	339	327	-	105	> 100	> 100	
GJV	"	1848	9.15	332	331	190	332	332	322	-	92	90	93	
"	"	1923	9.7	322	321	192	321	319	313	-	77	75	78	
"	"	1956	10.3	322	321	194	320	319	311	-	77	75	78	
"	"	2100	11.35	322	321	195	319	319	310	-	77	76	78	
"	"	2137	12.0	322	321	194	319	319	311	-	77	76	78	
"	"	2148	12.1	311	313	194	312	310	307	-	67	67	69	
"	"	2200	12.35	300	303	195	307	303	303	-	58	57	59	
"	"	2208	12.45	295	396	196	305	301	302	-	52	52	53	
"	"	2218	12.6	279	282	195	302	297	299	-	40	40	40	
"	"	2228	12.8	279	270	195	297	292	294	-	31	31	31	Water Coil on for
"	"	2238	13.0	254	254	194	292	288	290	-	19	19	20	cooling
JEY	"	2300	13.35	257	249	191	281	278	278	-	14	14	15	
"	"	2315	13.6	255	250	186	275	272	274	-	15	14	15	

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LIMITORQUE

LOG SHEET --- Page 3

OPERATOR	DATE	CLOCK TIME (2400 hr.)	COUNTER TIME (hr.)	TEMPERATURE (of) CHAMBER TC#1	CHAMBER THERM.	COND-ENSATE TC #2	SWITCH COMP #1 TC #5	SWITCH COMP #2 TC #7	LIMITORQUE MOTOR #1 TC #6	LIMITORQUE MOTOR # 2 OMIT	PRESSURE (PSIG) CHAM. GAGE	SWITCH COMP GAGE #1	SWITCH COMP GAGE #2	REMARKS
JEY	7/31/72	2330	13.85	253	251	183	269	266	267		15	15	16	
"	"	2345	19.1	252	250	180	264	260	250		15	14	15	
"	"	2900	14.35	252	251	182	259	257	251		16	15	16	Press.chart Recorder off
"	8/1/72	0820	22.7	247	251	179	247	246	238		16	16	17	
GJV	"	1756	32.3	249	251	168	244	243	233		16	17	17	
"	8/2/72	0831	46.8	250	252	165	248.	247	238		16	17	17	
"	"	1756	56.3	242	253	167	246	243	238		16	16	17	
JEY	8/3/72	0825	70.8	248	251	181	250	250	249		15	16	17	
GJV	"	1756	80.3	248	251	248	249	249	249		15	17	17	
"	8/4/72	0843	95.1	248	251	248	249	249	249		15	16	17	
JEY	8/4/72	1425	100.7	248	251	249	250	250	249		15	16	17	
GJV	"	1538	102.0	248	251	247	248	248	248		15	16	17	Start of drip
JEY	"	1559	102.3	237	237	225	242	242	240		10	16	15.5	
GJV	8/5/72	0900	set elec. heater air at 10 PSI - All water out of tank											
"	"	1022	120.7	195	220	233	184	185	184		11	off	off	
LEH	"	1505	125.4	202	240	242	204	208	205		11	off	off	
"	8/7/72	0845	0168		WATER IN BOTTOM OF TANK									
JEY	"	2339	0182	182	212	181	181	187	182		10	-	-	
"	8/8/72	0839	0191.0	183	209	186	185	171	187		10	-	-	
GJV	"	2344	206.1	186	211	186	186	192	188		10	-	-	
"	8/9/72	1138	218.0	189.	210	192	189	194	190		11	-	-	
"	"	1745	224.1	191	210	115	190	197	113		10	-	-	
"	8/10/72	0915	239.6	188	208	111	187	194	190		10	-	-	

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LIMITORQUE

LOG SHEET --- Page 6

OPERATOR	DATE	CLOCK TIME (2400 hr.)	COUNTER TIME (hr.)	TEMPERATURE (of) CHAMBER TC#1	CHAMBER THERM.	COND-ENSAT TC #2	SWITCH COMP #1 TC #5	SWITCH COMP #2 TC #7	LIMITORQUE MOTOR #1 TC #6	LIMITORQUE MOTOR # 2 OMIT	PRESSURE (PSIG) CHAM. GAGE	SWITCH COMP GAGE #1	SWITCH COMP GAGE #2	REMARKS
GJV	8/10/72	1720	247.7	188	211	191	187	193	189	-	11	-	-	
"	8/11/72	0848	263.2	187	209	190	186	193	189		11	-	-	
"	"	1734	271.9	191	209	194	190	197	192		10	-	-	
"	"	2138	276.0	192	212	194	190	197	193		10	-	-	
"	8/13/72	1052	313.2	187	212	191	186	193	189		10	-	-	
"	8/14/72	0841	335.0	187	211	191	186	193	189		10	-	-	
"	"	2012	346.5	193	2.2	196	191	199	195		10	-	-	
"	8/15/71	0850	359.3	192	214	194	190	198	194		10	-	-	
JEY	8/16/72	0830	382.8	190	211	194	190	197	193		10	-	-	Removed ½ bucket condensate Removed ½ " " @12:12p
GJV	8/17/72	0838	407.0	188	211	192	187	194	190		10	-	-	
"	8/18/72	0836	431.0	190	211	193	189	197	192		10	-	-	
"	"	1728	439.8	191	211	194	189	196	192		10	-	-	
"	8/19/72	2345	470.1	193	213	196	190	198	194		10	-	-	
"	8/21/72	0847	503.1	190	210	193	189	195	192		10	-	-	
"	"	1707	511.5	192	216	195	191	198	194		10	-	-	
"	8/22/72	0836	527.0	188	217	194	189	197	192		10	-	-	
"	"	1744	536.1	189	212	187	185	184	187		10	-	-	
"	8/23/72	1759	560.3	189	213	193	188	195	191		10	-	-	
"	8/24/72	0835	574.9	188	211	189	188	189	188		10	-	-	
JEY	8/25/72	0930	599.8	190	211	- not legible on chart					10	-	-	
GJV	"	1737	608.0	194	210	196	195	197	196		10	-	-	
LEW	8/26/72	1415	628.6		212	198	203	203	102		11	-	-	
GJV	8/27/72	1317	651.6	195	210	195	193	195	195		10	-	-	
JEY	8/28/72	0836	670.9	200	209	204	204	204	203		11	-	-	

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LOG SHEET --- Page 5

OPERATOR	DATE	CLOCK TIME (2400 hr.)	COUNTER TIME (hr.)	TEMPERATURE (of) CHAMBER TC #1	CHAMBER THERM.	COND-ENSAT TC #2	SWITCH COMP #1 TC #5	SWITCH COMP #2 TC #7	LIMITORQUE MOTOR #1 TC #6	LIMITORQUE MOTOR # 2 OMIT	PRESSURE (PSIG) CHAM. GAGE	SWITCH COMP GAGE #1	SWITCH COMP GAGE #2	REMARKS
GJV	8/28/72	1803	680.4	200	212	201	190	196	194		10	-	-	
"	8/29/72	0859	695.3	191	215	197	189	197	191		10	-	-	
"	"	1755	704.2	191	210	196	190	198	193		10	-	-	
"	8/30/72	0838	719.0	200	212	202	202	203	199		10	-	-	
"	"	1454	725.2	191	209	203	203	205	205		0	-	-	5 mins.after shutting air off, htrs.off,pwr.off, & removing condensate while reducing press. to 0 psig.

GFV	8/30/72	1504	Cover removed to autoclave
		-	Picture taken
		1530	Switch comp. cover removed to new operator - a very strong noxious odor was evident immediately.

Appendix

APPENDIX B

LIST OF INSTRUMENTS USED IN OBTAINING TEST DATA

APPENDIX B

LIST OF INSTRUMENTS USED IN OBTAINING TEST DATA

1. Honeywell-Brown Electronik 2-pen recorder, Model No. Y153X(22)-VV-X-IV-K-(G)(V), Ranges: 0 to 500°F with Type J thermocouples: 0 to 200 psig with Ametek Pressure Transducer. (Calibrated 4/13/72).

2. Honeywell-Brown Electronik Multipoint Recorder, Model No. 15305846-24-02-2-000-030-10 097, 0 to 500°F with Type T Thermocouples. (Calibrated 4/13/72.)

3. Westinghouse Industrial Analyzer, Type PG-191,25 to 150 Hz, Style 292B948A09. Connected for 25 A, 600 V, and 25 kW full-scale readings. (Calibrated 3/13/72.)

4. Westinghouse AC Wattmeter, Type PF-44, Style PH 10632N3 2, used in conjunction with Weston Potential Transformers, Model 311, No. 3283 and No. 3284, and Universal Current Transformers, Serial Nos. 56975 and 56976, for 25-kW full scale. (Calibrated 3/13/72.)

5. Sanborn 150, 4-channel recorder, with DC Coupling Pre-Amplifier, Model 150-300. (Calibrated 6/29/72.)

6. James G. Biddle Megger, Insulation Tester, No. 325603, 500 Vdc. (Calibrated 4/13/72.)

7. Ametek Pressure Transducer, Model 50-200-G-B/C. (Calibrated 12/16/71.)

8. 2 Giannini & Co. Pressure Transmitters, 0 to 300 psig. (Calibrated 7/30/72.)

9. Lonergan Maximon Gage, Type OA, 0 to 200 psig. (Calibrated 4/14/72.)

APPENDIX C

Reliance Electric Company

Certificate of Complicance for Heat Aging

RELIANCE ELECTRIC COMPANY
CERTIFICATE of COMPLIANCE

Limitorque Corp.
5114 Woodall Road
Lynchburg Va. 24502

March 3, 1972

EQUIPMENT:	Qty. 1, R56 Frame, 25 ft.lbs. Start Torque	
REFERENCE:	Purchase Order No.	355696-A
FILE:	Order No.	601962-P

We certify that the equipment identified above has been designed, manufactured, inspected, and/or tested in accordance with the requirements established by the following specifications:

Insulation G.F.I. 226.59
Finish G.F.I. 336.163
Class H Radiation Insulation
Heat aged 100 hrs. at 180°C
Rotor treatment U-475 Varnish
Winding Epoxy coated 4824-3A
Drain in B.E. Shield - U.L. approved

R. G. Lunsford

R.G. Lunsford, Manager
Quality Control Department
Madison, Indiana

PHILADELPHIA D/O (RPH)

RGL:st

APPENDIX D

Radiation International, Inc.

Certification of Test Unit Irradiation

May 23, 1972

Mr. W. H. Steigelmann, Manager
Nuclear Systems Laboratory
Franklin Institute Research Laboratory
20th and Race Streets
Philadelphia, Pennsylvania . 19103

Dear Mr. Steigelmann:

This will summarize the parameters pertinent to the irradiation of Limitorque Corporation's materials, described below, per your Case C-3327.

Motor

SN601962P	)	Motor used in FIRL test
Reliance Electric Company	)	report #F-C3441

Magnetic Brake and Motor

Motor: SN601960P
Reliance Electric Company

Brake: Magnetic Brake
Reliance Electric Company
Model X7-62008-26
SN-2-53276
6 Ft.-Lb. Torque, 460V

Valve and Motor

Limitorque
SMB Size 0
SN 144068
Motor - Limitorque
Reliance Electric Company
SN601961-P

Components were placed in a cobalt-60 gamma field of 1.0 Mrad per hour intensity for a period of 4 hours, and received a total minimum dose of 4 Mrad. They were then shipped via RII truck to Ogden Technical Labs for testing. The units were then received for further irradiation, and were exposed in a 1.0 Mrad field for an additional 200 hours or 200 Mrad. Portions of the outer sides of the components received a 25% higher dose to assure that inner portions received the designated 204 Mrad. Components were turned several times during exposure to assure a more uniform dose distribution. Irradiation was in air at ambient temperature and pressure. Radiant heat from the source heated the samples somewhat, but did not exceed 100°F, as confirmed by measurement of an oil solution in the same relative position.

Dosimetry was performed using a Victoreen Model 555 Integrating Dose Rate Meter and Probe. The unit was calibrated on January 15, 1971 by the Victoreen Instrument Company, using cobalt-60 and cesium-137 sources whose calibrations are traceable to the U.S. National Bureau of Standards. A copy of the calibration certificate is available.

Following irradiation, components were visually inspected for obvious irradiation damage. None was noted.

Irradiation was completed on May 8, 1972 and picked up by FIRL May 9, 1972.

Very truly yours,

George R Dietz

George R. Dietz
Manager, Radiation Services

GRD:km

APPENDIX E

Ogden Technology Laboratories, Inc.

Seismic Test Report

UNIVERSAL REPORT NO. ____

ORIGINATORS REPORT NO. 7192-9

REVISION ____

REPORT OF TEST ON

OPERATOR VALVE
P/N 144068
TWO (2) 25' lb.motors

TEST PERFORMED BY Ogden Technology Laboratories,Inc.

TEST AUTHORIZED BY LIMITORQUE CORPORATION

CONTRACT NUMBER ____

PURCHASE ORDER NUMBER 360943

OTL JOB NUMBER 8909

	Date	Signature	
Test Initiated			
Test Completed	4/26/72		
Report Written By	9/26/72	H. Golinger	H. Golinger
Technician			
Test Engineer	9/26/72	H. Golinger	H. Golinger
Supervisor Gen.Mgr.	9/26/72	A. Helfand	A.Helfand
Supervisor			
Quality Assurance	9/26/72	J. Bonner	J. Bonner
Government Repr. (if applicable)			
Final Release			

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Notices

When Government drawings, specifications or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have in any way formulated, furnished, or supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation of conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

ADMINISTRATIVE DATA

TEST REPORT:	7I92-9
TEST CONDUCTED:	Vibration Test
MANUFACTURER:	Limitorque Corporation 5114 Woodall Road Lynchburg, Va. 24502
MANUFACTURER'S TYPE OR MODEL NO.:	Operator Valve, SMB-0-25, S/N 144068 1 25' lb. motor with brake 1 25' lb. motor without brake
DRAWING, SPECIFICATION OR EXHIBIT:	Per P.O. 360943
QUANTITY OF ITEMS TESTED:	Three (3)
SECURITY CLASSIFICATION OF ITEMS:	Unclassified
DATE TEST COMPLETED:	26 April 1972
TEST CONDUCTED BY:	Ogden Technology Laboratories, Inc.
DISPOSITION OF SPECIMENS:	Returned to Limitorque Corporation
DATE OF TEST REPORT:	26 September 1972
MANUFACTURER'S PURCHASE ORDER NO.:	360943
ABSTRACT:	Refer to Test Results, Para. 4.0.

1.0 TEST EQUIPMENT

1.1 Electro-Hydraulic Vibration Machine
Ogden Technology Laboratories, Inc.
Type: 6"/25K
Calibration: None required

1.2 Data Track
Research, Inc.
Model: FGE-5110
Calibration: Before each use

1.3 Servo Amplifier
Moog
Model: 82-104
Calibration: None required

1.4 Function Generator
Hewlett-Packard Corp.
Model: 202A
Calibration Interval: 6 months
Last Calibration: 3/27/72

1.5 Recording Oscillograph
Consolidated Electrodynamics Corp.
Model: 5-124
Calibration: System calibration prior to use

1.6 Signal Amplifier
Unholtz-Dickie Corporation
Model: 607-RMG-3A
Calibration Interval: 6 months
Last Calibration: 4/16/72

1.7 Accelerometer (5)
Endevco Corporation
Model: 2215C
Calibration Interval: 6 months
Last Calibration: 12/6/71

All instrumentation and equipment calibration is conducted in accordance with Specification MIL-Q-9858A as further defined in MIL-C-45662A "Calibration System Requirements" and is traceable to the National Bureau of Standards.

2.0 TEST SEQUENCE

2.1 Vibration Test

3.0 TEST PROCEDURE

3.1 Vibration Test

Each of the three (3) test items was individually subjected to vibration testing along each of the three (3) mutually perpendicular axes over the frequency range of 1 to 35 Hz with a maximum acceleration of 1.0 g's in order to determine natural frequencies. Three (3) accelerometers were utilized to monitor for the presence of natural frequencies recorded upon a direct print oscillograph. Functional operation of each test item was performed by cognizant personnel of Limitorque Corporation.

At each noted natural frequency (if any) three (3) cycles of vibration at an excitation of 5.3 to 5.8 g's were performed. A one (1) minute rest period was allowed after each 3 cycles. If no natural frequencies were apparent (as was the case) a 10-second dwell was performed at 2, 4, 6, 9.......N Hz utilizing maximum available control displacement up to a cut-off level of 3 g's and at 5.3 to 5.8 g's at 35 Hz. Limitorque personnel monitored the equipment.

4.0 TEST RESULTS

4.1 Vibration Test

No apparent natural frequencies were determined as a result of this testing. In all cases for all test items vibration was applied at 3 g's for ten (10) seconds at all even numbered frequencies from 2 Hz to 34 Hz and at a level between 5.3 and 5.8 g's at 35 Hz.

Photographs of the test item set-ups are included in Appendix A.

There was no visible evidence of damage noted to any unit as a result of this test.

5.0 RECOMMENDATIONS

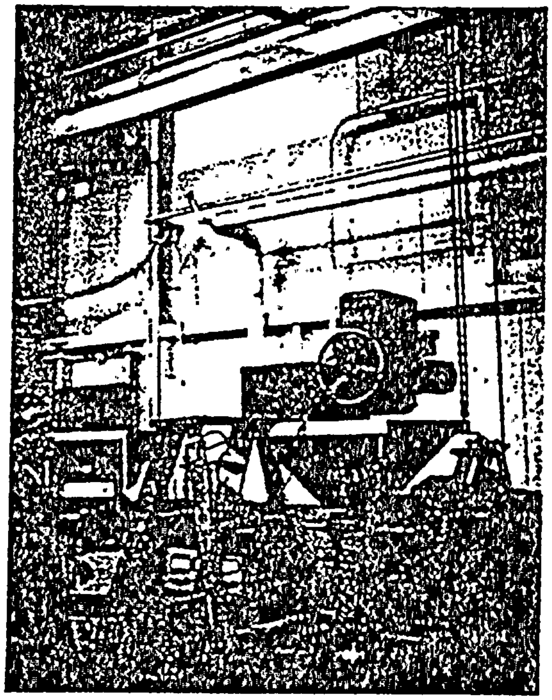
None. Test results submitted herein are merely presented for your evaluation.

APPENDIX A

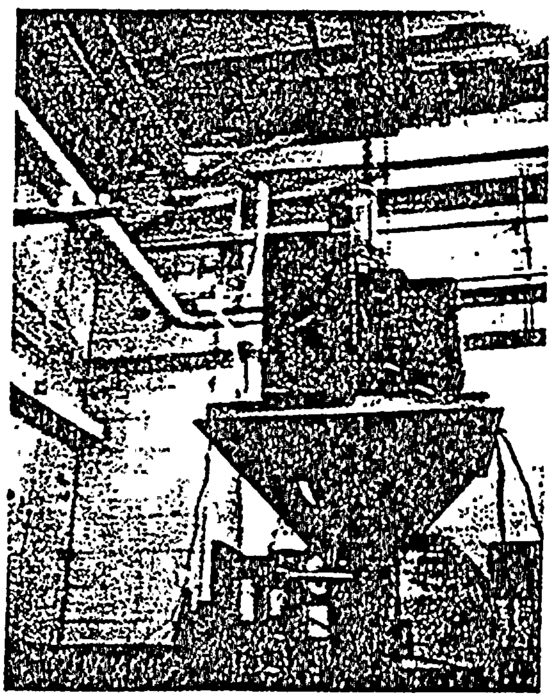
Photographs

VALVE OPERATOR SMB-0-25

S/N 144068

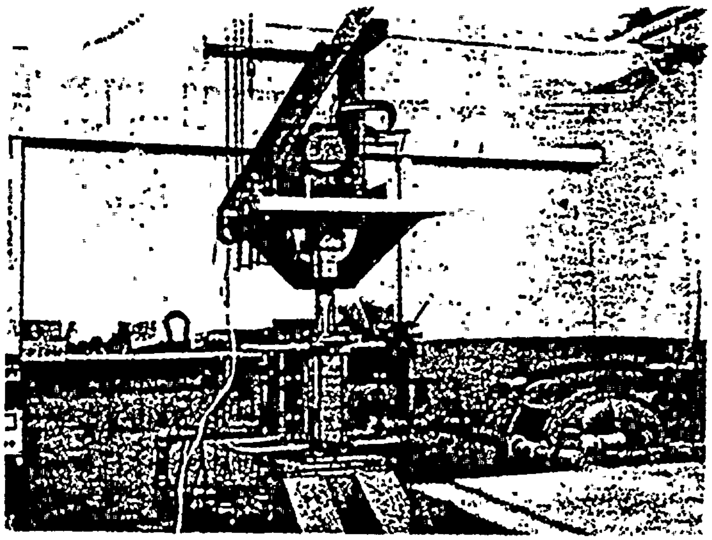


Y AXIS

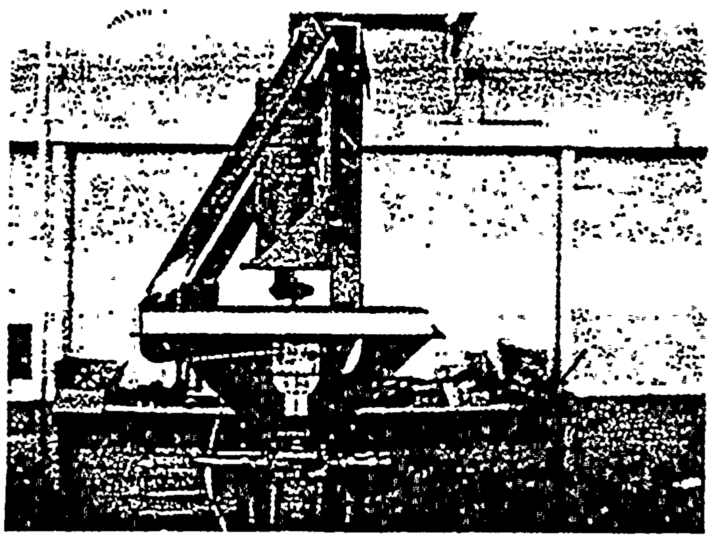


X AXIS

MOTOR WITH BRAKE

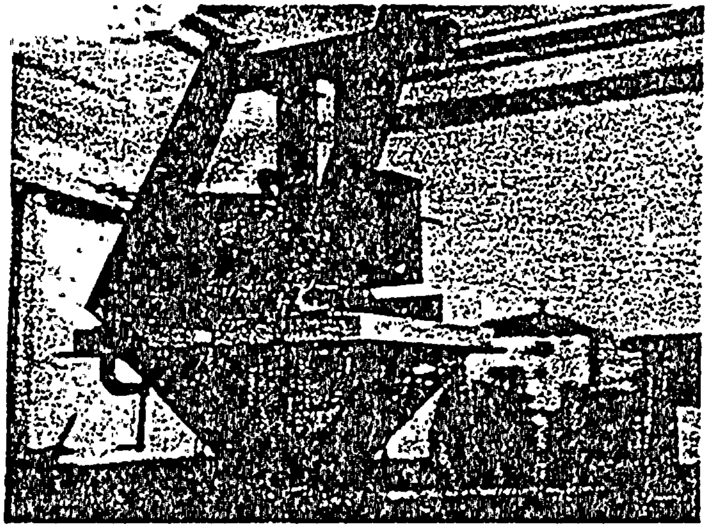


LATERAL AXIS



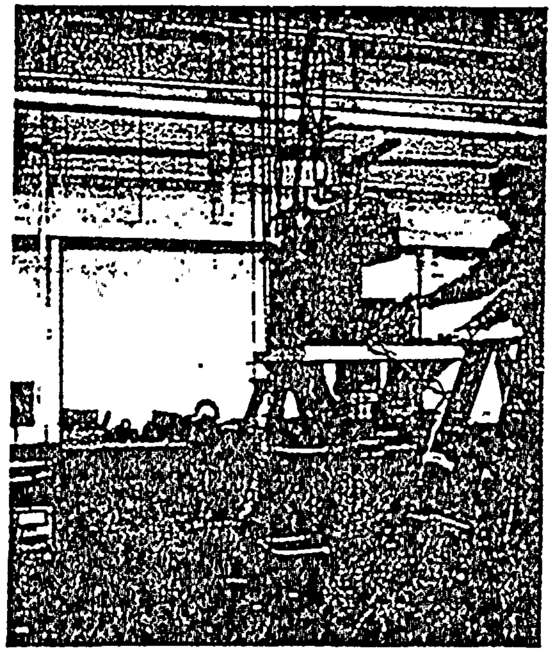
LONGITUDINAL AXIS

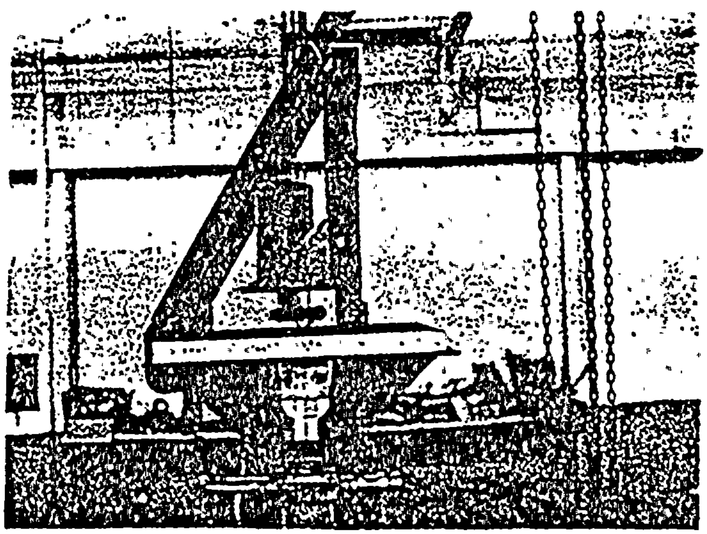
MOTOR WITHOUT BRAKE



LATERAL AXIS

VERTICAL AXIS





LONGITUDINAL AXIS

APPENDIX B

Test Data Sheets

DATA SHEETS

Ogden Technology Laboratories, Inc.

Job Number: 8959 Engineer: [illegible signature]

Test: Unit Part No:

Test Technician: Unit Serial No:

Date Photo Taken: Date 4-23-77

X-Axis Valve Operator

2 6" da
4 3g
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
35 5g

1500 - Y axis - Valve operator : start scan 1-34 Hz
1510 - Start endurance

2	6"	18	3g	34	3
4	3"	20		35	5g 1 MIN
6	3g	22			
8		24			
10		26			
12		28			
14		30			
16		32			

DATA SHEETS

Ogden Technology Laboratories, Inc.

Job Number: 8969 Engineer: Solinger

Test: VIBRATION Unit Part No: SMVQ-25

Test Technician: HS Unit Serial No: 144068

Date Photo Taken: 4-24-72 Date 4-24-72

0800-1100- set up in Vertical (z) | Valve operator motor w/o brake

1Hz → 2Hz @ 6" d.a.

2Hz → 34Hz @ ±1g

1100 Start scan

1107 - Completed

1107 - Start 10 second dwell at

2 Hz - 6" d.a.

4 Hz - 3g

6 Hz - 3g — accel #1 - control base

8 Hz - 5.5g — #2 - motor end

10 Hz - 5.5g — #3 - handwheel end

12 Hz - 5.3g

14 Hz - 5.4g

16 Hz - 3g

18 Hz - 3g

20 Hz - 3g

22 Hz - 3g

24 Hz - 3g

26 Hz - 3g

28 Hz - 3g

30 Hz - 3g

32 Hz - 3g

34 Hz - 3g

35 Hz - 5.3g

1300 - Changing Valve operator to X axis - motor with brake in Z axis

1355 - Start scan - 1 to 34 Hz

OTL/ENG/1

DATA SHEETS

Ogden Technology Laboratories, Inc.

Job Number: 8709 Engineer: Selinge

Test: Unit Part No:

Test Technician: Unit Serial No:

Date Photo Taken: Date 4-26-72

0800 - Motor set in long axis - start scan
0815 - Completed - non op.
0830 - Completed resonance dwells - 2-34 @ 3g
motor running. 35 @ 5g
accel 1 - control
accel 2 - shaft end
accel 3 - rear end
0900 - Changing to motor with brake
0940 - Start 1g scan 1Hz to 34Hz
accel 3 - brake end
0945 - Completed - non operating
0946 - Start 2-34Hz @ ±3g 35Hz @ ±5g
1000 - Completed - unit operating
1300 - Changed motor with brake to 3rd axis
1330 - Completed all testing on this unit
1430 - Start survey on motor with brake
accel #3 on end of motor
1500 - Completed all testing on this unit

No visible damage noted on any unit.

OTL/ENG/1

APPENDIX C

PWR Containment Qualification

Report 600456

NUCLEAR POWER STATION

QUALIFICATION TYPE TEST REPORT

LIMITORQUE VALVE ACTUATORS
FOR PWR SERVICE

PROJECT #600456

Tested per IEEE Standard 382-1972

Test Performed 7 June 1974 to 22 November 1974

Prepared by Limitorque Corporation

Test Laboratory

Prepared by Walter L. Sykes
Walter L. Sykes
Test Engineer

Date 12/9/75

Approved W J Denkowski
W. J. Denkowski
Chief Engineer

Date Dec 9, 75

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APPENDICES

PWR Qualification

1.0 Introduction

A typical Limitorque Valve Actuator, SMB-0 with a 40 ft-lb motor (SMB-0-40) was submitted for qualification to the type test specified by IEEE std. 382- '72' for service in a Pressurized Water Reactor (PWR) containment chamber in Nuclear Power Station application.

The SMB-0-40 Valve Actuator was subjected to mechanical aging simulation to approximate 40 years service life, radiation exposure (Both Normal Life levels plus accumulative doses) and other environmental conditions all as indicated in IEEE Std. 382-'72'. Additional load cycling was performed after LOCA environmental conditions to determine the post accident abilities of the valve actuator.

2.0 Identification of Sample Valve Actuator

TEST UNIT

A limitorque SMB-0 Nuclear Valve Actuator with a 40 ft-lb nuclear containment motor (RH Insulation Class) was constructed per standard nuclear bill of materials and standard nuclear motor specifications. The following information was taken from the identification tags:

PWR Qualification

Valve Actuator Type/Size SMB-0

Manufacturer ....Limitorque Corporation

Order Number 600456-A

Serial Number 189835

Electric Motor Information:

Size ....40 ft-lb stall
8 ft-lb run

Manufacturer ....Reliance Electric Company

Identification number 2Y267074A1EZ

Full Load Speed ....1735 RPM

Frequency ....60 Hz

Voltage ....460 Volts

Insulation Class ....RH

Type ....P

3.0 Type Test Procedure

The type test plan as described in IEEE Std. 382-'72', paragraph 4, consists of three basic parts:

1. Aging Simulation
2. Seismic Qualification
3. Accident Environmental Simulation

As an added test margin, the test actuator was submitted to additional load cycling after completion of all the required environmental conditions and prior to final inspection. This additional load cycling is not a requirement of IEEE Std. 382-'72'. A base test motor was processed with the Test Unit for additional engineering information.

3.1 Aging Simulation (IEEE Std. 382 para. 4.2)

3.1.1 Thermal Aging

Thermal aging was performed on the motor stators by the motor manufacturer (Reliance Electric Company) in cooperation with Limitorque Corporation.

The motor stator was heat aged for 100 hours at 180°C. A certificate of compliance was supplied by Reliance Electric Company verifying the thermal aging of the stator (see Appendix A.)

3.1.2 Mechanical Aging

Mechanical Aging was performed on the Test Unit by the Limitorque Test Laboratory. Data on the Aging & Post test Cycling is presented in Appendix B. Although IEEE Std. 382- '72' requires 500 cycles, the unit was cycled thru 1208 cycles,

each cycle consisting of one close stroke and one open stroke at room ambient conditions. The Limitorque Valve Actuator was seated at the end of the close stroke and the seating thrust monitored. The thrust applied was equivalent to the thrust & torque ratings of the SMB-0 actuator. A typical stroke time of 40 sec. was chosen for the actuator operating time.

3.1.3 Radiation Aging (IEEE Std. 382-'72' Part II Section 1)
The Aging dose of 4 Megarads was combined with the accident dose (200 Megarad) per IEEE Std. 382-'72' part III and is discussed in the following section 3.3 of this report.

3.2 Seismic Qualification (IEEE Std. 382 Para. 4.3)
The Seismic Qualification was performed by Lockheed Electronics, Inc. Environmental Laboratory on a Reaction Vibration machine. The Test Unit with motor, was scanned in each of the three major axis over a frequency range of 5 to 35 Hz to search for resonance. No resonance was found.

The Valve Actuator was mounted on a test fixture to provide simulated valve seating loads, during the dwell portions of the seismic qualifications. The load imposed was equal to the rating of the test actuator.

The vibration machine was adjusted to a displacement (0.050" D. A.) equivalent to 3 g's acceleration at a frequency of 35 Hz. The test sample was then vibrated for a period of ten (10) seconds at each even integer of frequency from 6 Hz to 34 Hz. The unit was operated during the dwell through one cycle from open limit-to-torque switch seated position and back to original point. The vibration machine was adjusted to a displacement (0.100" D. A.) equivalent to 6 g's acceleration at a frequency of 35 Hz. The test sample was then vibrated for a period of ten (10) seconds at 35 Hz and operated during the dwell.

The dwell tests above were performed in each of the three major axis. A report on the Seismic Qualification was prepared by Lockheed Electronics Corporations Environmental Laboratory (Report No.3521-4811 and is presented in Appendix D.) The duration of each stroke was 40 seconds.

3.3 Radiation Exposure (IEEE Std. 382 Part II Section 1)

The Limitorque Actuator and motor were subjected to a Gamma Ray Irradiation of 204 Megarads per IEEE Std. 382-'72' requirements.

The Test Unit was placed in a Cobalt-60 and Cesium-137 field of 1 Mrad/hour at an air equivalent dose.

A total radiation dose of 204 Megarads was applied after thermal aging, mechanical aging and seismic qualification.

The radiation exposure was performed by Isomedix Corporation. A Test Certification was supplied by Isomedix Corporation and is presented in Appendix C.

3.4 Accident Simulation (IEEE Std. 382-'72')

3.4.1 Test Description

The test was performed at Limitorques' Environmental Test Facility, see figures 1, 2 and 3 in Appendix E. A schematic of the instrumentation system and a summary of instruments used during the test are presented in Figure 4 and Table I located in Appendix F. The limitorque Actuator was mounted on a thrust tube attached to the side of the test chamber with the stem thrusting against the load cell mounted

externally to the test chamber. (see Figure 1, Appendix E)

Control and power lead connections were made through flexible pressure tight conduit.connections run between the units and the access ports of the test chamber. The external wire harness was run to a junction box, where terminal strips provided access to each lead for monitoring insulation resistance. The terminal strips were wired to a control system (see Figure 4, Appendix F). The control panel illustrated in Figure 3,(Appendix E) contains a power monitoring system to monitor line voltage, current in each of the three (3) motor legs and the power consumption of the motor.

Pressure and temperature were monitored on the multipoint temperature recorder and strip chart recorder mounted on the test console (Figure 3, Appendix E). In addition to the automatic monitoring system, the temperature and pressure was monitored by a pressure gauge and two thermometers mounted in the side wall of the test chamber (see Figures 1 and 4.)

During the rapid temperature and pressure transients, the chamber ambient and limit switch compartment internal temperature and pressure were monitored continuously on the strip chart recorder.

Cooling coils mounted inside the chamber provided cooling capacity to reduce the temperature in the chamber to the various temperature plateaus.

A double spray system provided a reliable source of chemical spray during the test profile. Flow meters mounted on the panel near the test chamber (see Figure 1, Appendix E) monitored the chemical fluid flow. Spray nozzles mounted on two sets of manifolds (3 nozzles per manifold) with the ability to switch manifold provided the proper spray pattern. The pressure in each active manifold set was monitored to indicate any restriction of the spray nozzle orifice. A back flush system was provided to back flush the spray manifold.

3.4.2 Test Procedure for LOCA Test

The Limitorque Valve Actuator was exposed to steam and chemical spray in accordance with the

criteria listed in Table 1 in the "IEEE Guide for Type Test of Class 1 Electric Valve Operators for Nuclear Power Generating Stations" IEEE Std. 382-'72'. The temperature/pressure profile is illustrated in Figure 5, which also shows the schedule for measuring the insulation resistance of the power and control leads and cycling of the Limitorque Valve Actuators.

During the first four days of the test, the specified temperature and pressures were maintained by the controlled injection of steam into the test chamber. During the remainder of the test, the 200 ^{o}F/10 psig state was maintained by filling the test chamber with air controlled to the proper pressure and using electrical heaters. The atmosphere was kept saturated with water vapor by maintaining condensate in the bottom of the tank and by daily injections of steam.

3.5 Post Test Inspection

A visual inspection of the limit switch compartment and the limit and torque switches was performed at the conclusion of the accident simulation.

Specified Accident Profile

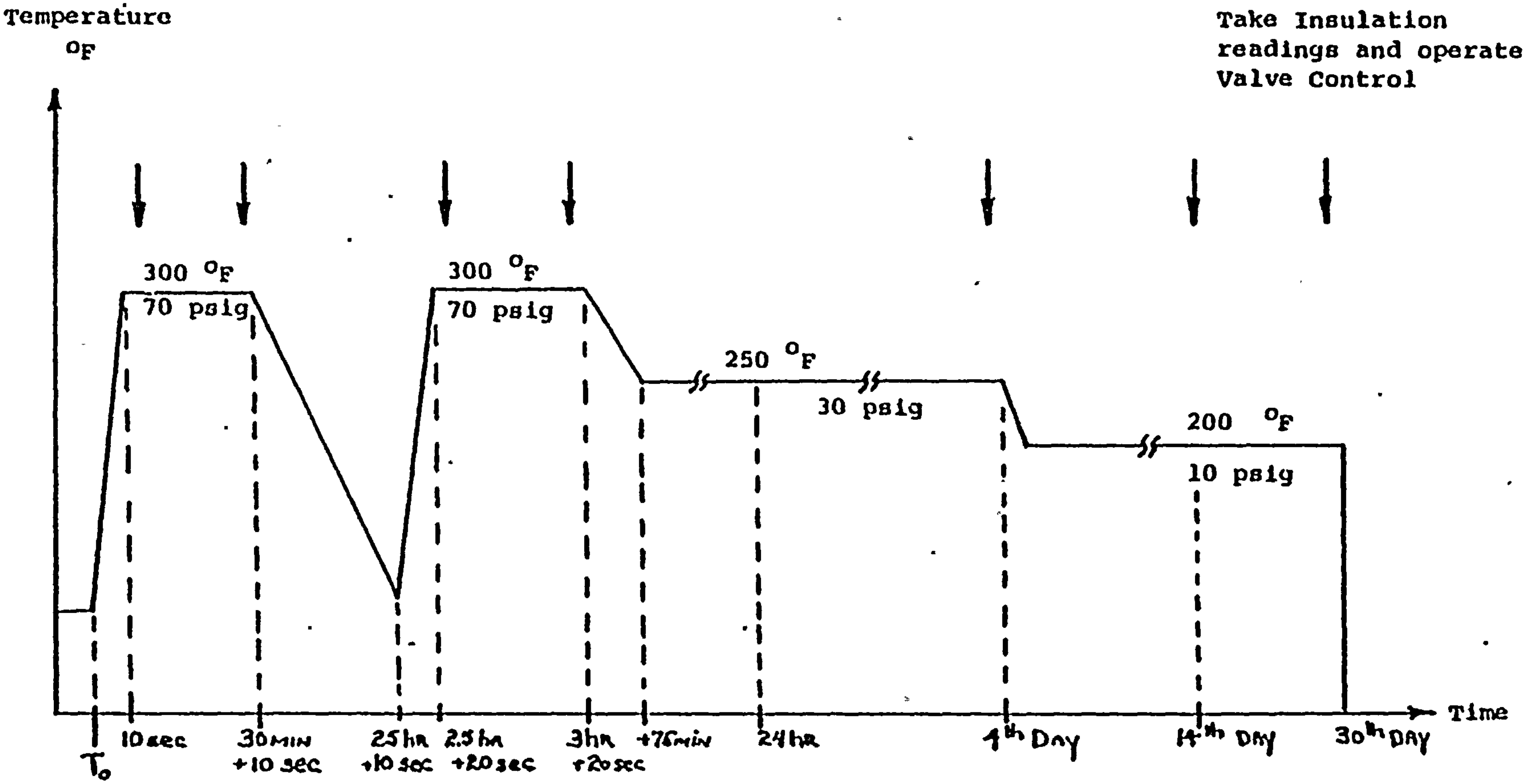


Figure 5

3.6 Post LOCA Load Cycling Test

Similar to that performed at pre-test mechanical aging, the unit was cycled for a total of 794 cycles (one close & one open stroke percycle) at room ambient conditions (data supplied in Appendix B).

3.7 Final Inspection

A complete physical inspection of the test samples was made after the completion of the Post LOCA Load Cycling to observe the conditions of the actuator.

4.0 Test Results

4.1 Mechanical Aging

The unit was initally tested on 7 June 1974 and a thrust output of 20,162 lbs. was obtained at a torgue switch setting of 1-3/4. (This value is an average of 24 readings.) The unit remained on the test stand and was automatically cycled at room ambient conditions.

The cycling test was performed from 7 June 1974 to 10 June 1974 for a total of 1208 cycles consisting of one torque switch closure in each cycle.

The load was measured after the completion of the mechanical aging and an average of 10 readings produced a thrust output of 19,920 lbs.

The test data obtained is presented in Appendix C.

4.2 Seismic Qualification

The Seismic Qualification was performed at Lockheed Electronics Environmental Laboratory on 12 June 1974. The data recorded is presented in Lockheed test Report No. 3521-4811. (Appendix D.) The thrust load was not monitored during seismic testing; however, thrust readings taken after seismic and radiation, 19,350, average of three readings, was within three (3) percent of the post mechanical aging value. The output characteristics did not change during seismic testing or irradiation. The valve actuator and its limit and torque switch functioned during seismic testing.

4.3 Radiation Aging & Accident Exposure

The exposure to radiation of the Test Unit was performed on 18 July 1974 at Isomedix Corporation. A total dose of 204 Megarads was used. A Test Certification may be found in Appendix C.

4.4 Accident Environmental Simulation Test Results

The LOCA Test was performed at Limitorques' Environmental Test Facility. The environmental test was started 22 August 1974 and completed 21 September 1974.

4.4.1 Temperature and Pressure Profile

The profile specified in paragraph 3.2.5 of this report was closely followed as evidenced in Figure 6. The transient data was obtained by means of the strip chart recorder. At the transient time of ten (10) seconds, the temperature was a temperature within 91% of the specified temperature (300°F.) A temperature of 300°F was reached in 15.2 seconds. The second transient closely approximated the first reaching a temperature of 300°F in 13.8 seconds. Copies of the actual strip chart data are presented in Figures 7 & 8.

After the transient and a dwell of 30 minutes at 300°F, the test ambient was brought to a stable condition of 250°F and 30 psig. The actual temperature conditions were within minus 2% and plus 6% of specified temperature and the pressure conditions were within plus or minus 3.5%. These conditions were maintained for the balance of four (4) days.

At a test time of 96.1 hours (approx. 4 days) the test ambient was lowered to 200°F and 10 psig. The chamber was maintained at these conditions by means

ACTUAL ACCIDENT PROFILE

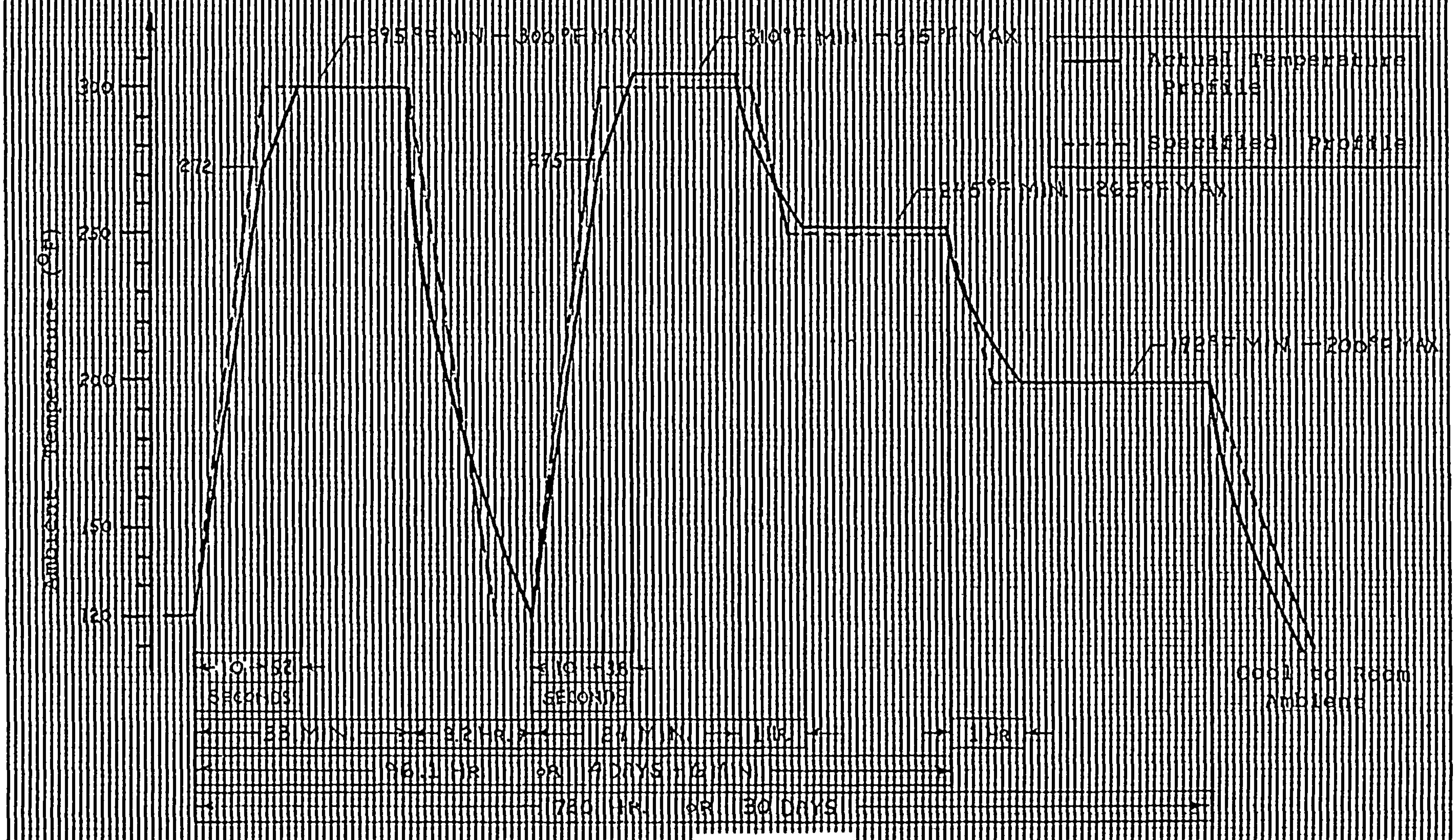


FIGURE 6

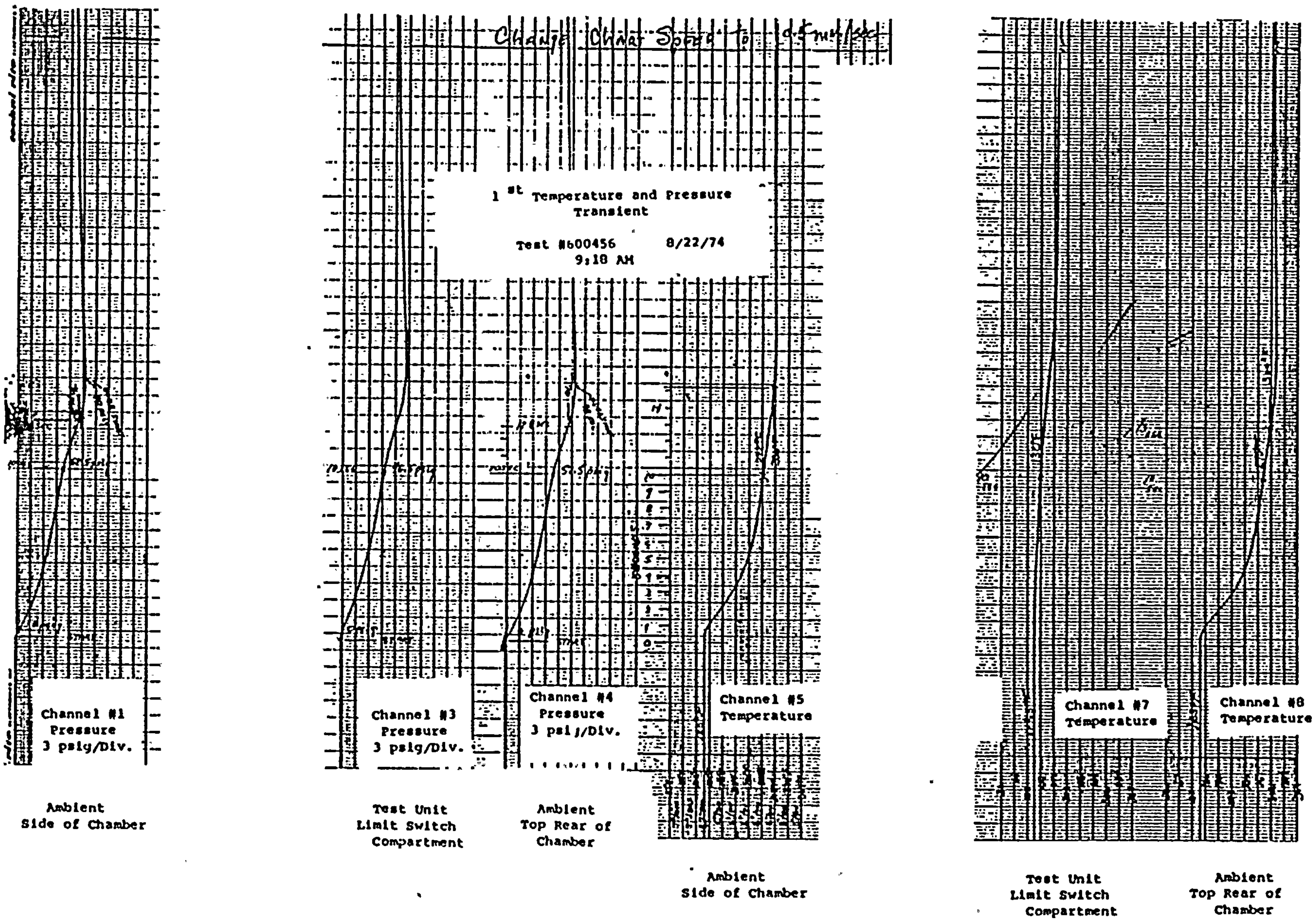

1 st Temperature and Pressure Transient
Test #600456 8/22/74
9:18 AM
Channel #1
Pressure
3 psig/Div.
Channel #3
Pressure
3 psig/Div.
Channel #4
Pressure
3 psig/Div.
Channel #5
Temperature
Channel #7
Temperature
Channel #8
Temperature
Ambient
Side of Chamber
Test Unit
Limit Switch
Compartment
Ambient
Top Rear of
Chamber
Ambient
Side of Chamber
Test Unit
Limit Switch
Compartment
Ambient
Top Rear of
Chamber

Figure #7

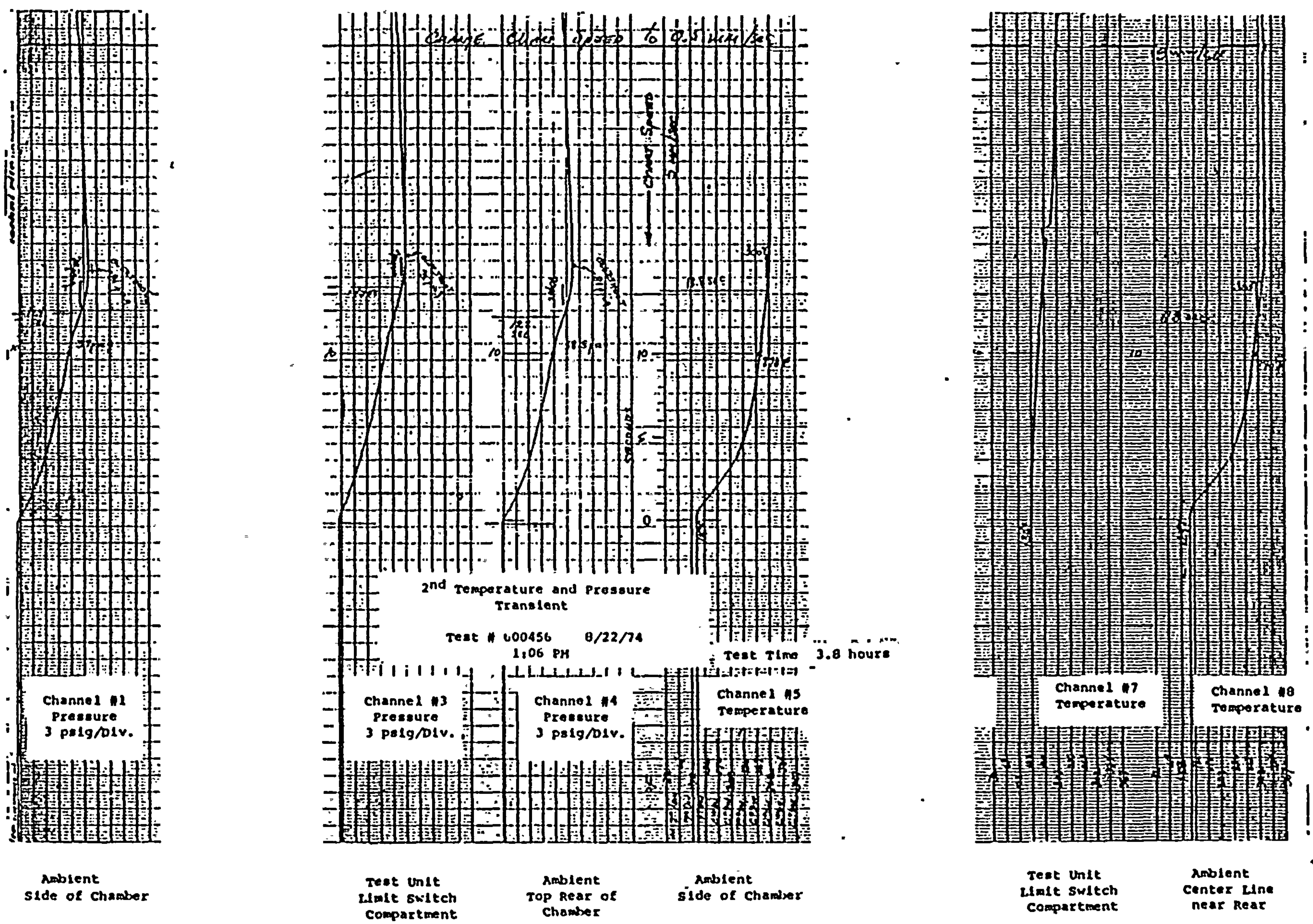

2nd Temperature and Pressure Transient
Test # 600456   8/22/74
1:06 PM
Test Time 3.8 hours
Channel #1
Pressure
3 psig/Div.
Channel #3
Pressure
3 psig/Div.
Channel #4
Pressure
3 psig/Div.
Channel #5
Temperature
Channel #7
Temperature
Channel #8
Temperature
Ambient
Side of Chamber
Test Unit
Limit Switch
Compartment
Ambient
Top Rear of
Chamber
Ambient
Side of Chamber
Test Unit
Limit Switch
Compartment
Ambient
Center Line
near Rear

Figure #8

of strip heaters and air injection through a pressure controlled solenoid valve. Once stability was reached, the ambient was maintained within plus 0% and minus 4% of specified temperature and plus 10% and minus 0% of specified pressure.

4.4.2 Chemical Spray Delivery

The chemical mixture (per Table 1 of IEEE Std. 382-page 12) was prepared prior to start of the LOCA test and pH values measured. Tank No. 1 had a pH of 10.9 after initial mixing. Tank No. 2 had a pH of 10.5 after initial mixing. The pH was monitored on a sample taken from Tank No. 1 at a test time of 0.1 hours (pH=11.1) and after 4.4 hours (pH=11.1). A sample of Tank No. 2 taken at 24 hours had a pH reading of 10.5.

The chemical flow was maintained at 0.6 gal/min in each spray manifold or an overall flow rate of 1.2 gal/min. A check was made of the average flow rate by recording the total amount of chemical solution used in a given period of time. These average flow rates agreed with the recorded instantaneous flow rates.

4.4.3 Chamber Humidity

The relative humidity of the chamber was maintained at 100 percent by the periodic injection of steam and by maintaining the vapor condensate at the bottome of the chamber at the same temperature as the air/vapor mixture. The content of air in the air vapor mixture was minimized by venting the chamber during the thermal transients.

4.4.4 Insulation Resistance Measurements

Insulation resistance measurements to ground were made periodically on the power and control leads of the Test Unit prior to operating the valve actuator (see Table II.)

4.4.5 Operator Cycling Data

The test unit functioned without problems throughout the entire test. It is worthy to mention that during the final operational cycle (719.1 hours) the close indicating light exhibited a very dim glow when it should have been extinquished.. This phenomena was noticed only on the "close" light circuit and no other indicating lights or circuits

TABLE II

Insulation Resistance of Power and Control Leads

(All resistances are in Megohms except where a K indicates Kilo-ohms)

(all measurements made to ground)

Time After Start Test (hr.)	MOTOR LEADS			CONTROL CIRCUIT LEADS														
	T-1	T-2	T-3	CL-1	61	71	41	43A	43B	43C	45A	45B	51	53A	53B	53C	55A	55B
*0	400	400	400	180	180	180	2000	180	180	180	180	180	180	190	180	180	180	180
0.15	160K	160K	160K	300K	400K	400K	40.0	400K	400K	400K	400K	400K	400K	400K	400K	400K	400K	400K
0.5	120K	120K	120K	280K	280K	280K	5.0	280K	280K	280K	280K	280K	280K	280K	280K	280K	280K	280K
3.9	100K	100K	100K	2.0	2.0	2.0	6.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4.2	50K	50K	50K	400K	400K	400K	2.4	400K	400K	400K	400K	400K	400K	400K	400K	400K	400K	400K
95.5	80K	80K	80K	2.0K	2.0K	3.0K	40K	2.0K	2.0K	2.0K	2.0K	2.0K	2.0K	2.0K	2.0K	2.0K	2.0K	2.0K
334.9	60K	60K	60K	1.5K	1.5K	2.0K	5.0K	1.5K	1.5K	1.5K	1.5K	1.5K	1.5K	1.5K	1.5K	1.5K	1.5K	1.5K
719.1	60K	60K	60K	2.0K	2.0K	3.0K	5.0K	1.7K	1.7K	1.7K	1.7K	1.7K	1.7K	1.7K	1.7K	1.7K	1.7K	1.7K

*Check prior to start of test.

exhibited these characteristics. Subsequent investigation concluded that the current flow through this light to duplicate the dim glow was insignificant and coupled with its occurrence in the final hour of a 30 day test did not constitute a malfunction.

The megger readings diminished during the environmental test and the current & power requirements did increase slightly as the test in the environmental chamber continued; however, this had no effect on the actuator performance. The stroke time remained constant throughout the test.

Also a slight variation in the measured output thrust was noted and was attributed to a change in stem efficiency rather than actuator output torque change. It was noted that during periods of non-operation, the thrust tended to become lower, whereas during periods of frequent operations, the thrust increased. Probably, the ambient temperature & moisture effected the lubricity of the lubricant used on the stem.

A summary of the cycling data is presented in Table III.

TABLE

VALVE ACTUATOR CYCLING DATA

Time After Start of Test (hr.)	Potential (volts)			OPEN STROKE					CLOSE STROKE							
				Run Current (Amps)			Power (Watts)	Stroke Time (Secs)	Run Current (Amps)			Peak Current *(Amps) (T-3)	Power (Watts)		Stroke Time (Secs)	Seating Thrust (lbs)
	T-1 T-3	T-1 T-2	T-2 T-3	T-1	T-2	T-3			T-1	T-2	T-3		Run	*Peak		
** 0	490	495	490	4.6	4.8	4.6	620	42	4.6	4.8	4.4	5.0	620	1350	42	19,375
.3	475	480	480	4.5	4.6	4.5	620	42	4.3	4.3	4.2	5.1	600	1300	43	19,425
.6	485	490	485	4.7	4.8	4.6	680	42	4.8	4.9	4.5	5.1	680	1320	43	20,825
4.1	485	490	485	4.8	4.9	4.6	620	42	4.8	5.0	4.6	5.1	610	1300	43	21,600
4.3	490	490	480	4.8	5.0	4.7	650	42	4.8	5.0	4.6	5.1	640	1350	43	22,150
95.5	495	500	495	5.1	5.2	5.0	725	42	5.2	5.3	4.9	5.3	750	1500	43	22,650
335.4	485	490	485	4.8	4.9	4.6	650	41	4.9	5.0	4.6	5.0	650	1400	42	21,600
719.1	495	500	490	4.9	5.2	4.9	675	42	5.0	5.2	4.7	5.0	675	1500	42	18,550
719.5	495	500	490	5.0	5.2	4.9	700	42	5.0	5.2	4.7	5.6	675	1900	42	21,350

* Due to rapid rise of current and power, considering the slow meter response times, these values to be considered as approximation of actual peak.

** Check prior to start of test.

4.5 Post LOCA Inspection

The post LOCA Inspection was performed 21 September 1974 after opening the test chamber. Photographs were taken of the test unit with the limit switch compartment cover in place (see Figure9). Externally, the Test Unit was clean looking with no unusual deposits. The limit switch compartment had approximately one-eighth (1/8) of an inch of condensate in the bottom of the compartment.

Both the limit and torque switches were clean and functioned without mechanical difficulties. The motor lead protective sleeving was split in several areas; however, no damage was noted to the motor lead insulation.

4.6 Post LOCA Load Cycling

The post LOCA Load Cycling was performed by the Limitorque Test Laboratory from 30 September 1974 to 4 October 1974.

The thrust output of the Test Unit was measured prior to the start of the load cycling. The thrust output was found to be 16,392 (an average of 6 readings). This was accomplished at the same torque

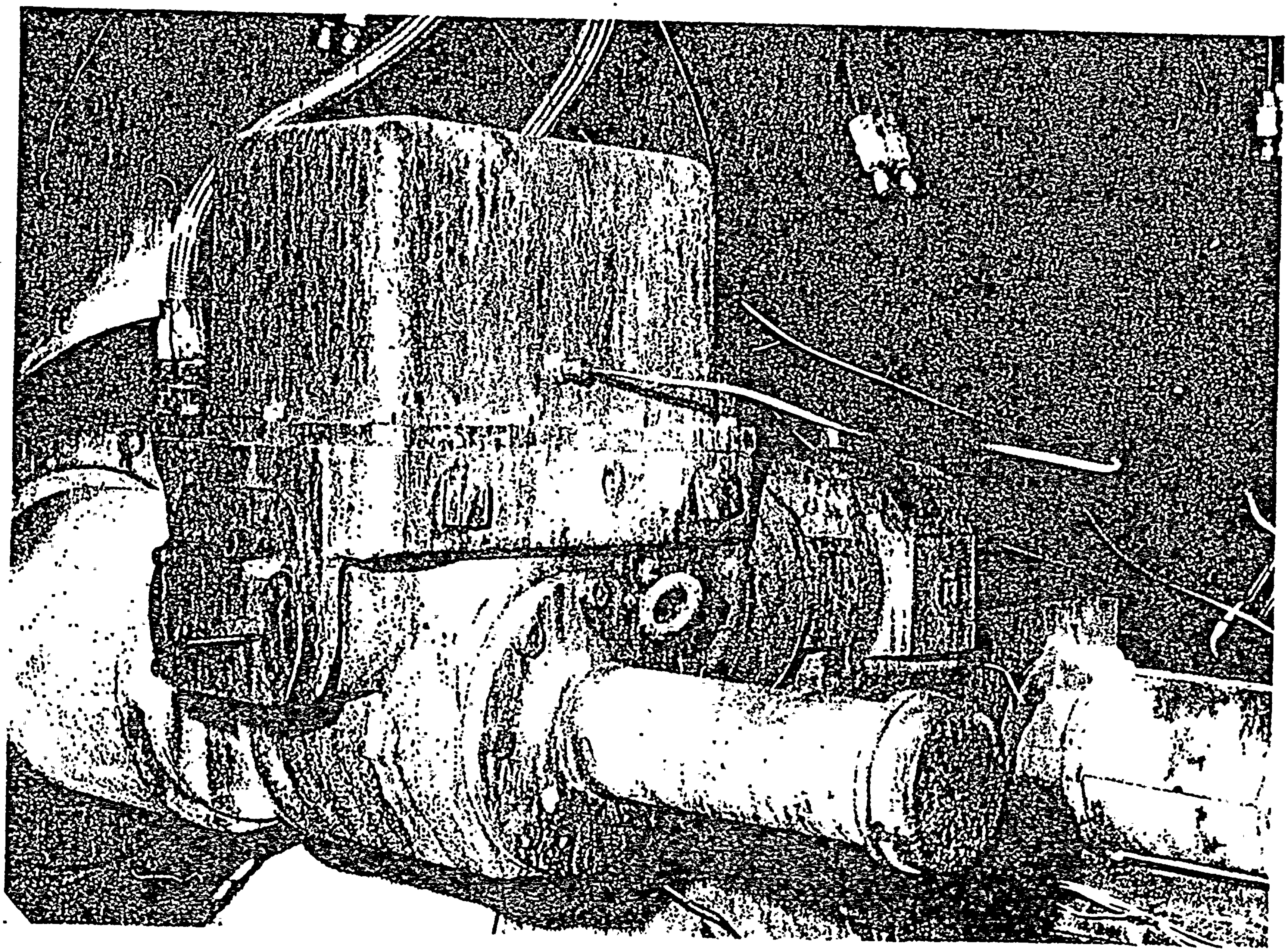


Figure 9 Post LOCA Conditions

4.7 Final Inspection and Dismantling

4.7.1 Motor Inspection and Dismantling

The motor (used with the test unit during LOCA test) mounted on the Test Unit was removed from the SMB valve actuator and dismantled for inspection. The inspection was performed on 21 November 1974 with representatives from Reliance Electric Company in attendance.

The rotor turned freely prior to dismantling the motor. The stator and rotor showed little evidence of corrosive build-up and no evidence of physical damage. The end bell was particularly clean with little evidence of water. The bearing lubricant was moist and the bearing turned freely.

4.7.2 Valve Control Inspection and Dismantling

The SMB-0-40 Valve Actuator was completely dismantled for inspection on 22 November 1974. Photographs of the valve actuator components are presented in Figure 10.

The torque switch and limit switch were removed from the SMB-0 Valve Actuator and the

switch setting (1-3/4) as that used throughout the test.

The torque output of the actuator as controlled by the torque switch remains constant with the same torque switch setting, however, the thrust monitor in the test stem depends upon several factors including the efficiency of the acme threads. The lower thrust output monitored after the unit was brought to room temperature was attributed to a degradation of stem efficiency as a result of corrosion of the steel stem and deposition of foreign materials from the exposure to the steam and chemical spray and not attributable to changes in the torque switch operating train or reduction in the torque output of the actuator.

The effect of the corrosion was most noticeable after the stem was exposed to room ambient conditions for several hours. After the completion of the 794 cycles, the thrust monitored returned to its original value indicating the repeated cycling had removed the corrosive deposits in the stem thread area. The cycling data and thrust reading are presented in Appendix B.

PWR Qualification

A Base Test motor which experienced all the environmental conditions was installed on the test actuator after the planned post LOCA cycling to obtain cyclic information on the base motor and provide additional load cycling on the test unit. The SMB-0 Actuator (with the base test motor) was cycled for an additional 2184 cycles.

The SMB-0 Actuator functioned without difficulty throughout the additional 2184 cycles.

A summary of the load cycles accumulated on the test unit is as follows:

PreTest Mechanical Aging ::..........	1208	cycles
LOCA Testing cycles	9	cycles
Post LOCA Load cycling	794	cycles
Base Test Motor cycling	2184	cycles
TOTAL	4195	cycles

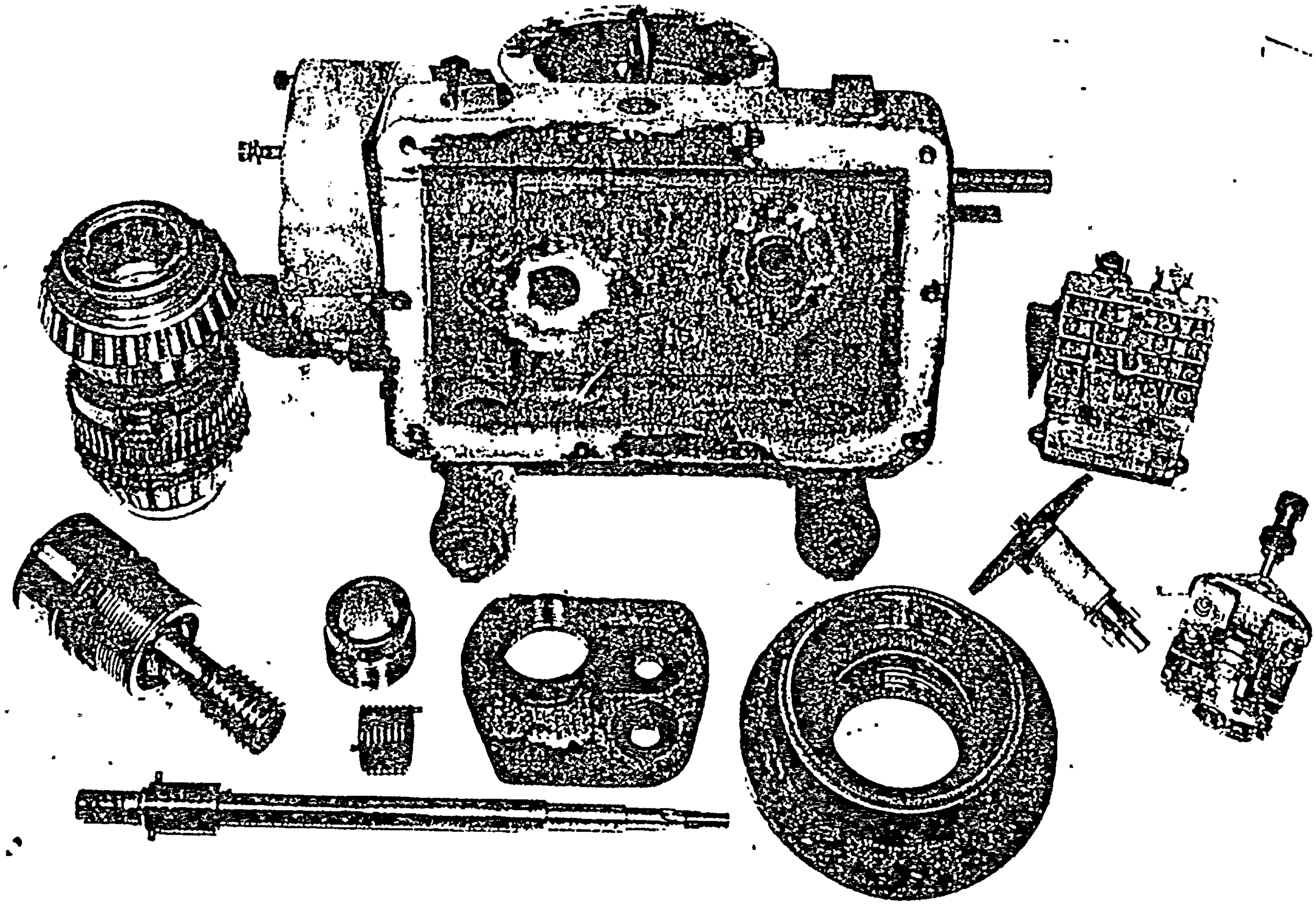


Figure 10
Test Unit Final Inspection

following observations were made:

a.) The torque switch and limit switches worked freely.

b.) The torque switch and limit switch pinions both showed signs of lubrication.

The grease in the main housing and the handwheel clutch compartment was dark in color but maintained its lubricity. A slight amount of separation of the grease was noted. The O-Ring and bearings seemed in good condition with no wear noted.

5.0 Conclusion

The Limitorque Valve Actuator SMB-0-40 was subjected to a qualification test consisting of a 30-day exposure to a steam chemical environment, including two temperature & pressure transients from 120 degrees F to 300 degrees F in approximately 10 seconds. Prior to environmental testing, the motor was heat aged, the unit was mechanically tested and subjected to gamma ray irradiation. The unit was cycled with simulated valve seating loads during environmental testing at elevated temperatures and pressures and after environmental test was additionally cycled with a simulated valve seating load.

PWR Qualification

Since the unit performed satisfactorily, throughout the test, it is concluded this test qualifies similar Limitorque Valve Actuators for use in a PWR containment chamber where environmental conditions depicted by Table I in IEEE Std. 382-'72' are encountered.

APPENDIX A

Reliance Electric Company - Certificate

of Compliance

RELIANCE ELECTRIC COMPANY

CERTIFICATE OF COMPLIANCE

Limitorque Corporation
5114 Woodall Road
Lynchburg, Virginia 24502

RECEIVED
JUN 7 1974
PHILA. GEAR

EQUIPMENT: Electric Motor

REFERENCE: Purchase Order No. 600426-C

FILE: Sales Order No. 2Y-267074A1

We certify that the equipment identified above has been designed, manufactured, inspected, and/or tested in accordance with the requirements established by the following specifications: RCP-242, Limitorque D/S 21-49-001-1 We further certify that the stator was heat aged 100 hours at 180°C.

B. L. Hoskins

Quality Control Department

4200 BENEFIT ROAD / ASHTABULA, OHIO 44004 / TELEPHONE 216-992-2175

GENERAL OFFICES / CLEVELAND, OHIO

APPENDIX B

INITIAL TORQUE SWITCH SETTING

MECHANICAL AGING

POST MECHANICAL AGING THRUST MEASUREMENT

POST SEISMIC QUALIFICATION AND RADIATION THRUST MEASUREMENT

POST ENVIRONMENTAL THRUST MEASUREMENT

POST ENVIRONMENTAL LOAD CYCLING

POST LOAD CYCLING THRUST MEASUREMENT

SUMMARY OF LOAD CYCLING DATA

Specimen: TEST UNIT

Limtorque Valve Actuator
Type: SMB
Size: 0
Serial No. 189835
Motor size 40 ft-lb
I. D. #2Y267074A1EZ

Instrumentation:

Load Cell: Capacity 20, 000 pounds
Manufacturer BLH
Serial No. 2512

Strain Indicator:

Manufacturer BLH
Type N
Serial No. 443604

<u>INITIAL TORQUE SWITCH SETTING</u> Date: 6/7/74

No. of Readings	Torque Switch Setting	Thrust Output * (pounds)
5	"1"	11,070
5	"1½"	16,010
24	"1 3/4"	20,162

*Average of all readings

<u>MECHANICAL AGING</u> Date: 6/7/74 to 6/10/74

Definition: One (1) cycle
Open Limit actuation to close torque Switch actuation to open limit actuation. Two (2) strokes per cycle.
Stroke Time: 54 sec *
Cycle Time: 1 min. 53 sec
Duty Cycle: 'RUN' 7 cycles - 'OFF' 10 min.
Load (Thrust): 20,162 pounds
Total No. of Cycles: 1208

SUMMARY OF LOAD CYCLING DATA (continued)

* The unit was cycled for mechanical aging on a different load stand than was used in the test and since the stroke was longer in this stand, a longer stroke time was obtained.

POST MECHANICAL AGING THRUST MEASUREMENT Date: 6/10/74

No. of Readings	Torque Switch Setting	Thrust Output * (pounds)
10	"1 3/4"	19,920

POST SEISMIC QUALIFICATION AND RADIATION THRUST MEASUREMENT Date: 8/19/74

No. of Readings	Torque Switch Setting	Thrust Output * (pounds)
3	"1 3/4"	19,250

* Average of all readings

POST ENVIRONMENTAL TEST THRUST MEASUREMENT Date: 9/30/74

No. of Readings	Torque Switch Setting	Thrust Output * (pounds)
6	"1 3/4"	16,392

Note: The low output thrust readings are a result of poor stem efficiency as a result of accumulated deposits on the acme threads of the stem. The thrust measured during the last test point of the environmental test was 21,350 pounds.

SUMMARY OF LOAD CYCLING DATA (continued)

POST ENVIRONMENTAL LOAD CYCLING Date: 9/30/74 - 10/4/74

Definition: One (1) cycle
Open limit to close torque switch actuation to open limit. Two (2) strokes per cycle.
Stroke Time: 40 sec
Duty Cycle: 'RUN' 7 cylces - 'OFF' 10 minutes
Load (Thrust): 16,392 at start
19,667 at finish
Total No. of Cycles: 794

Note: The increase in thrust output is due to improved stem efficiency. The repeated cycling removed the corrosion in the threaded area of the stem.

The load cycling was discontinued during the night and ran during the first shift.

POST LOAD CYCLING THRUST MEASUREMENT Date: 10/4/74

No. of Readings	Torque Switch Setting	Thrust Output (pounds)
3	"1 3/4"	19,667

Note: The output thrust returned to the value recorded after the pre-test mechanical aging.

APPENDIX C

Radiation Exposure - Isomedix Certificate of Performance

ISOMEDIX

July 19, 1974

Mr. W. J. Denkowksi
Chief Engineer
Limitorque Corporation
181 South Gulph Road
King of Prussia, Pa. 19406

Dear Mr. Denkowski:

This will summarize the perimeters pertinent to the irradiation of one valve operator and motor assembly. Identification on the valve operator and motor assembly was:

SMB O Valve Control
s/n 189835
Reliance 40 lb-ft motor
I.D. 2Y267074A1EZ

Units were placed in a co-60 field of $1x10^6$ rad per hour, at an air equivalent dose. They were rotated several times during the exposure to achieve a more uniform dose distribution. Total dose received to the centerline of the unit was 204 mrad (air equivalent) with an overdose factor on the edges of the units of 1.2. Irradiation was in air and ambient temperature in a slight negative pressure. The temperature of the samples during irradiation did not exceed 100°F.

Dosimetry was performed using a Victoreen Model 555 Integrating Dose Rate Meter and Probe. The unit was calibrated on January 15, 1974 by the Victoreen Instrument Company, using Cobalt-60 and Cesium-137 sources whose calibrations are traceable to the U.S. National Bureau of Standards. A copy of the calibration certificate is available.

Confirming dosimetry utilizing a Red Perspex system was also completed.

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

CHICAGO DIVISION • 7828 Nagle Ave., Morton Grove, Illinois 60053 (312) 966-1160

Irradiation was completed July 18, 1974 and the units returned to you under separate cover.

Very truly yours,

George R Dietz

George R. Dietz
Manager, Radiation Services

GRD:km

APPENDIX D

Seismic Qualification - Lockheed Test Report

TEST REPORT NO. 3521-481.1

REPORT OF TEST

ON

LIMITORQUE CORPORATION
SMBO OPERATOR W/MOTOR (40 FT. LB.)
AND
MOTOR (25 FT. LB.)

REPORT WRITER: R. F. Soltis

R. F. Soltis

TEST ENGINEER: Wm A. Black

W. A. Black

LOCKHEED ELECTRONICS COMPANY, INC.
PLAINFIELD, NEW JERSEY

DATE: June 17, 1974

APPROVED BY: Nat Johnson

N. Johnson, Manager
Environmental Laboratory

LEC

FORM LEC 197

LEC

TEST REPORT NO. 3521-4811

PURPOSE OF TEST:	To subject the test specimens to the Seismic Test referenced in Limitorque Corporation Purchase Order Number 600456 dated June 11, 1974.
MANUFACTURER:	Limitorque Corporation 5114 Woodall Road Lynchburg, Virginia 24502
SPECIMENS TESTED:	(a) SMB0 Operator with 40 ft. lb. motor. S/N 189835 (b) Reliance 25 ft. lb. motor ID NO: 2Y287074 A 1EZ
APPLICABLE DOCUMENTS:	Limitorque Corporation Purchase Order Number 600456 dated June 11, 1974.
PROJECT NUMBER:	24-8041-3811
QUANTITY OF SPECIMENS TESTED:	One (1) each
SECURITY CLASSIFICATION OF SPECIMENS TESTED:	Unclassified
DATE TEST COMPLETED:	June 12, 1974
TEST CONDUCTED BY:	LOCKHEED ELECTRONICS COMPANY, INC. ENVIRONMENTAL LABORATORY
DISPOSITION OF SPECIMENS TESTED:	Returned to Limitorque Corporation per Lockheed Electronics Company, Incorporated Packing Slip Number 97449 dated June 12, 1974.
ABSTRACT:	The test specimens were subjected to the Seismic Test referenced in Limitorque Corporation Purchase Order Number 600456 dated June 11, 1974. This test was completed with no visible evidence of external damage or resonances.
TEST APPARATUS:	Reaction-Type Vibration Machine, LAB Company Model RVH-72-5000, S/N 51401.

FORM LEC 197A

TEST APPARATUS: (Continued)

Vibration Pickups, MB Company Type 124, S/N 14074 and Type 126, S/N 14006.

Vibration Meter, MB Company Model M-6, S/N 539.

Dial-A-Gain Amplifiers, Unholtz-Dickie Model 610M, E. L. Number 463 and Model 610RM-3G, E. L. Number 464.

Accelerometers, Endevco Model 2221D, S/N NA94 and FC55.

TEST PROCEDURE:

The test specimens were secured to the test machine, as shown in Figures 1 through 3, and subjected to the following Seismic Test in accordance with Limitorque Corporation Purchase Order Number 600456 dated June 11, 1974.

1. To determine resonant frequencies, an exploratory scan was performed in each of the three (3) major axes over the frequency range of 5 to 35 Hz with a maximum input acceleration of 1.0 g's.

2a. With no resonant frequencies present, the test specimen was subjected to 10 second dwells at the frequencies specified by the Limitorque Corporation representative (see data sheets) in each axis. The vibration amplitude was maintained at the maximum controllable displacement from 5 Hz to the frequency at which 3 g's was attained. The input was then maintained at 3 g's from that frequency up to 34 Hz.

2b. The test specimen was vibrated at 35 Hz at an input level of 6 $\pm$ ¼ g's for a ten (10) second dwell.

The test specimens were actuated during part 2, and all performance monitoring was performed by and the data retained by Philadelphia Gear Corporation personnel.

FORM LEC 197A

LEC

TEST REPORT NO. 3521-4811

TEST RESULTS:

The Vibration Test was completed with no visible evidence of external damage noted to either test specimen.

There were no resonances detected in the three (3) axes of vibration.

RECOMMENDATIONS:

None. Data merely submitted.

Test Engineer: Wm A. Black

W. A. Black

FORM LEC 197A

FIGURE 1

TEST SETUP - X AXIS

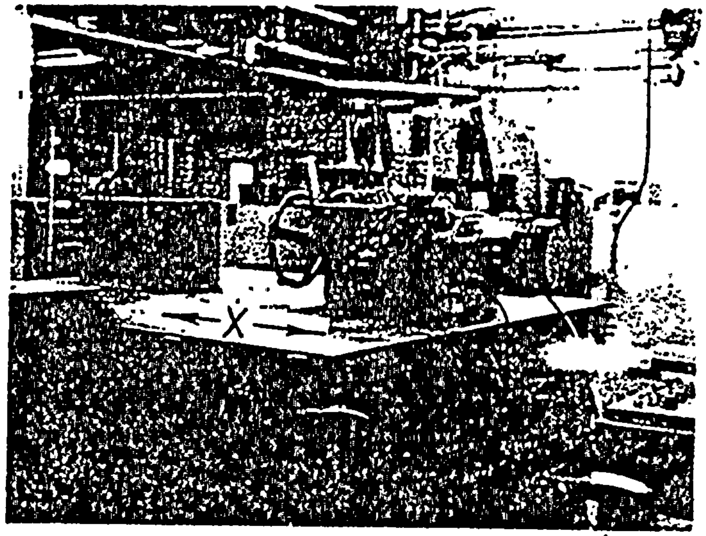


FIGURE 2

TEST SETUP - Y AXIS
A. SMBO OPERATOR W/40' LBS. MOTOR
B. MOTOR 25' LBS.

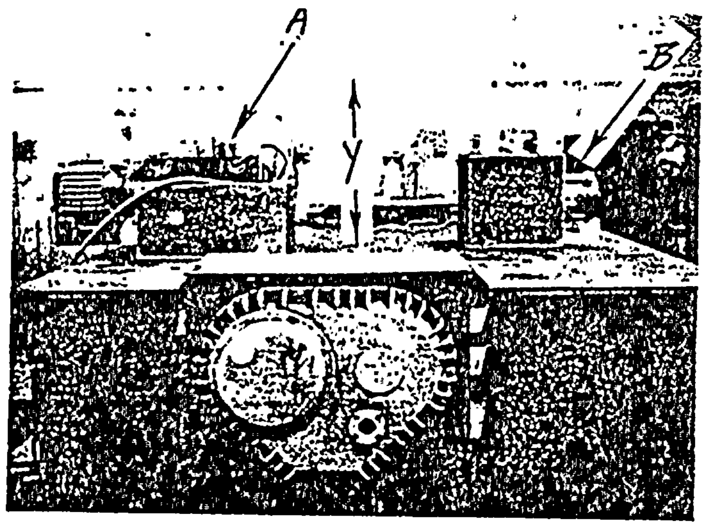
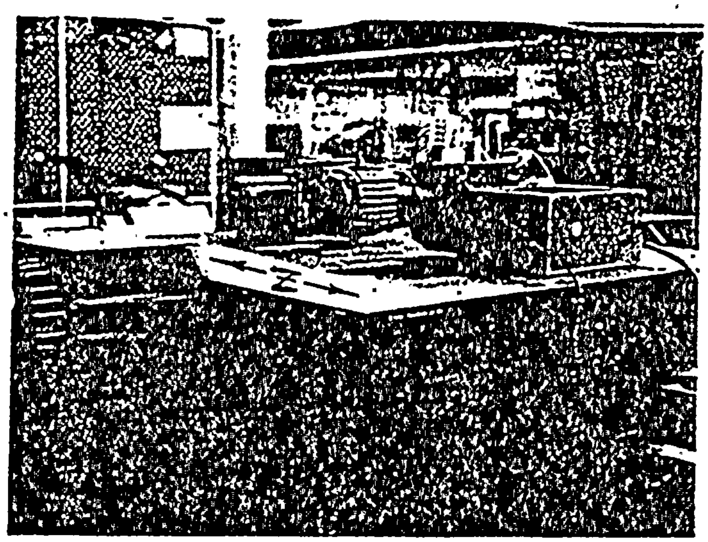


FIGURE 3

TEST SETUP - Z AXIS



VIBRATION TEST DATA SHEET

AXIS: 2 Axis

REPORT NO.	3521 - 4811
DATE:	6/12/74

Hz	EXPLORATORY (Para. 1) INPUT	EXPLORATORY (Para. 1) CH. 1	EXPLORATORY (Para. 1) CH. 2	VARI.FREQUENCY(Para.2.2) INPUT	VARI.FREQUENCY(Para.2.2) CH. 1	VARI.FREQUENCY(Para.2.2) CH. 2
4						
5	.014	.016	.013			
6	.016	.016	.014	.054	.049	.047
7	.017	.016	.016			
8	.018	.017	.017	.054	.050	.052
9	.018	.017	.018			
10	.018	.017	.0125	.052	.052	.056
11	.018	.017	.019			
12	.018	.017	.019	.051	.054	.058
13	.017	.018	.020			
14	.017	.018	.020	.050	.054	.059
15	.017	.018	.021			
16	.017	.018	.021	.050	.054	.060
17	.017	.018	.021			
18	.017	.019	.022	.050	.054	.062
19	.017	.019	.022			
20	.017	.019	.022	.049	.055	.063
21	.017	.019	.022			
22	.017	.019	.023	.048	.056	.064
23	.017	.019	.023			
24	.017	.019	.023	.048	.056	.067
25	.017	.019	.023			
26	.017	.019	.023	.048	.056	.066
27	.017	.019	.023			
28	.017	.019	.024	.048	.056	.068
29	.017	.019	.024			
30	.017	.019	.024	.048	.056	.069
31	.017	.019	.024			
32	.0165	.0195	.0245	.048	.056	.072
33	.0165	.0195	.0245			
34	.0165	.0195	.0245	.048	.056	.072
35	.0165	.0195	.0245			
36						
37						
38						
39						
40						
41						
42						
43				Operator actuated during		
44				this portion of test		
45						
46						
47						
48						
49						
50						
	RES. none Hz					

NOTE: RECORDED DATA IS DOUBLE AMPLITUDE (INCHES)

ENDURANCE TEST (PARA.2.23)		
Hz	INPUT	DURATION
35	.100	10 sec.

TEST SPECIMEN NOMENCLATURE

1 mtr. with fixture
1 SMBO Operator with motor

SERIAL NO.

MANUFACTURER

LIMITORQUE CORPORATION

ACCELEROMETER LOCATION

CH. 1	side of motor
CH. 2	top of unit

REMARKS:

TEST ENGINEER

Wm. C. Black

FORM LEC 922B

VIBRATION TEST DATA SHEET

AXIS: X Axis

REPORT NO. 3521 - 4811
DATE: 6/12/74

Hz	EXPLORATORY (Para. 1) INPUT	CH. 1	CH. 2	VARI.FREQUENCY(Para.2.2) INPUT	CH. 1	CH. 2
4						
5	.014	.014	.015	.038	.044	.035
6	.017	.015	.016			
7	.018	.016	.016			
8	.019	.0165	.017			
9	.019	.017	.018			
10	.019	.017	.019	.052	.050	.050
11	.0185	.018	.020			
12	.0185	.018	.020			
13	.018	.018	.021			
14	.018	.018	.021			
15	.018	.018	.021	.050	.052	.058
16	.0175	.019	.022			
17	.0175	.019	.022			
18	.017	.019	.022			
19	.017	.019	.023			
20	.017	.019	.023	.048	.054	.062
21	.017	.019	.023			
22	.017	.019	.023			
23	.017	.019	.0235			
24	.017	.019	.024			
25	.017	.019	.024	.047	.055	.066
26	.0165	.019	.024			
27	.0165	.019	.025			
28	.0165	.019	.025			
29	.0165	.0195	.025			
30	.016	.0195	.026	.047	.056	.072
31	.016	.0195	.026			
32	.016	.0195	.027			
33	.016	.0195	.027			
34	.016	.0195	.028			
35	.016	.0195	.028	.047	.056	.086
36						
37						
38						
39						
40				Operator actuated during		
41				this portion of test		
42						
43						
44						
45						
46						
47						
48						
49						
50						
	RES. none Hz					

FORM LEC 922B

NOTE: RECORDED DATA IS DOUBLE AMPLITUDE (INCHES)

ENDURANCE TEST (PARA.2.23)		
Hz	INPUT	DURATION
35	.100	10 sec

TEST SPECIMEN NOMENCLATURE

1 motor with fixture
1 SMBO Operator with motor

SERIAL NO.

MANUFACTURER

LIMITORQUE CORPORATION

ACCELEROMETER LOCATION

CH. 1	rear of motor
CH. 2	front of handwheel

REMARKS:

TEST ENGINEER

Wm. C. Black

SHEET 6 of 7

VIBRATION TEST DATA SHEET

AXIS: Y Axis

REPORT NO.	3521 - 4811
DATE:	6/12/74

Hz	EXPLORATORY (Para. 1) INPUT	CH. 1	CH. 2	VARI. FREQUENCY (Para.2.2) INPUT	CH. 1	CH. 2
4						
5	.009	.016	.010			
6	.009	.014	.012	.052	.049	.032
7	.013	.017	.013			
8	.014	.017	.014			
9	.015	.017	.015			
10	.0155	.017	.016	.051	.049	.042
11	.016	.017	.016			
12	.0165	.017	.017			
13	.017	.017	.017			
14	.017	.018	.017			
15	.017	.018	.0175	.049	.052	.047
16	.017	.018	.018			
17	.017	.018	.018			
18	.017	.018	.018			
19	.017	.018	.0185			
20	.017	.0185	.019	.048	.052	.050
21	.017	.0185	.019			
22	.017	.0185	.019			
23	.017	.019	.019			
24	.017	.019	.020	.048	.054	.052
25	.017	.019	.020			
26	.017	.019	.020			
27	.017	.019	.0205			
28	.017	.0195	.021			
29	.017	.0195	.021			
30	.017	.020	.022	.048	.056	.058
31	.017	.020	.0225			
32	.017	.020	.023			
33	.017	.020	.023			
34	.017	.020	.024			
35	.017	.0205	.024	.049	.058	.062
36						
37						
38						
39						
40				Operator actuated during		
41				this portion of test		
42						
43						
44						
45						
46						
47						
48						
49						
50						
	RES. none Hz					

FORM LEC 922B

NOTE: RECORDED DATA IS DOUBLE AMPLITUDE (INCHES)

ENDURANCE TEST (PARA.2.23)		
Hz	INPUT	DURATION
35	.100	10 sec

TEST SPECIMEN NOMENCLATURE

1 motor with fixture
1 SMBO Operator with motor

SERIAL NO.

MANUFACTURER

LIMITORQUE CORPORATION

ACCELEROMETER LOCATION

CH. 1	Top of motor
CH. 2	Top front of Handwheel

REMARKS:

TEST ENGINEER

Wm. C. Black

SHEET 7 of 7

APPENDIX E

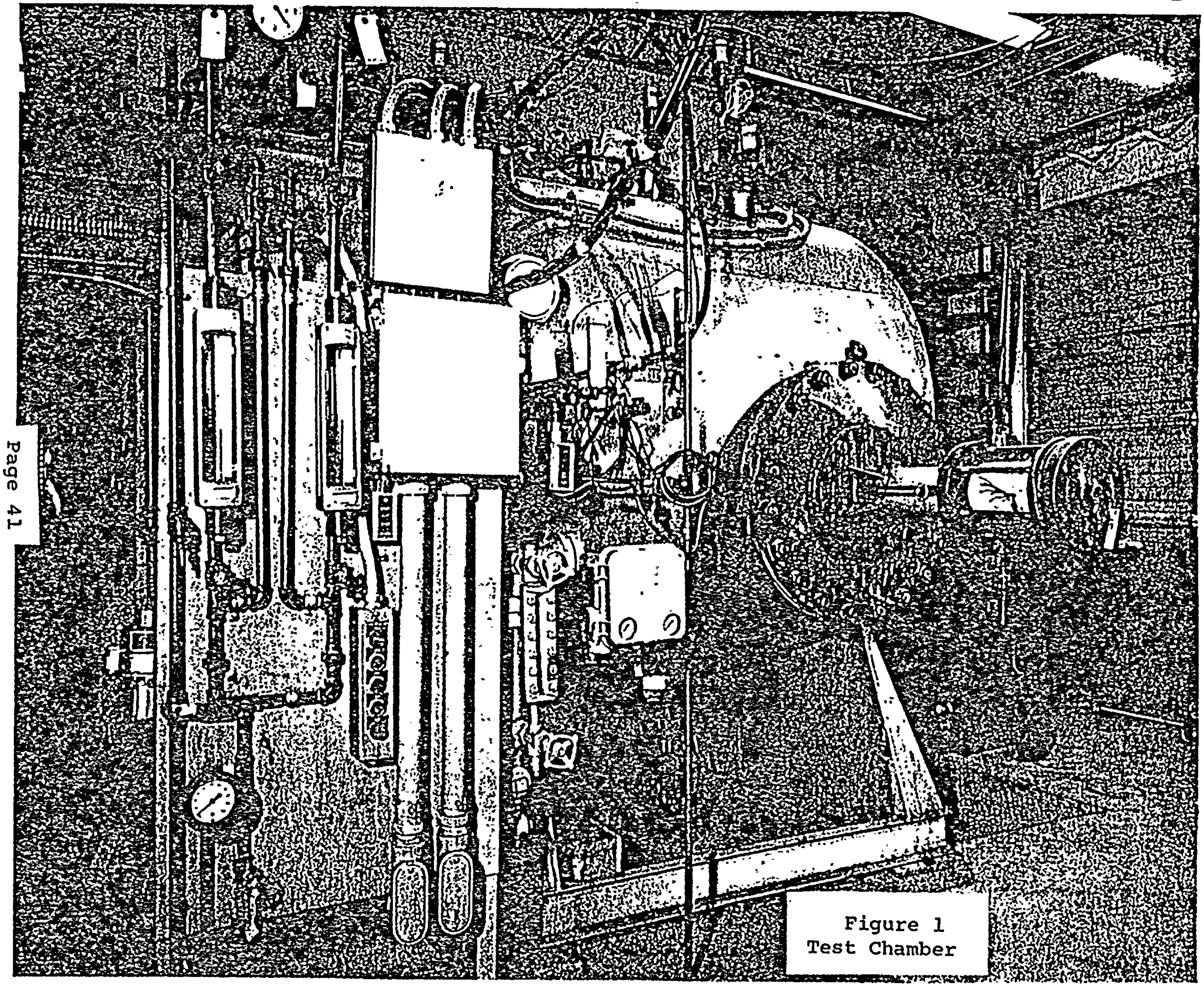


Figure 1
Test Chamber

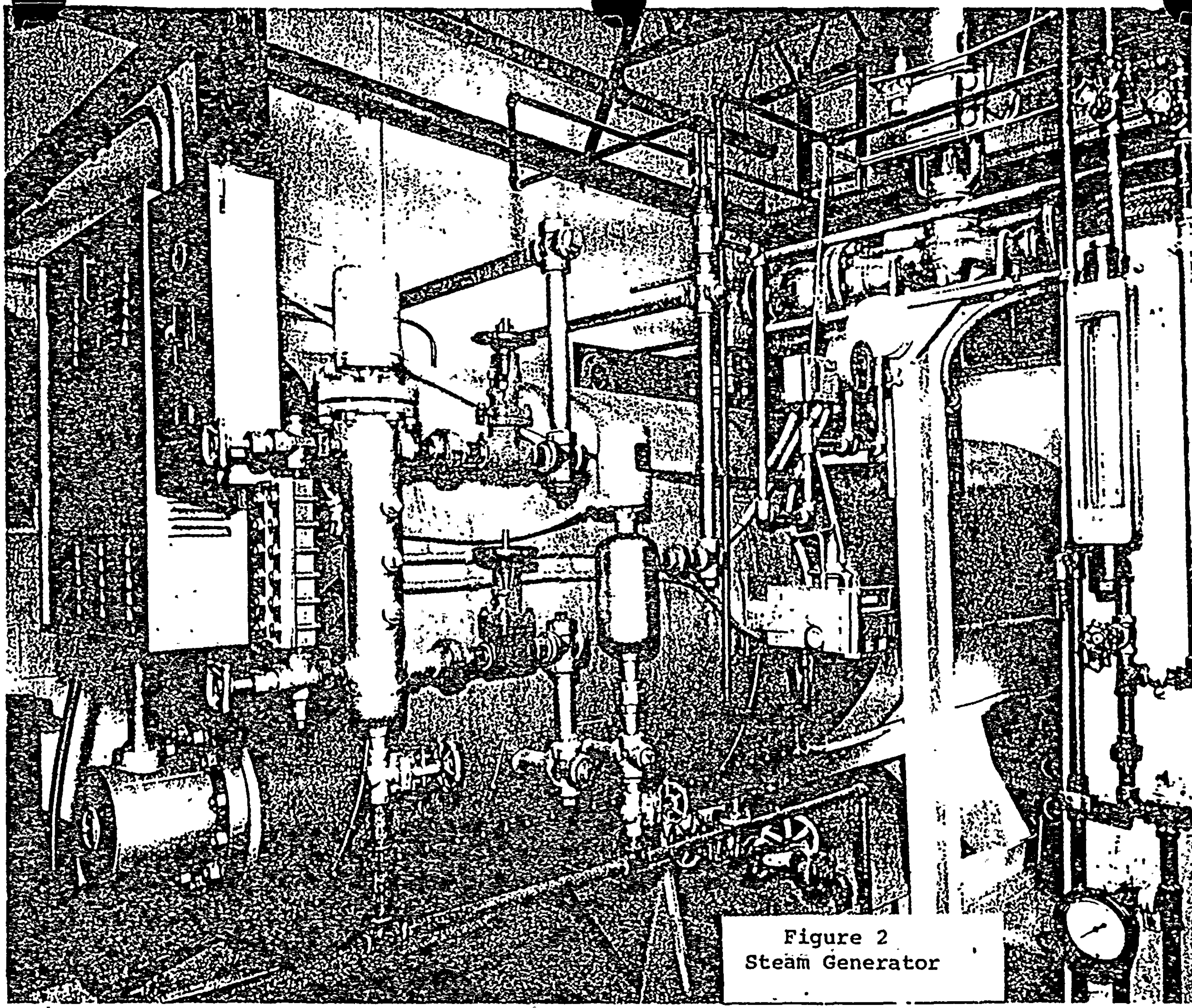


Figure 2
Steam Generator

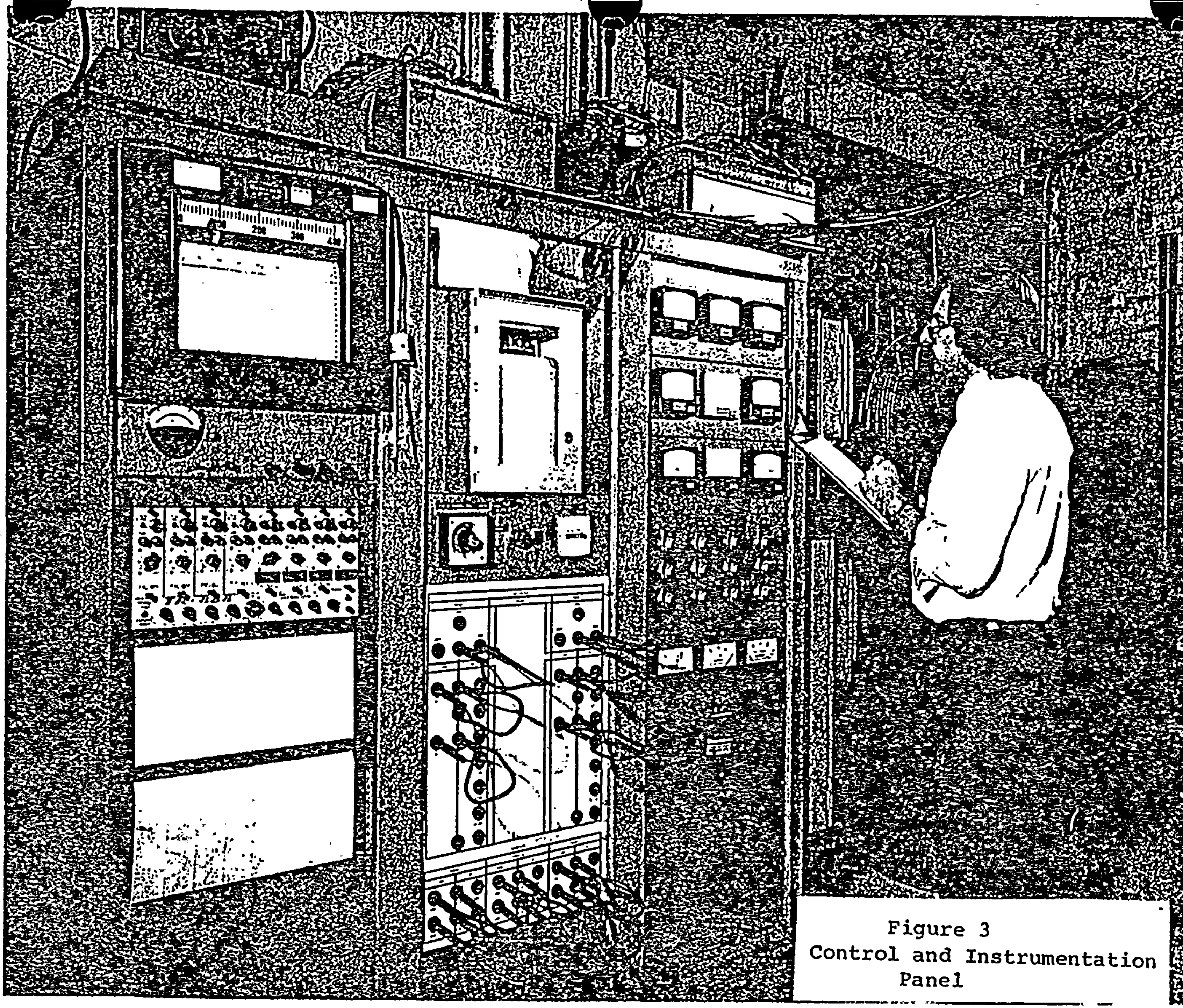


Figure 3
Control and Instrumentation Panel

APPENDIX F

Figure 4	- Schematic - Instrumentation
Table I	Summary of Instruments used for Data Acquisition

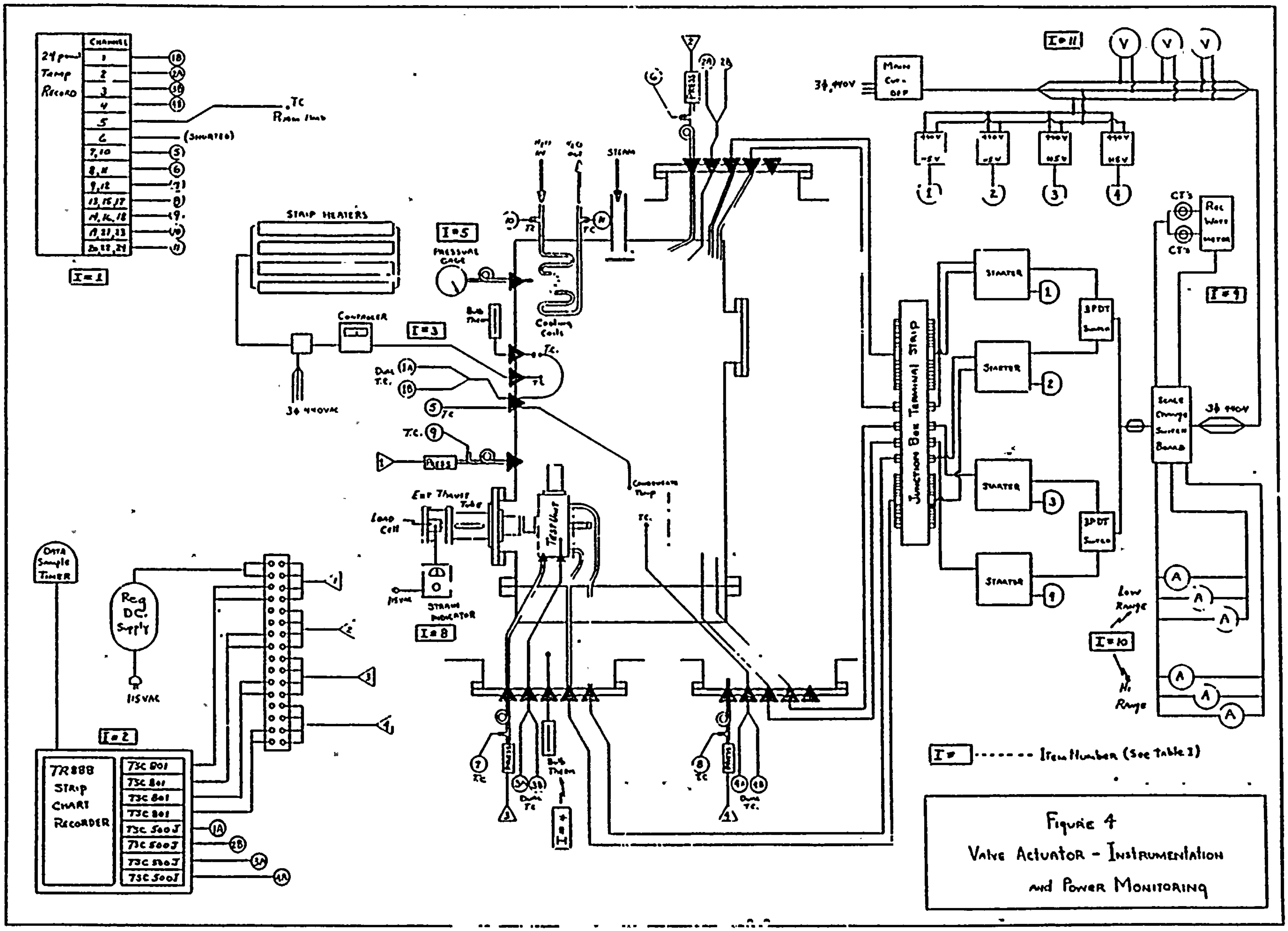


Figure 4
Valve Actuator - Instrumentation and Power Monitoring

TABLE I

SUMMARY OF DATA ACQUISITION SYSTEM

Measurement Categories IEEE Std.382 Par.4.5.1	PARAMETER	Item No.	MEASURING SYSTEM: Indicator	Signal Conditioner	X-Ducer	Monitoring Point	LAST CALIBRATION	NEXT CALIBRATION
I - ENVIRONMENT	TEMPERATURE	1.	Multipoint	1	1B T. C.-J(2)	Chamber Amb.	Feb. 1974	Feb. 1975
			Temperature	2	2A T. C.-J(2)	Test Unit		
			Recorder	3	3B T. C.-J(2)	L.S.Comp		
			Type J T. C.	4	4B T. C.-J(2)	Chamber Amb.		
				5	- -	Room Amb.		
			Honeywell	6	- -	Shorted		
			Model No.	7,10	5 T. C.-J	Condensate		
			K153x80-c-	8,11	6 T. C.-J	Press x-D#2		
			II-W6-65	9,12	7 T. C.-J	Press x-D#3		
			Serial No.	13,15,17	8 T. C.-J	Press x-D#4		
			T11806-83004	14,16,18	9 T. C.-J	Press x_D#1		
				19,21,23	10 T. C.-J	H_2O input		
				20,22,24	11 T. C.-J	H_2O output		
	TEMPERATURE & PRESSURE	2.	Strip Chart	1 Amplif.	Press x-D#1	Chamber Amb.	Mar. 1974	Sept. 1974
			Recorder	2 "	Press x-D#2	Test Unit		
			8 Channel	3 "	Press x-D#3	L.S. Comp.		
				4 "	Press x-D#4	Chamber Amb.		
			Gulton	5 T.C. Mod.	1A T.C.-J(2)	Chamber Amb.		
			TR888	6 "	2B T.C.-J(2)	Test Unit		
				7 "	3A T.C.-J(2)	L.S. Comp.		
			S/N	8 "	4A T.C.-J(2)	Chamber Amb.		
			3042802					

Note: Amp. TSC 801
T.C.Mod. TSC 500J

TABLE I (continued)

SUMMARY OF DATA ACQUISITION SYSTEM

Measurement Categories, IEEE Std. 382 para. 4.5.1	PARAMETER	Item No.	Measuring System: Indicator	Measuring System: Signal Conditioner	Measuring System: X-Ducer	Monitoring Point	LAST CALIBRATION	NEXT CALIBRATION
I - Environment	TEMPERATURE	3	Mercury bulb Thermometer Wexler 50-400 F			Chamber Ambient	New 2/74	2/75
		4	Bi-metal Dial Thermometer Wexler 50-400 F			Chamber Ambient	New 2/74	2/75
	Pressure	5	Dial Pressure Gage Ashcroft 30 in Hg to 200 psig			Chamber Pressure	5/74	11/74
	Time	6	Time of Day Wall-Clock			Time of Day	-	-
		7	Running Time Clock 1000 hours 0.1 hr. Resolution			Total Test Time	-	-
II Power & Cycle Time	LOAD	8	Strain Indicator Bridge BL &H Typen S/N 443604		20,000 lb Load Cell BL&H U-1 S/N 2512	Test Unit Thrust Output	12/73	12/74

TABLE I (continued)

SUMMARY OF DATA ACQUISITION SYSTEM

MEASUREMENT Categories IEEE Std. 382 Para. 4.5.1	PARAMETER	Item No.	Measuring System			Monitoring Point	LAST Calibration	Next Calibration
			Indicator	Signal Condit.	X-Ducer			
II - POWER & CYCLE TIME	POWER	9.	3 phase Recording Watimeter Esterline Angus Model A 601C S/N 192358			Power Consumption of operator	New ?/74	2/75
	CURRENT	10.	Panel Meters 3 meters one in each phase Low Range - 3-0-10 amp meters Triplett Type 430 Hi Range - 3-0-50 amp meters Triplett Type 430			Test Unit Current	New 3/'74	3/75
	VOLTAGE	11.	Panel Meters 3 meters one across each phase 0-500VAC Triplett Type 430			Test Unit Voltage	New 3/74	3/75

TABLE I (continued)

SUMMARY OF DATA ACQUISITION SYSTEM

Measurement Categories	PARAMETER	Item No.	Measuring System: Indicator	Measuring System: Signal Conditioner	Measuring System: X-Ducer	Monitoring Point	LAST CALIBRATION	NEXT CALIBRATION
II Power & Cycle	TIME	12	Stopwatch Hever S/N 512406			Stroke Time	-	-
III Fluid Characteristics	FLOW	13	Flow Meters (2) Fisher & Porter Model: 10A1735Y, 10A1735 S/N: 7309A0574A1, 7407A0403A1			Chemical Flow	New 2/74	2/75
	PRESSURE	14	2 Dial Pressure Gages (2) Wesler Model BA14P 1 Acco Helicoid 0-200 psig			Manifold Pressure Pump Pressure	~~New~~ 2/74 Indicator only	2/75
	PH	15	PH Meter			PH of Chem. Solution	Comparison Against Standard Solution	
V Electrical Resistance		16	Megohmmeter James G. Biddle Model 21159 S/N 732521			Motor & Control Leads	New 2/74	2/75

APPENDIX D

Outside Containment Qualification

Report B0003

Qualification Type Test Report

Limitorque Valve Actuators

For Class 1E Service

Outside Primary Containment

In Nuclear Power Station Service

Per IEEE 382-72 & IEEE 323-71

Test Performed Nov. 13, 1974 to Jan. 23, 1975

PROJECT NO. 600461

REPORT NO. B0003

Prepared by-

LIMITORQUE CORPORATION TEST LABORATORY

PREPARED BY Thomas O. Hess Jr.
T. Hess Jr. - Test Eng.

DATE: May 28, 1976

APPROVED: W J Denkowski
W. Denkowski- Vice Pres. Eng.

DATE: June 2, 76

ACCEPTED: Charles Formica
C. Formica -Q.A. Administrator

DATE: June 7, 1976

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PROFILE AND DATA SHEETS

APPENDICES

1.0 Purpose of Test

The purpose of this test was to determine the capabilities of a Limitorque Valve Actuator (type SMB) equipped with an electric motor with Class B insulation to satisfactorily operate during a Post LOCA or Steam Line Break environmental condition. The parameters stipulated in the test plan were obtained by Limitorque Corporation from Power Plant designers and consultants using IEEE 382 as a guide for formulating a test plan. The valve actuator is considered acceptable on provision it proves capable of satisfactorily operating against a simulated valve load in both opening and closing directions within 15 days following the start of environmental exposure.

2.0 Test Plan

The test was conducted in Limitorque Corporation's Environmental Facility at King of Prussia, Pa. One Limitorque Valve Actuator (Unit #1), one test motor #1 and one test motor #2 (all with Class B insulation) was subjected to test conditions according to the following test plan.

2.1 Thermal Aging

2.1.1 Install the Valve Actuator with motor on a mechanism to simulate seating load and the two test motors in the Environmental Chamber.

2.1.2 Establish an ambient condition in the chamber of 165°F. and 100% relative humidity at atmospheric pressure and retain this condition for 200 hours.

2.1.3 Cycle - The valve actuator to close position and then to open position once per hour for a total of 200 cycles.

2.1.4 Operate the motors once per hour for 30 seconds in one direction and for 30 seconds in the other direction for the duration of thermal aging.

2.2 Mechanical Aging

2.2.1 Cycle the valve actuator for 200 cycles during thermal aging. Cycle the unit for 1800 additional times at room ambient to obtain a total of 2000 closing and opening strokes. All valve simulated cycles to be completed at the approximate output rating of the actuator.

2.2.2 At room ambient, run each motor for 15 minutes in one direction and then for 15 minutes in the opposite direction.

2.3 Radiation Exposure

2.3.1 Irradiate the test actuator with motor to 2.0×10^7 rads (gamma radiation) and the two test motors to 2.04×10^8 rads (gamma radiation) at the rate of 1.0×10^6 rads per hour. Rev. A

2.4 Seismic Aging

2.4.1 Install three (3) accelerometers on the Limitorque valve control housing arranged to measure accelerations in each of these axes (one vertical and two horizontal).

2.4.2 Mount the Limitorque valve control with fixture to the shaker table with the axis of the stem nut mounted vertically.

Rev. A 12-15-81 - Added Missing Phrase

2.4.3 Connect the limit switches and torque switches into the control. Connect a contact of the limit switch in series with the torque switch to detect switch chatter. Connect spare switch contacts to lights for further indication of chatter.

2.4.4 Scan in each of the 3 axes at a minumum of .1g from 5HZ to 33HZ, dwelling for 6 seconds at each frequency. Repeat scan from 33HZ to 5HZ, dwelling at each integer frequency. Record the accelerometer readings at each scan dwell point of each of three axes,- V (vertical) H_1 (horizontal parallel to motor axis) and H_2 (horizontal perpendicular to motor axis) for determination of cross coupling. Note resonance frequency in axis being scanned. (Resonance is defined as a minimum acceleration multiplication factor of 2).

2.4.5 Prepare to conduct dwell test in vertical axis V at resonant frequency determined in step 4 (Dwell at 33HZ, if resonant frequencies not evident).

A. On basis of 6.0g on V axis and 3.2g on both H_1 and H_2 axes, determine dwell g-level as follows:

1) At dwell frequency, note cross coupling on V axis determined during scan on H_1 and H_2 axes.

2) If any cross coupling noted, calculate acceleration adder to V axis.

a) H_1 axis

$$\text{Adder} = \frac{3.2g \times \text{cross couple g level at scan}}{\text{g-level of scan at dwell frequency}}$$

b) H_2 axis

$$\text{Adder} - \frac{3.2g \times \text{cross couple g level at scan}}{\text{g-level of scan at dwell frequency}}$$

c) Add resultant of a) and b) to 6.0g, establishing the G-level for the dwell test.

B. Conduct dwell test for 30 seconds on V axis using g-level determined from A.2.c. During the dwell, operate the unit in an open and close stroke. (Simulated thrust seat at same torque switch setting established during mechanical aging). Note results.

2.4.6 Prepare to conduct swell test in horizontal axis H_1 at resonant frequency determined in step 2.4. (Dwell at 33HZ if resonant frequencies not evident).

A. On basis of 6.0g on H_1 axis and 3.2 on both H_2 and V axes, determine dwell g level as indicated in 2.3.5A except substitute V axis for H_1 axis.

B. Conduct dwell test as indicated in 2.4.5B.

2.4.7 Prepare to conduct dwell test in horizontal axis H_2 at resonant frequency determined in step 3. (Dwell at 33HZ if resonant frequencies not evident).

A. On basis of 6.0g on H_2 axis and 3.2g on both H_1 and V axes, determine dwell g level as indicated in 2.3.5A, except substitute V axis for H_2 axis.

B. Conduct dwell test as indicated in 2.4.5B

2.5 Environmental Test

2.5.1 Install valve actuator with thrust tube and two test motors in test chamber.

2.5.2 Fill bottom of test chamber with water to assure saturation of the atmosphere in the chamber.

2.5.3 Heat test chamber to 120°F.

2.5.4 Conduct transient temperature rise (120°F. to 250°F.) in 10 secs.

2.5.5 Hold 250°F. for 30 mins.

2.5.6 Cool to 120°F. @ 90°F/hr. ave.

2.5.7 Conduct second transient temperature rise (120°F. to 250°F.) in 10 secs.

2.5.8 Hold 250°F for 24 hours.

2.5.9 Cool to 200°F. @ 90°F./hr. ave.

2.5.10 Hold 200°F. for 16 days after start of test.

2.5.11 Megger and cycle actuator prior to start of test and the following nominal times after start of test.

Event 3	.3 hours
Event 6	2.6 hours
Event 19	23.4 hours
Event 21	25.7 hours
Event 80	383.5 hours

3.0 Identification of Actuator and Test Motors

3.1 Test Actuator with Motor (Unit #1)

3.1.1 Limitorque Actuator

Model	SMB-0
Order No.	600461
Serial No.	195004

3.1.2 Motor

Manufacturer	Reliance Electric
I.D. No.	447014-BZ
Start Torque	25 ft. lbs.
Run Torque	5 ft. lbs.
Horsepower	1.6
RPM	1700
Duty	15 min.
Volts	230/460
Amps.	8.0/4.0
Temperature Rise	75°C.
Insulation	Class B

3.2 Test Motor #1

3.2.1

Manufacturer	Reliance Electric
I.D. No.	447014-JZ
Start Torque	25 ft. lbs.
Run Torque	5 ft. lbs.
Horsepower	1.6
RPM	1700
Volts	230/460
Amps.	8.0/4.0
Temperature Rise	75°C.
Insulation	Class B

3.3 Test Motor #2

3.3.1

Manufacturer	Electric Apparatus
I.D. No.	742-19564K-09
Start Torque	40 Ft. lbs.
Run Torque	8 ft. lbs.
Horsepower	2.6
RPM	1705
Volts	220/440
Amps	11.6/5.8
Temperature Rise	75°C.
Insulation	Class B

In addition (2) Engineering Development Units and motor were included for Limitorque information.

4.0 Test Procedure

4.1 Thermal Aging

4.1.1 The Valve Actuator Unit #1 was installed on a test stand to establish a thrust load of 20,000 lbs. A thrust load of 20,350 lbs. (approx. 466 ft. lbs. torque at a torque switch setting of 2-1/2) was measured. (an average of 6 readings)

4.1.2 A thrust tube was then installed in the Valve Actuator Unit #1 and the two test motors were mounted on a stand. After the Actuator and motors were placed in the environmental chamber, they were wired to an external control source with a timing circuit that would operate them once per hour.

4.1.3 The Valve Actuator was set for a 30 second stroke time and the test motors were run hourly for 30 seconds in each direction of rotation.

4.1.4 The Test Chamber was filled to the bottom of the rail with water to insure 100% relative humidity. The chamber was then heated to 165°F. at 0 psig pressure and the ambient maintained for 199.8 hours.

4.1.5 The Actuator and test motors cycling was started Nov. 4, 1974 and completed Nov. 13, 1974 with a total of 176 cycles. Failure of the timer circuit (not part of the normal Valve Actuator Control) prevented the completion of the 200 cycles originally planned.

4.2 Mechanical Aging

4.2.1 The Test Chamber Cover was removed, the strip heaters deenergized and the test motors disconnected from the timing circuit.

4.2.2 The Valve Actuator cycling continued on Nov. 13 with the unit operating on an accelerated timing sequence completing 1817 additional cycles. The mechanical aging was concluded Nov. 19, 1974.

4.2.3 The test motors were run on Nov. 13 for a total of 15 minutes in one direction and for 15 minutes in the other direction on Nov. 14, 1974.

4.3 Radiation Exposure

4.3.1 The Limitorque Valve Actuator and two test motors received 2.0×10^7 Rads gamma ratiation at Isomedix, Inc., Parsippany, N.J. Irradiation was completed on Nov. 22, 1974. A copy of the Isomedix certificate of compliance is in Appendix II.

4.4 Seismic Aging

4.4.1 Seismic Aging was conducted at Aero Nav Laboratories,Inc., College Point, New York according to the procedure listed in Section 2.4.1. The two test motors were mounted on the table next to Valve Actuators and received the same aging as the unit. The Seismic Aging was completed Dec. 3, 1974. A copy of Aero Nav test reports 5720 and 5722 are included in Appendix III.

4.5 Environmental Test

4.5.1 The environmental test was initiated on Jan. 6, 1975 according to the test plan presented in Section 2.5. The test profile is presented in Fig. 1. The operating characteristics of test unit #1 is included in figures 2A and 2B, of test motor #1 in figure 3 and of test motor #2 in figure 4.

4.5.2 Event 19 (24 hours after test start)

Event 21 (25.8 hours after test start)

Valve Actuator Unit #1 operated satisfactorily in the "close" direction, but in the "open" direction of stroke, overran the "open" limit. The torque switch would normally have prevented this over travel, but was unable to operate due to the fact the thrust tube had no stop in the opening direction. It is surmised this was caused by a momentary electrical short due to localized condensate build up, a malfunction of the reversing contactor or a combination of both. Since this did not occur before event 19, during event 20, nor recurred after event 21, it is assumed this was caused by an abnormal condition during this short time period.

Both the "open" and "close" indicator lights exhibited a very dim glow when it should have been extinguished which could be attributed to a floating ground. (The ground had been removed to facilitate meggering of the control circuit). Also an investigation concluded the current flow to duplicate the dim glow was insignificant and did not constitute a mal-function.

TEMPERATURE PROFILE

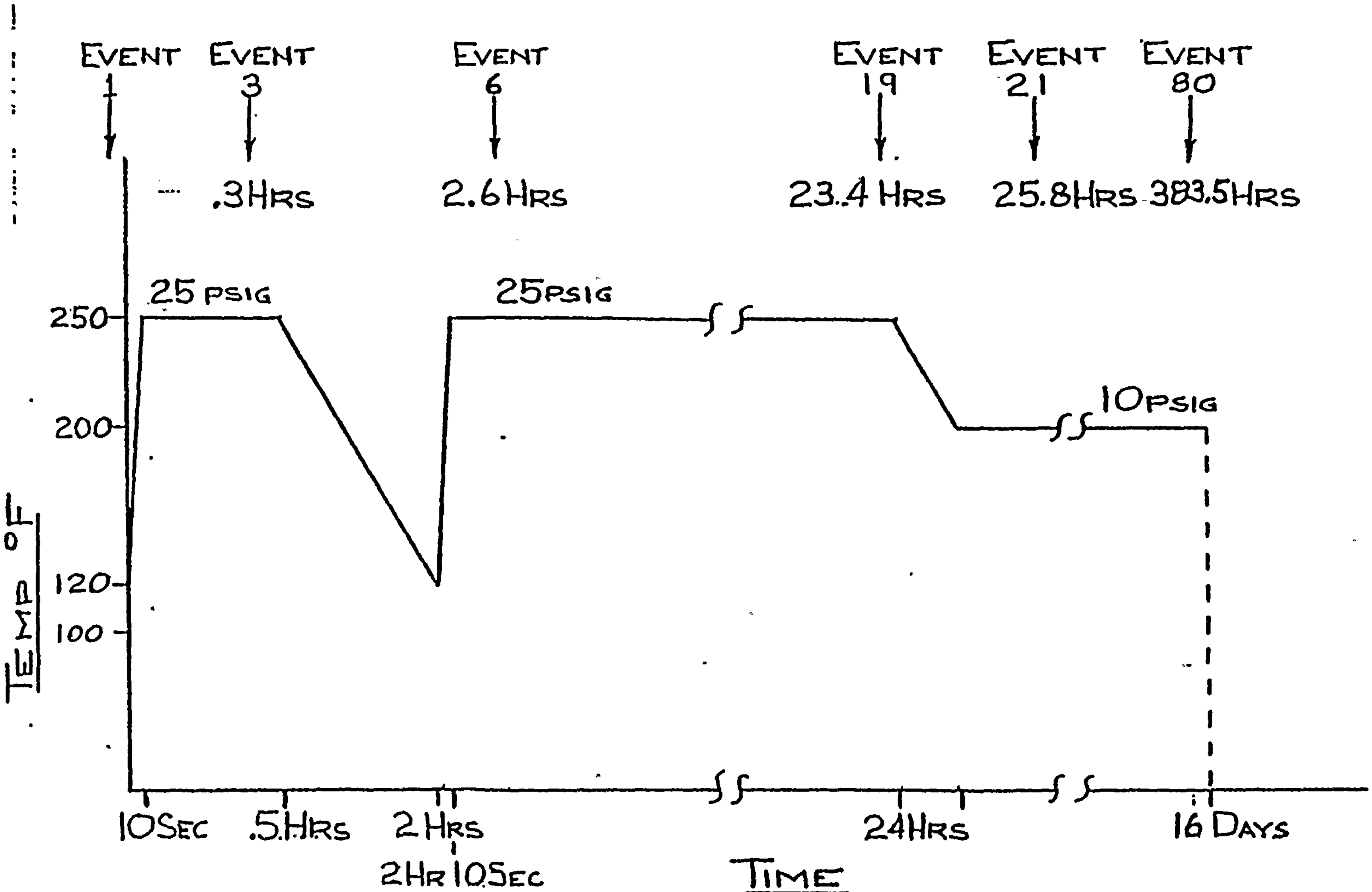


FIGURE 1

UNIT 1 CONTROL LEAD INSULATION RESISTANCE - ACCIDENT SIMULATION

INSULATION RESISTANCE TO GROUND
all values in ohms x 10^3 unless otherwise noted

Event No.	Run time hr.	CL1	61	71	41	43A	43B	43C	45A	45B	51	53A	53B	53C	55A	55B
0	0	500 M	500 M	500 M	2000 M	500 M	500 M	500 M	500 M	500 M	500 M	500 M	500 M	500 M	500 M	500 M
1	0	1.7M	1.7M	1.7M	4M	1.7M	1.7M	1.7M	1.7M	1.7M	1.7M	1.7M	1.7M	1.7M	1.7M	1.7M
3	0.3	.1M	.1M	.1M	.5M	.1M	.1M	.1M	.1M	.1M	.1M	.1M	.1M	.1M	.1M	.1M
6	2.6	.04M	.04M	.04M	.08M	.04M	.04M	.04M	.04M	.04M	.04M	.04M	.04M	.04M	.04M	.04M
19	23.4	1.2K	1.2K	2.1K	4K	1.3K	1.3K	1.3K	1.3K	1.3K	1.3K	1.3K	1.3K	1.3K	1.3K	1.3K
21	25.8	3K	3K	4K	12K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K	3K
80	383.5	2K	2K	3K	5K	2K	2K	2K	2K	2K	2K	2K	2K	2K	2K	2K

FIGURE 2A

UNIT - 1 ELECTRICAL CHARACTERISTICS - ACCIDENT SIMULATION

Event No.	Run Time	Insulation Resistance (ohms)			Potential (volts)			Operator "Opening" Running Current (Amp)			Power	Stroke Time	Operator "Closing" Running Current (Amp)			Est. Peak	Power (watt)		Stroke Time
	hr	T_1	T_2	T_3	T_1-T_2	T_2-T_3	T_1-T_3	T_1	T_2	T_3	Watt	Sec	T_1	T_2	T_3	T_1	Run	Peak	Sec
0	0	∞	∞	∞	495	500	490	3.8	4.2	3.9	500	30	4.0	4.0	3.6	4.5	500	1K	30
1	0	24M	24M	24M	500	500	500	3.8	4.2	3.8	450	30	4.0	4.2	3.8	4.5	450	1.1K	31
3	0.3	5M	5M	5M	495	500	495	3.9	4.2	3.9	450	30	4.1	3.9	3.8	4.4	450	1.1K	31
6	2.6	1.5M	1.5M	1.5M	495	500	495	3.8	4.2	3.9	475	30	4.1	4.0	3.8	-	500	1.25K	31
19	23.4	2.9K	2.9K	2.9K	490	495	490	3.8	4.0	3.8	500	-	4.0	3.8	3.7	4.5	550	1.325K	31
21	25.8	40K	40K	40K	495	500	490	3.8	4.0	3.8	475	30	4.0	3.8	3.7	4.5	475	1.3K	31
80	383.5	15K	15K	15K	495	500	495	3.7	4.1	3.8	475	33	4.0	3.9	3.7	4.6	475	1.4K	33

FIGURE 2B

TEST MOTOR #1 - ELECTRICAL CHARACTERISTICS - ACCIDENT SIMULATION

Event No.	Run Time	Insulation Resistance (Ohms)			Potential (Volts)			Operator "Opening" Running Current (Amp)			Power	Stroke Time	Operator "Closing" Running Current (Amp)			Est. Peak	Power (Watt)		Stroke Time
	(h)	T_1	T_2	T_3	T_1-T_2	T_2-T_3	T_1-T_3	T_1	T_2	T_3	Watt	Sec	T_1	T_2	T_3	T_1	Run	Peak	Sec
0	0	∞	∞	∞	495	500	490	3.8	3.7	3.9	350	30	4.0	3.9	3.6	-	350	-	30
1	0	∞	∞	∞	495	500	495	3.9	3.8	3.9	350	30	4.0	3.9	3.6	-	375	-	30
3	0.3	175M	175M	175M	495	490	495	4.0	3.9	3.7	375	30	4.0	3.8	3.6	-	375	-	30
6	2.6	.4M	.4M	.4M	500	500	495	3.9	3.8	4.0	400	30	4.1	3.9	3.7	-	400	-	30
19	23.4	.1M	.1M	.1M	495	500	495	3.8	3.8	3.9	400	30	4.0	3.9	3.7	-	400	-	30
21	25.8	.6M	.6M	.6M	495	500	495	3.8	3.7	3.8	375	30	4.0	3.9	3.6	-	400	-	30
80	383.5	1.2M	1.2M	1.2M	490	495	490	3.9	3.9	3.6	375	30	3.8	3.8	3.8	-	375	-	30

FIGURE 3

TEST MOTOR #2 - ELECTRICAL CHARACTERISTICS - ACCIDENT SIMULATION

Event No.		Insulation Resistance (Ohms)			Potential (Volts)			Operator "Opening" Running Current (Amps)			Power	Stroke Time	Operator "Closing" Running Current (Amps)			Est. Peak	Power (Watt)		Stroke Time
	hr.	T_1	T_2	T_3	T_1-T_2	T_2-T_3	T_1-T_3	1	2	3	Watt	Sec	1	2	3	1	Run	Peak	Sec
0	0	∞	∞	∞	495	500	490	6.5	6.0	6.5	800	30	7.0	6.2	5.6	-	800	-	30
1	0	2000M	2000M	2000M	495	500	495	6.5	6.2	6.6	800	30	7.2	6.3	5.7	-	800	-	30
3	0.3	.6M	.6M	.6M	490	495	490	6.9	6.0	5.6	800	30	8.0	6.0	6.3	-	800	-	30
6	2.6	.1M	.1M	.1M	500	500	495	6.5	6.1	6.5	800	30	7.1	6.1	5.7	-	850	-	30
19	23.4	5K	5K	5K	490	495	490	6.4	6.0	6.4	850	30	7.0	6.0	5.8	-	850	-	30
21	25.8	.2M	.2M	.2M	495	500	495	6.4	6.0	6.4	800	30	7.0	6.1	5.6	-	800	-	30
80	383.5	40K	40K	40K	490	495	490	7.0	6.2	5.6	825	30	6.5	6.0	6.4	-	825	-	30

FIGURE 4

4.5.3 Post-Test Inspection

A white powdery deposit was found on the limit switch gear housing, the metalic frame parts of the torque switch and the end bells of the Reliance motors. Photographs are included in Appendix IV. All internal mechanical elements were in excellent condition with no mechanical damage or excessive wear being observed.

5.0 Conclusions

Since no detrimental effects due to aging were discernable, the unit is qualified for a 40 year life as described in aging criteria. The Valve Actuator and Test Motors operated satisfactorily throghout the Environmental LOCA Test, proving its capability of operating under conditions imposed as previously outlined. It is therefore concluded this test generically qualifies Limitorque Valve Actuators type SMB/SB for Class IE Service outside Primary Containment for conditions as defined in this report.

APPENDIX I

INSTRUMENTATION & CALIBRATION

TABLE I

SUMMARY OF DATA ACQUISITION SYSTEM

MEASUREMENT CATEGORIES, IEEE STD. 382 para. 4.5.1	PARAMETER	ITEM NO.	MEASURING SYSTEM			MONITORING POINT	LAST CALIBRATION	NEXT CALIBRATION
			INDICATOR	SIGNAL CONDITIONER	X-DUCER			
I - ENVIRONMENT	TEMPERATURE	1.	Multipoint	1	1B T.C.-J(2)	Chamber Amb	Feb. 1974	Feb. 1975
			Temperature	2	2A T.C.-J(2)	Test Unit		
			Recorder	3	3B T.C.-J(2)	L.S. Comp		
			Type J T.C.	4	4B T.C.-J(2)	Chamber Amb		
				5	- -	Room Amb.		
			Honeywell	6	- -	Shorted		
			Model No.,	7,10	5 T.C.-J	Condensate		
			K153x80-c-	8,11	6 T.C.-J	Press x-D#2		
			II-W6-65	9,12	7 T.C.-J	Press x-D#3		
			Serial No.	13,15,17	8 T.C.-J	Press x-D#4		
			T11806-83004	14,16,18	9 T.C.-J	Press x-D#1		
				19,21,23	10 T.C.-J	H_2O input		
				20,22,24	11 T.C.-J	H_2O output		
	TEMPERATURE & PRESSURE	2.	Strip Chart	1 Amplif.	Press x-D#1	Chamber Amb	Sept. 1974	March 1975
			Recorder	2 "	Press x-D#2	Test Unit		
			8 Channel	3 "	Press x-D#3	L.S. Comp.		
				4 "	Press x-D#4	Chamber Amb		
			Gulton	5 T.C. Mod	1A T.C.-J(2)	Chamber Amb		
			TR888	6 "	2B T.C.-J(2)	Test Unit		
				7 "	3A T.C.-J(2)	L.S. Comp.		
			S/N 3042802	8 "	4A T.C.-J(2)	Chamber Amb		
			Note: Amp. TSC 801 T.C. Mod. TSC 500J					

TABLE I (continued)

SUMMARY OF DATA ACQUISITION SYSTEM

MEASUREMENT CATEGORIES, IEEE STD. 382 para. 4.5.1	PARAMETER	ITEM NO.	MEASURING SYSTEM: INDICATOR	MEASURING SYSTEM: SIGNAL CONDITIONER	MEASURING SYSTEM: X-DUCER	MONITORING POINT	LAST CALIBRATION	NEXT CALIBRATION
I - ENVIRONMENT	TEMPERATURE	3	Mercury bulb Thermometer Wexler 50-400 F.			Chamber Ambient	New 2/74	2/75
		4	Bi-metal Dial Thermometer Wexler 50-400 F.			Chamber Ambient	New 2/74	2/75
	PRESSURE	5	Dial Pressure Gage Ashcroft 30 in Hg to 200 psig			Chamber Pressure	11/74	5/75
	TIME	6	Time of Day Wall-clock			Time of Day	-	-
		7	Running Time Clock 1000 hours, 0.1 hr. Resolution			Total Test Time	-	-
II-POWER & CYCLE TIME	LOAD	8	Strain Indicator Bridge BL & H Typen S/N 443604		20,000 lb. Load Cell BL & H U-1 S/N 2512	Test Unit Thrust Output	12/74	12/75

TABLE I (continued)

SUMMARY OF DATA ACQUISITION SYSTEM

MEASUREMENT CATEGORIES, IEEE STD. 382 para. 4.5.1	PARAMETER	ITEM NO.	MEASURING SYSTEM			MONITORING POINT	LAST CALIBRATION	NEXT CALIBRATION
			INDICATOR	SIGNAL CONDITIONER	X-DUCER			
II - POWER & CYCLE TIME	POWER	9	3 phase Recording Watimeter Esterline Angus Model A 601C S/N 192358			Power Consumption of Operator	New 2/74	2/75
	CURRENT	10	Panel Meters 3 meters one in each phase Low Range - 3-0-10 amp meters Triplett Type Hi Range - 3-0-50 amp meters Triplett Type 430			Test Unit Current	New 3/74	3/75
	VOLTAGE	11	Panel Meters 3 meters one across each phase 0-500VAC Triplett Type 430			Test Unit Voltage	New 3/74	3/75

TABLE I (continued)

SUMMARY OF DATA ACQUISITION SYSTEM

MEASUREMENT CATEGORIES	PARAMETER	ITEM NO.	MEASURING SYSTEM: INDICATOR	MEASURING SYSTEM: SIGNAL CONDITIONER	MEASURING SYSTEM: X-DUCER	MONITORING POINT	LAST CALIBRATION	NEXT CALIBRATION
II Power & Cycle	TIME	12	Stopwatch Hever S/N 512406			Stroke Time	-	-
III Fluid Characteristics	FLOW	13	Flow Meters (2) Fisher & Porter Model: 10A1735Y, 10A1735 S/N: 7309A0574A1, 7407A0403A1			Chemical Flow	New 2/74	2/75
	PRESSURE	14	2 Dial Pressure Gages (2) Wesler Model BA14P 1 Acco Helicoid 0-200 psig			Manifold Pressure Pump Pressure	New 2/74 Indicator only	2/75
	PH	15	PH Meter			PH of Chem. Solution	Comparison Against Standard Solution	
V Electrical Resistance		16	Megohmmeter James G. Biddle Model 21159 S/N 732521			Motor & Control Leads	New 2/74	2/75

APPENDIX II

CERTIFICATE OF COMPLIANCE - RADIATION EXPOSURE

ISOMEDIX

Mr. W. J. Denkowski
Chief Engineer
Limitorque Corporation
181 South Gulph Road
King of Prussia, Pa. 19406

Dear Mr. Denkowski:

This will summarize the parameters pertinent to the irradiation of three valve operators, three motor assemblies, and several small miscellaneous pieces of electrical equipment. Identification of the test equipment is per your Order #600461, dated November 12, 1974. Included were:

Valve Operators

1. 1 each SMB0 unit, 25 ft.# Reliance Motor, Class B
2. 1 each SMB000 unit, 25 ft.# Reliance Motor, Class B
3. 1 each SBB1 unit, 40ft.# Electric Apparators Motor Class B

Motors

4. 5 ft.# Paramount Motor
5. 25 ft.# Reliance Motor
6. 40 ft.# Electric Apparatus Motor

Other

7. 3 bags, plastic limit switch and torque switch parts contained in Valve Operators.
8. 1 Helipot contained in Item 3.

In Phase I of the exposure, all units were placed in a co-60 field of $1x10^6$ rad per hour at an air equivalent dose. They were rotated several times during the exposure to achieve a more uniform dose distribution. Total dose received to the centerline of all units was 20 Mrad (air equivalent) with an overdose factor on the edges of the units of up to 1.2. Irradiation was in air at ambient temperature in a slight negative pressure. The temperature of the samples during irradiation did not exceed 100^oF.

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

CHICAGO DIVISION • 7828 Nagle Ave., Morton Grove, Illinois 60053 (312) 966-1160

Phase I of the irradiation was completed on November 21, 1974, and all units were picked up by your personnel.

Phase II of the test included exposing only the motors and miscellaneous parts to an additional 184 Mrad. The procedure was identical to the Phase I step, and irradiation was completed on December 16, 1974. Their total dose was 204 Mrad, with an overdose factor of up to 1.2 on the outer edges of the units.

Dosimetry was performed using a Victoreen Model 555 Integrating Dose Rate Meter and Probe. The unit was calibrated on January 15, 1974 by the Victoreen Instrument Company, using Cobalt-60 and Cesium-137 sourcees whose calibrations are traceable to the U.S. National Bureau of Standards. A copy of the calibration certificate is available. Dosimetry utilizing a Red Perspex system was also completed, and confirmed the Victoreen readings.

Very truly yours,

George R. Dietz

George R. Dietz
Manager, Radiation Services

GRD:dp

APPENDIX III

TEST REPORT - SEISMIC AGING

AERO NAV
LABORATORIES, INC.

14-29 112TH STREET • COLLEGE POINT, N.Y. 11356 • (212) 939-4422

(UNCLASSIFIED)

REPORT OF SEISMIC TEST ON SMBO-25 MOTOR ACTUATOR FOR LIMITORQUE CORPORATION KING OF PRUSSIA, PENNSYLVANIA

TESTED BY	[illegible]	ETL REPORT	5720
CHECKED BY	[illegible]	AERO NAV SALES ORDER	711-408
APPROVED BY	[illegible]	CUSTOMER P.O.	600461
DATE	6 JANUARY 1975		
GOVERNMENT QAR	NONE		

ADMINISTRATIVE DATA

DATE
6 January 1975

PURPOSE OF TEST:	To determine the effects of Seismic Vibration on the physical and operational characteristics of the submitted specimen.
MANUFACTURER:	LIMITORQUE CORPORATION 181 S. Gulph Road King of Prussia, Pennsylvania 19406
MANUFACTURER TYPE AND SERIAL NUMBER:	See Paragraph 2.0 for name plate data.
DRAWINGS SPECIFICATIONS OR EXHIBIT:	Tested in accordance with detailed instructions of client and Limitorque Test Procedure (O/N 383964)
QUANTITY OF ITEMS TESTED:	One (1) only
EQUIPMENT: REPORT:	Unclassified Unclassified
DATE TEST COMPLETED:	25 November 1974
TEST CONDUCTED BY:	AERO NAV LABORATORIES, INC. 14-29 112th STREET COLLEGE POINT, NEW YORK 11356
DISPOSITION OF SPECIMEN:	Returned to client
ABSTRACT:	It is the function of the Aero Nav Laboratories, Inc., as an impartial testing agency in performing this test, to subject the specimen to seismic vibration of magnitude and direction as specified in the detailed specifications.

FACTUAL DATA

1.0 DESCRIPTION OF TEST APPARATUS:

1.1 Vibration Machine and Control System, Type RVH-72-5000, Serial No. 51402, manufactured by L.A.B. Corporation. Calibration Due: 28 March 1975.

1.2 Accelerometers, Model 2213E, Serial Nos. CP36, CP37, CP48, LA57, CP38 and CP43, manufactured by Endevco Corporation. Calibration Due: 18 January 1975.

1.3 Amplifier, Model 2616, Serial No. CA13, manufactured by Endevco Corporation. Calibration Due: 18 January 1975.

1.4 Power Supply, Model 2622, Serial No. CA24, manufactured by Endevco Corporation. Calibration Due: 18 January 1975.

1.5 Band Pass Filter, Model No. 330M, Serial No. 2116, manufactured by Krohn-Hite Corporation. Calibration Due: 26 February 1975.

1.6 True R.M.S. VTVM, Model 320A, Serial No. 8622, manufactured by Ballantine Labs. Calibration Due: 3 March 1975.

2.0 NAME PLATE DATA:

2.1 Actuator: (See Page 3A for Motor Description)

Limitorque Corp. King of Prussia, Pa.
Type - SMB-0 Size - 0
Order - 500461B, SN - 195004

2.2 Extra Motor:

Limitorque Corp. King of Prussia, Pa.
ID No. - 4470 14 - JZ
Start - 25 LB FT, H.P. 1.6 Run 5 LB FT
SF Type - P FR - P56, PH. 3
RPM - 1700 HZ - 60 Volts 230/460
Code AMPS - 8.0/4.0
AMP °C - 40, Ins Class B
Duty - 15 min.
Reliance Electric Company
Cleveland, Ohio

2.1 SMB-O SN-195004

Motor - Reliance

25 ft. lb. start - 5 ft. lb. run
1D 447014-BZ
Type P - 56 Frame
1700 RPM
230/460 volt - 3 phase, 60 hz.
8.0/4.0 amps.
Class B insulation - 15 minute duty
40 degree C.

FACTUAL DATA

3.0 METHOD OF TEST:

The submitted specimen mounted in a fixture supplied by Limitorque Corporation was affixed to the table of the seismic simulator in such a manner that the axis of the stem nut was vertical. Five (5) accelerometers were used to monitor resonant conditions of the actuator.

A spare motor was also mounted on the seismic simulator and was subjected to the same conditions as the valve actuator, however, the motor was not monitored in any way.

During the test the actuator was electrically connected to a control console supplied by Limitorque.

3.1 Resonant Frequency Search:

The specimen was subjected to a resonant frequency search from 5 to 33 Hz. The applied excitation levels were in accordance with Table I. The frequency range was increased in discrete steps of 1 Hz and vibration was maintained at each frequency for a period of not less than six (6) seconds.

The above test was performed in each of the three (3) mutually perpendicular axis.

Table I - Amplitudes of Vibration

Frequency (Hz)	Acceleration (G peak)
5 - 33	0.1 to .75

3.2 Seismic Dwell Test:

Upon completion of the resonant frequency search in each axis, the specimen was subjected to a seismic dwell test at each of the resonant frequencies noted during the resonant frequency search. If no resonant frequencies were noted the seismic dwell test was performed at 33 Hz. Five (5) thirty (30) second dwells were performed at 1/2g levels, and one (1) thirty (30) second dwell was performed at full g level.

During the dwell tests the unit was operated through its open and closed stroke.

4.0 RESULTS OF TEST:

The following observations were noted and recorded during the above detailed test procedure:

4.1 Vertical Axis: (along the Actuator Stem) (Machine Axis - Horizontal)

Accelerometer Locations and Orientation:

Input - On Table - Horizontal direction of Vibration

Outputs - A- On Actuator near Stem - Vertical and perpendicular to direction of Vibration.

B- On end of Motor - Horizontal in direction of Vibration.

C- On end of Motor - Vertical and perpendicular to direction of Vibration.

D- On Actuator near Handwheel Shaft - Horizontal and perpendicular to direction of vibration.

E- On Actuator near Stem - Horizontal in direction of Vibration.

FACTUAL DATA

RESULTS OF TEST (continued)

4.1.1 Resonant Frequency Search:

Frequency (Hz)	Input (G's)	Outputs (G's) A	B	C	D	E
5	0.240	0.035	0.270	0.120	0.060	0.240
6	0.380	0.050	0.370	0.250	0.100	0.370
7	0.470	0.060	0.500	0.150	0.150	0.470
8	0.660	0.060	0.670	0.250	0.200	0.640
9	0.370	0.002	0.370	0.100	0.040	0.400
10	0.490	0.020	0.480	0.100	0.050	0.470
11	0.600	0.040	0.600	0.120	0.045	0.570
12	0.670	0.030	0.660	0.100	0.060	0.640
13	0.160	0.058	0.170	0.050	0.060	0.150
14	0.190	0.020	0.190	0.060	0.040	0.180
15	0.220	0.025	0.230	0.100	0.050	0.210
16	0.250	0.025	0.260	0.080	0.040	0.240
17	0.280	0.035	0.280	0.110	0.050	0.270
18	0.310	0.030	0.320	0.060	0.040	0.300
19	0.350	0.037	0.360	0.090	0.050	0.340
20	0.390	0.040	0.400	0.040	0.040	0.360
21	0.430	0.055	0.450	0.080	0.045	0.430
22	0.470	0.057	0.480	0.060	0.025	0.470
23	0.500	0.060	0.520	0.070	0.030	0.500
24	0.550	0.068	0.057	0.090	0.035	0.550
25	0.600	0.085	0.640	0.180	0.060	0.610
26	0.650	0.090	0.700	0.180	0.070	0.670
27	0.220	0.050	0.300	0.130	0.060	0.250
28	0.240	0.052	0.320	0.110	0.050	0.270
29	0.260	0.060	0.350	0.110	0.060	0.290
30	0.270	0.065	0.360	0.120	0.050	0.320
31	0.290	0.074	0.400	0.130	0.200	0.500
32	0.310	0.080	0.420	0.150	0.250	0.500
33	0.330	0.090	0.450	0.170	0.200	0.420

FACTUAL DATA

RESULTS.OF TESTS (continued)

4.2 Horizontal Axis: (perpendicular to Motor Axis)
(Machine Axis - Vertical)

Accelerometer Locations and Orientation:

Input - On Table - Vertical - in direction of vibration

Outputs A-On Actuator near Stem - Vertical - in direction of Vibration
B-On end of Motor - Horizontal - Perpendicular to direction of Vibration
C-On end of Motor - Vertical - in direction of Vibration
D-On actuator near handwheel shaft - Horizontal and perpendicular to direction of Vibration
E-On actuator near stem - Horizontal - perpendicular to direction of Vibration

RESULTS OF TESTS (continued)

4.2.1 Resonant Frequency Search:

Frequency (Hz)	Input (G's)	Outputs (G's) A	B	C	D	E
5	0.230	0.230	0.030	0.230	0.040	0.035
6	0.340	0.340	0.035	0.340	0.040	0.060
7	0.410	0.410	0.035	0.400	0.040	0.040
8	0.540	0.530	0.040	0.540	0.024	0.050
9	0.690	0.690	0.050	0.680	0.035	0.045
10	0.220	0.220	0.048	0.250	0.040	0.050
11	0.250	0.250	0.040	0.240	0.025	0.025
12	0.300	0.290	0.030	0.300	0.015	0.020
13	0.340	0.330	0.030	0.330	0.015	0.023
14	0.390	0.380	0.035	0.380	0.100	0.150
15	0.460	0.450	0.045	0.460	0.040	0.040
16	0.530	0.510	0.035	0.520	0.035	0.050
17	0.580	0.570	0.045	0.580	0.100	0.200
18	0.660	0.650	0.060	0.700	0.200	0.100
19	0.320	0.310	0.040	0.340	0.040	0.025
20	0.350	0.350	0.050	0.380	0.200	0.200
21	0.380	0.390	0.070	0.420	0.150	0.200
22	0.420	0.430	0.050	0.470	0.200	0.200
23	0.450	0.470	0.050	0.500	0.200	0.200
24	0.490	0.520	0.058	0.570	0.100	0.150
25	0.540	0.570	0.070	0.640	0.120	0.150
26	0.240	0.250	0.090	0.290	0.100	0.100
27	0.260	0.290	0.110	0.380	0.100	0.100
28	0.270	0.290	0.070	0.350	0.060	0.060
29	0.290	0.320	0.080	0.370	0.150	0.100
30	0.300	0.330	0.070	0.400	0.120	0.150
31	0.320	0.360	0.080	0.440	0.120	0.200
32	0.350	0.390	0.080	0.480	0.080	0.120
33	0.370	0.420	0.090	0.540	0.200	0.200

FACTUAL DATA

RESULTS OF TESTS (continued)

4.3 Horizontal Axis: (Parallel to Motor Axis)
(Machine Axis - Horizontal)

Accelerometer Locations and Orientation:

Input - On Table - Horizontal - in direction of vibration

Outputs A-On Actuator near Stem - Horizontal and perpendicular to direction of vibration

B-On Motor End - Horizontal and perpendicular to direction of vibration

C-On Motor End - Vertical and perpendicular to direction of vibration

D-On Actuator near Handwheel Shaft - Horizontal - in direction of vibration

E-On Actuator near Stem - Vertical and perpendicular to axis of vibration

FACTUAL DATA

RESULTS OF TESTS (continued)

4.3.1 Resonant Frequency Search:

Frequency (Hz)	Input (G's)	Outputs (G's) A	B	C	D	E
5	0.170	0.020	0.060	0.050	0.200	0.050
6	0.230	0.025	0.060	0.070	0.300	0.030
7	0.330	0.050	0.070	0.045	0.340	0.050
8	0.440	0.040	0.070	0.050	0.410	0.080
9	0.530	0.040	0.060	0.030	0.530	0.080
10	0.650	0.035	0.050	0.030	0.650	0.020
11	0.180	0.015	0.040	0.035	0.200	0.100
12	0.210	0.015	0.045	0.030	0.200	0.025
13	0.240	0.020	0.040	0.035	0.250	0.030
14	0.290	0.015	0.030	0.030	0.280	0.035
15	0.330	0.015	0.030	0.030	0.310	0.050
16	0.370	0.030	0.050	0.035	0.370	0.040
17	0.420	0.017	0.040	0.030	0.400	0.060
18	0.470	0.015	0.030	0.030	0.480	0.090
19	0.520	0.013	0.030	0.030	0.560	0.070
20	0.590	0.015	0.030	0.030	0.570	0.080
21	0.650	0.025	0.055	0.035	0.630	0.070
22	0.160	0.030	0.070	0.045	0.160	0.040
23	0.170	0.025	0.070	0.050	0.180	0.070
24	0.190	0.040	0.090	0.045	0.190	0.035
25	0.210	0.035	0.080	0.045	0.220	0.120
26	0.220	0.035	0.090	0.050	0.230	0.050
27	0.240	0.035	0.070	0.045	0.240	0.080
28	0.250	0.030	0.070	0.045	0.300	0.080
29	0.270	0.025	0.060	0.050	0.310	0.080
30	0.290	0.025	0.070	0.060	0.310	0.100
31	0.310	0.060	0.120	0.050	0.380	0.300
32	0.330	0.130	0.300	0.060	0.400	0.200
33	0.350	0.100	0.220	0.060	0.470	0.200

RESULTS OF TESTS (continued)

4.4 Seismic Dwell Tests:

4.4.1 Vertical Axis (along the actuator stem)

The Seismic Dwell tests were performed at 33 Hz for a duration of 30 seconds for each run.

Five runs were performed at an input of 3.0 g's and one run was performed at an input of 6.0 g's.

During the dwells the actuator was opened and closed.

There was no evidence of external physical damage as a result of the stress of this test.

4.4.2 Horizontal Axis (parallel to motor axis)

The Seismic Dwell tests were performed at 33 Hz for a duration of 30 seconds for each run.

Five runs were performed at an input of 4.9 g's and one run was performed at an input of 6.1 g's.

During the dwells the actuator was opened and closed.

There was no evidence of external physical damage as a result of the stress of this test.

4.4.3 Horizontal Axis (perpendicular to motor axis)

The Seismic Dwell tests were performed at 33 Hz for a duration of 30 seconds for each run.

Five runs were performed at an input of 3.2 g's and one run was performed at an input of 6.2 g's.

During the dwells the actuator was opened and closed.

There was no evidence of external physical damage as a result of the stress of this test.

5.0 VISUAL POST TEST EXAMINATION:

Visual post test examination revealed no evidence of any external physical damage as a result of the stress of this test.

6.0 RECOMMENDATIONS:

None, data merely submitted.

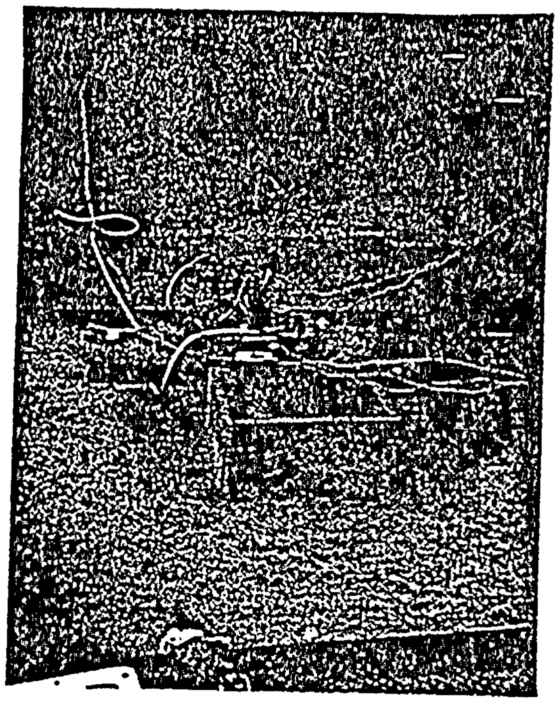
7.0 CONCLUSIONS:

Final evaluation of the submitted specimen for conformance to the requirements of the detailed specifications will be accomplished by Limitorque Corporation upon review of the results reported herein and further examination as required.

LIMITORQUE CORPORATION

KING OF PRUSSIA, PENNSYLVANIA

SMBO-25 MOTOR ACTUATOR



Seismic Test Setup

TEST REPORT

Subject: Pre Seismic Torque Switch calibration and Operation monitoring performed during seismic testing SMB-O-25.

Reference: Limitorque P.O. 383964

Aero Nav Report 5720

Unit Identification & Description

SMB-O Limitorque Valve Control with Reliance

25 ft. lb. motor

Unit Serial No. 195004

Motor I.D. No. 447014-BZ

Test Motor (#1)

I.D. No. 447014-JZ

Pre-Test Torque Switch Calibration

Procedure: Measure thrust output of SMB-O using a 2-3/8 x 1/4 x1/4 stem and 20,000 lb. load cell.

Results: A thrust load of 20,350 lbs. (Ave. of 6 readings) was obtained at a torque switch setting of 2-1/2.

Approximate Torque:

Torque = Thrust x Stem Factor

SF 2 3/8" x 1/4x 1/4 stem = .0229

Torque = 20,350 x .0229 - 466 ft. lbs.

Seismic Test Operation Monitoring

Procedure: All limit switch rotors were monitored by means of indicator lights.

Two (2) contacts (one each on each of two (2) spare rotors) were wired in series with a sensitive relay to detect chatter during the stroke of the actuator. The actuator was run from an open position (controlled by a limit switch) to a closed torqued-out position (controlled by the torque switch) back to the open limit position during each of the dwells and at the end of the seismic aging cycle. The test motor (#1) was mounted next to the SMB-O to receive the same seismic aging as the unit.

Results:

The unit functioned properly, performing all control functions and indicating functions. There was no evidence of contact chatter during the dwells.

Conclusion:

Due to severe "cross talk" detected on the seismic table, attempts to include "cross coupling" was disregarded and the unit run at 3g's for five dwells and 6g acceleration for one dwell in each axis. Later tests on an equivalent unit (Aero Nav Report 5772) proved cross coupling to be negligible. Since the Valve Actuator performed satisfactorily in all functions, and since later tests indicated negligible cross-coupling, the unit is considered qualified per IEEE 344-75 specification for seismic levels up to 6g's.

AERO NAV REPORT 5722

VERIFICATION OF SEISMIC AGING

TEST MOTOR #2

AERO NAV
LABORATORIES, INC.

14-29 112TH STREET • COLLEGE POINT, N.Y. 11356 • (212) 939-4422

(UNCLASSIFIED)

REPORT OF SEISMIC TEST ON SMB-1 MOTOR ACTUATOR FOR LIMITORQUE CORPORATION KING OF PRUSSIA, PENNSYLVANIA

TESTED BY		ETL REPORT	5722
CHECKED BY		AERO NAV SALES ORDER	711-408
APPROVED BY		CUSTOMER P.O.	600461
DATE	7 JANUARY 1975		
GOVERNMENT QAR	NONE		

(UNCLASSIFIED)

(UNCLASSIFIED)

ADMINISTRATIVE DATA

DATE
7 January 1975

PURPOSE OF TEST:	To determine the effects of Seismic Vibration on the physical and operational characteristics of the submitted specimen.
MANUFACTURER:	LIMITORQUE CORPORATION 181 S. Gulph Road King of Prussia, Pennsylvania 19406
MANUFACTURER TYPE AND SERIAL NUMBER:	See Paragraph 2.0 for name plate data.
DRAWINGS SPECIFICATIONS OR EXHIBIT:	Tested in accordance with detailed instructions of client and Limitorque Test Procedure (O/N 383964)
QUANTITY OF ITEMS TESTED:	One (1) only
EQUIPMENT:	Unclassified
REPORT:	Unclassified
DATE TEST COMPLETED:	3 December 1974
TEST CONDUCTED BY:	AERO NAV LABORATORIES, INC. 14-29 112th STREET COLLEGE POINT, NEW YORK 11356
DISPOSITION OF SPECIMEN:	Returned to client

ABSTRACT: It is the function of the Aero Nav Laboratories, Inc., as an impartial testing agency in performing this test, to subject the specimen to seismic vibration of magnitude and direction as specified in the detailed specifications.

FACTUAL DATA

1.0 DESCRIPTION OF TEST APPARATUS:

1.1 Vibration Machine and Control System, Type RVH-72-5000, Serial No. 51402, manufactured by L.A.B. Corporation. Calibration Due: 28 March 1975.

1.2 Accelerometers, Model 2213E, Serial Nos. CP36, CP37, CP48, LA57, CP38 and CP43, manufactured by Endevco Corporation. Calibration Due: 18 January 1975.

1.3 Amplifier, Model 2616, Serial No. CA13, manufactured by Endevco Corporation. Calibration Due: 18 January 1975.

1.4 Power Supply, Model 2622, Serial No. CA24, manufactured by Endevco Corporation. Calibration Due: 18 January 1975.

1.5 Band Pass Filter, Model No. 330M, Serial No. 2116, manufactured by Krohn-Hite Corporation. Calibration Due: 26 February 1975.

1.6 True R.M.S. VTVM, Model 320A, Serial No. 8622, manufactured by Ballantine Labs. Calibration Due: 3 March 1975.

2.0 NAME PLATE DATA:

2.1 Actuator: (See Page 3A for Motor Description)

Limitorque Corp. King of Prussia, Pa.
Type SMB Size - 1
Order 600461C Serial 195005

2.2 Extra Motor:

Serial - 742-19564K-09	Frame C184Y	RPM 1705
Start Torque - 40 ft lbs	Type Dat	Phase 3
Run Torque - 8 ft lbs	Hz 60	Code L
Volts - 220/440	°C Rise 75	Duty - 15 min
Amps - 11.6/5.8		SF 1.0

Ins - Class B

2.1 SMB-1 SN-195005

Motor

Electric Apparatus
40 ft. lb. start, 8 ft. lb. run
1D 733-18869-12
Type DAT - 140 Y Frame
1720 RPM
220/440 volt- 3 phase - 60 hz
12.6/6.3 amps.
Class B insulation - 15 minute duty
75 degree C rise

FACTUAL DATA

3.0 METHOD OF TEST:

The submitted specimen mounted in a fixture supplied by Limitorque Corporation was affixed to the table of the seismic simulator in such a manner that the axis of the stem nut was vertical. Five (5) accelerometers were used to monitor for resonant conditions of the actuator.

A spare motor was also mounted on the seismic simulator and was subjected to the same conditions as the valve actuator, however, the motor was not monitored in any way.

During this test the actuator was electrically connected to a control console supplied by Limitorque.

3.1 Resonant Frequency Search:

The specimen was subjected to a resonant frequency search from 5 to 33 Hz. The applied excitation levels were in accordance with Table I. The frequency range was increased in discrete steps of 1 Hz and vibration was maintained at each frequency for a period of not less than six (6) seconds.

The above test was performed in each of the three (3) mutually perpendicular axis.

Table I - Amplitudes of Vibration

Frequency (Hz)	Acceleration (G peak)
5 - 33	.1 to .75

3.2 Seismic Dwell Test:

Upon completion of the resonant frequency search in each axis, the specimen was subjected to a seismic dwell test at each of the resonant frequencies noted during the resonant frequency search. If no resonant frequencies were noted the seismic dwell test was performed at 33 Hz.

Five (5) thirty (30) second dwells were performed at 1/2 g levels, and one (1) thirty (30) second dwell was performed at full g level.

During the dwell tests the unit was operated through its open and closed stroke.

FACTUAL DATA

4.0 RESULTS OF TEST:

The following observations were noted and recorded during the above detailed test procedure:

4.1 Vertical Axis: (Along the actuator stem)
(Machine Axis - Horizontal)

Accelerometer Locations and Orientation:

Input - On Table - Horizontal - in direction of vibration

Outputs A-On actuator near stem - Horizontal - in direction of vibration
B-On end of motor - Horizontal - in direction of vibration
C-On end of motor - Vertical and perpendicular to direction of vibration
D-On actuator near stem - Vertical and perpendicular to direction of vibration
E-On actuator near hand wheel shaft - horizontal and perpendicular to direction of vibration

RESULTS OF TEST (continued)

4.1.1 Resonant Frequency Search:

Frequency (Hz)	Input (G's)	Outputs (G's) A	B	C	D	E
5	0.160	0.160	0.160	0.040	0.080	0.060
6	0.270	0.280	0.280	0.090	0.070	0.070
7	0.370	0.370	0.370	0.120	0.080	0.070
8	0.450	0.460	0.450	0.110	0.100	0.100
9	0.600	0.620	0.610	0.250	0.160	0.150
10	0.720	0.730	0.720	0.100	0.120	0.110
11	0.130	0.140	0.140	0.030	0.040	0.060
12	0.150	0.170	0.170	0.035	0.045	0.040
13	0.210	0.230	0.230	0.030	0.040	0.050
14	0.270	0.280	0.280	0.030	0.050	0.050
15	0.320	0.340	0.340	0.025	0.015	0.020
16	0.350	0.380	0.380	0.030	0.040	0.040
17	0.400	0.430	0.430	0.035	0.050	0.060
18	0.430	0.470	0.470	0.070	0.035	0.030
19	0.490	0.550	0.550	0.080	0.050	0.035
20	0.550	0.610	0.610	0.060	0.050	0.018
21	0.610	0.720	0.710	0.080	0.060	0.020
22	0.690	0.800	0.790	0.120	0.090	0.060
23	0.700	0.880	0.860	0.140	0.090	0.012
24	0.180	0.230	0.230	0.040	0.050	0.040
25	0.200	0.250	0.250	0.060	0.050	0.070
26	0.220	0.280	0.280	0.060	0.060	0.035
27	0.230	0.310	0.300	0.080	0.080	0.070
28	0.250	0.350	0.340	0.100	0.120	0.090
29	0.260	0.390	0.360	0.110	0.090	0.060
30	0.270	0.440	0.410	0.160	0.150	0.100
31	0.300	0.510	0.460	0.230	0.110	0.120
32	0.310	0.580	0.510	0.340	0.150	0.090
33	0.330	0.720	0.590	0.540	0.250	0.150

FACTUAL DATA

RESULTS OF TEST (continued:

4.2 Horizontal Axis: (Perpendicular to Motor Axis)
(Machine Axis - Vertical)

Accelerometer Locations and Orientation:

Input - On Table - Vertical - in direction of vibration

Outputs A-On actuator near stem - Horizontal - perpendicular to direction of vibration
B-On end of motor - Horizontal - perpendicular to direction of vibratior
C-On end of motor - Vertical - in direction of vibration
D-On actuator near stem - Vertical - in direction of vibration
E-On actuator near handwheel shaft - Horizontal and perpendicular to direction of vibration.

FACTUAL DATA

RESULTS OF TEST (continued)

4.2.1 Resonant Frequency Search:

Frequency (Hz.)	Input (G's)	Outputs (G's) A	B	C	D	E
5	0.170	0.012	0.017	0.180	0.170	0.012
6	0.250	0.013	0.019	0.250	0.240	0.013
7	0.290	0.013	0.022	0.300	0.280	0.012
8	0.370	0.018	0.022	0.390	0.360	0.025
9	0.440	0.025	0.035	0.480	0.450	0.060
10	0.580	0.035	0.030	0.610	0.560	0.050
11	0.640	0.044	0.035	0.710	0.660	0.035
12	0.790	0.060	0.040	0.850	0.780	0.070
13	0.250	0.027	0.060	0.250	0.250	0.050
14	0.290	0.070	0.065	0.330	0.350	0.060
15	0.330	0.050	0.200	0.360	0.320	0.070
16	0.380	0.048	0.040	0.420	0.400	0.060
17	0.420	0.060	0.045	0.480	0.430	0.025
18	0.460	0.070	0.065	0.530	0.490	0.050
19	0.510	0.090	0.070	0.630	0.540	0.035
20	0.570	0.110	0.065	0.700	0.580	0.050
21	0.640	0.170	0.080	0.850	0.680	0.060
22	0.700	0.170	0.090	0.940	0.750	0.050
23	0.190	0.050	0.045	0.250	0.210	0.045
24	0.210	0.065	0.120	0.300	0.250	0.070
25	0.230	0.080	0.160	0.350	0.270	0.080
26	0.240	0.090	0.090	0.380	0.290	0.035
27	0.250	0.110	0.080	0.430	0.330	0.100
28	0.270	0.120	0.080	0.470	0.370	0.110
29	0.360	0.400	0.090	0.540	0.400	0.130
30	0.320	0.190	0.110	0.630	0.420	0.120
31	0.330	0.220	0.130	0.720	0.470	0.110
32	0.350	0.290	0.150	0.850	0.550	0.150
33	0.370	0.340	0.180	1.000	0.600	0.200

RESULTS OF TEST (continued)

4.3 Horizontal Axis: (Parallel to Motor Axis)
(Machine Axis - Horizontal)

Accelerometer Locations and Orientation:

Input - On Table - Horizontal - in direction of vibration

Outputs A-On actuator near stem - Horizontal and perpendicular to direction of vibration
B-On motor end - Horizontal and perpendicular to direction of vibration
C-On motor end - Vertical and perpendicular to direction of vibration
D-On actuator near stem - Vertical and perpendicular to axis of vibration
E-On actuator near handwheel shaft - Horizontal - in direction of vibration.

RESULTS OF TEST (continued)

4.3.1 Resonant Frequency Search:

Frequency (Hz)	Input (G's)	Outputs (G's) A	B	C	D	E
5	0.130	0.025	0.020	0.025	0.025	0.160
6	0.170	0.025	0.070	0.060	0.070	0.180
7	0.250	0.030	0.055	0.060	0.070	0.300
8	0.320	0.035	0.055	0.060	0.060	0.350
9	0.390	0.035	0.045	0.050	0.070	0.470
10	0.530	0.035	0.050	0.060	0.070	0.560
11	0.630	0.070	0.075	0.075	0.060	0.670
12	0.740	0.065	0.070	0.080	0.080	0.760
13	0.240	0.015	0.040	0.035	0.080	0.280
14	0.260	0.018	0.045	0.040	0.060	0.370
15	0.320	0.016	0.050	0.040	0.070	0.390
16	0.360	0.017	0.050	0.050	0.075	0.450
17	0.380	0.014	0.045	0.045	0.060	0.410
18	0.400	0.025	0.050	0.060	0.070	0.450
19	0.490	0.018	0.080	0.080	0.070	0.510
20	0.550	0.024	0.060	0.090	0.070	0.550
21	0.610	0.070	0.075	0.160	0.065	0.620
22	0.660	0.050	0.090	0.150	0.055	0.670
23	0.700	0.035	0.110	0.180	0.080	0.760
24	0.170	0.030	0.060	0.080	0.035	0.170
25	0.180	0.030	0.080	0.090	0.040	0.190
26	0.180	0.035	0.070	0.090	0.043	0.210
27	0.200	0.035	0.070	0.100	0.070	0.230
28	0.210	0.040	0.080	0.120	0.070	0.270
29	0.230	0.055	0.080	0.140	0.090	0.290
30	0.240	0.060	0.100	0.160	0.160	0.360
31	0.260	0.065	0.090	0.190	0.150	0.380
32	0.280	0.076	0.065	0.220	0.110	0.400
33	0.290	0.090	0.080	0.250	0.130	0.430

RESULTS OF TEST (continued)

4.4 Seismic Dwell Tests:

4.4.1 Vertical Axis (along the actuator stem)

The Seismic Dwell tests were performed at 33 Hz for a duration of 30 seconds for each run.

Five runs were performed at an input of 3.0 g's and one run was performed at an input of 6.3 g's.

During the dwells the actuator was opened and closed.

There was no evidence of external physical damage as a result of the stress of this test.

4.4.2 Horizontal Axis (parallel to motor axis)

The Seismic Dwell tests were performed at 33 Hz for a duration of 30 seconds for each run.

Five runs were performed at an input of 3.0 g's and one run was performed at an input of 6.0 g's.

During the dwells the actuator was opened and closed.

There was no evidence of external physical damage as a result of the stress of this test.

4.4.3 Horizontal Axis (perpendicular to motor axis)

The Seismic Dwell tests were performed at 33 Hz for a duration of 30 seconds for each run.

Five runs were performed at an input of 3.0 g's and one run was performed at an input of 6.0 g's.

During the dwells the actuator was opened and closed.

There was no evidence of external physical damage as a result of the stress of this test.

FACTUAL DATA

5.0 VISUAL POST TEST EXAMINATION:

Visual post test examination revealed no evidence of any additional external physical damage as a result of the stress of this test.

6.0 RECOMMENDATIONS:

None, data merely submitted.

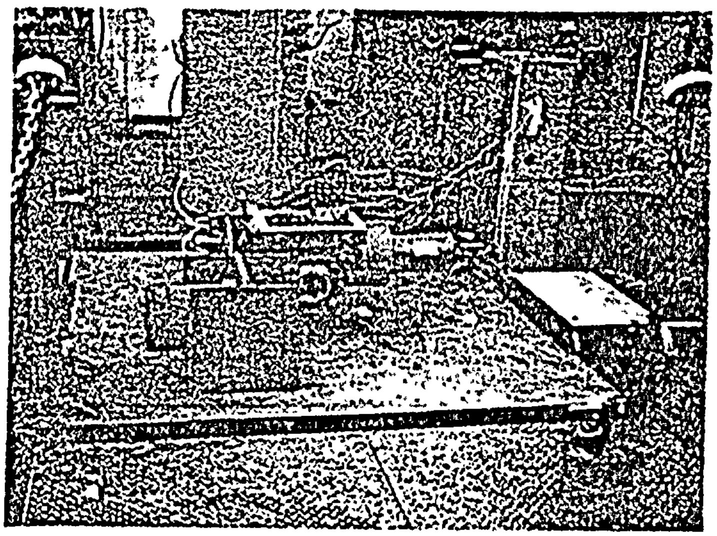
7.0 CONCLUSIONS:

Final evaluation of the submitted specimen for conformance to the requirements of the detailed specifications will be accomplished by Limitorque Corporation upon review of the results reported herein and further examination as required.

LIMITORQUE CORPORATION

KING OF PRUSSIA, PENNSYLVANIA

SMB-1 ACTUATOR



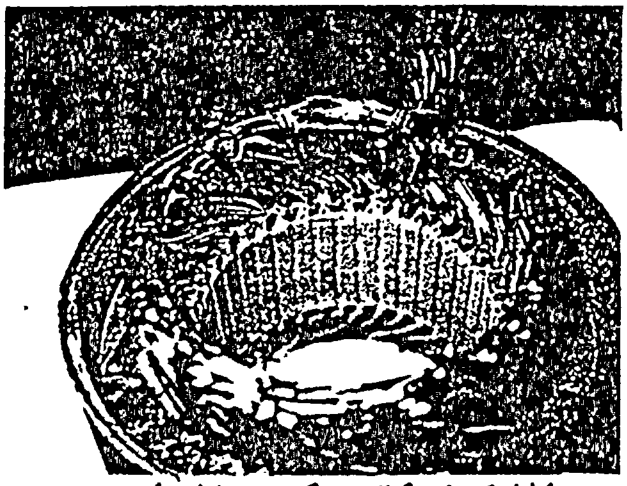
Seismic Test Setup

ETL 5722

S.O. 711-408

APPENDIX IV

PHOTOGRAPHS - AT TEST CONCLUSION



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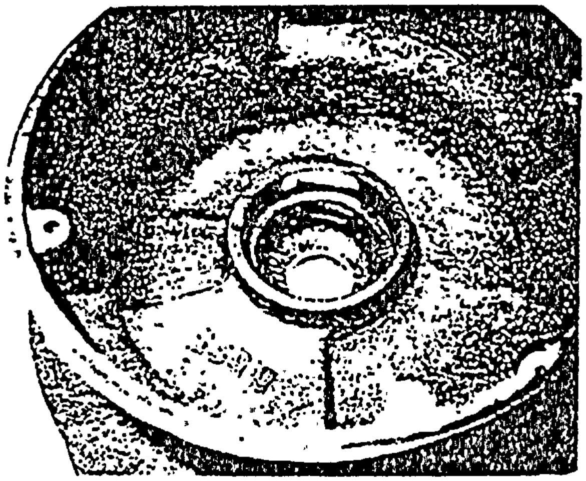

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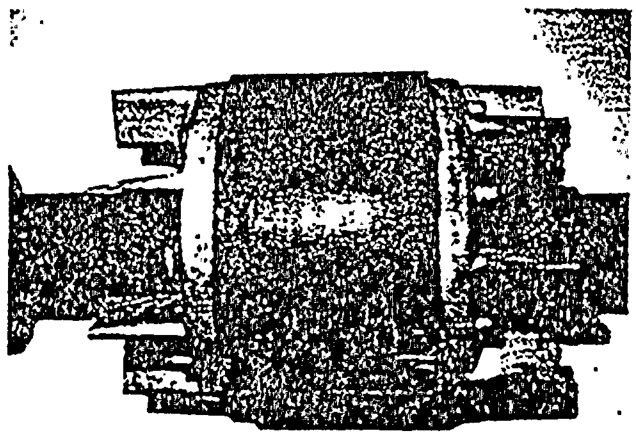

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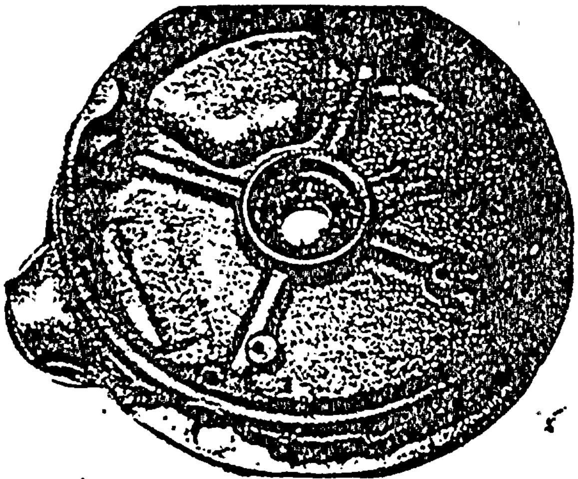
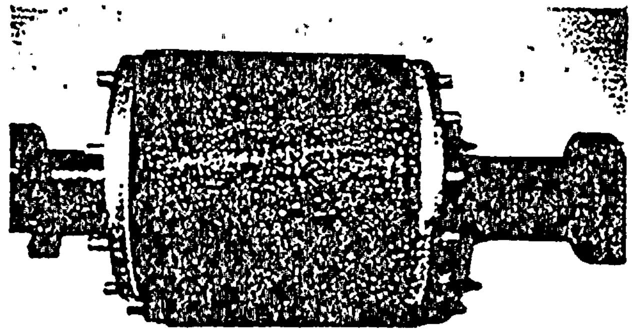
TEST MOTOR #2
POST TEST INSPECTION



447014-JZ P56 FR



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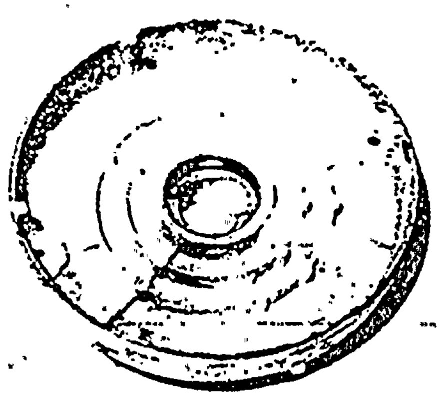

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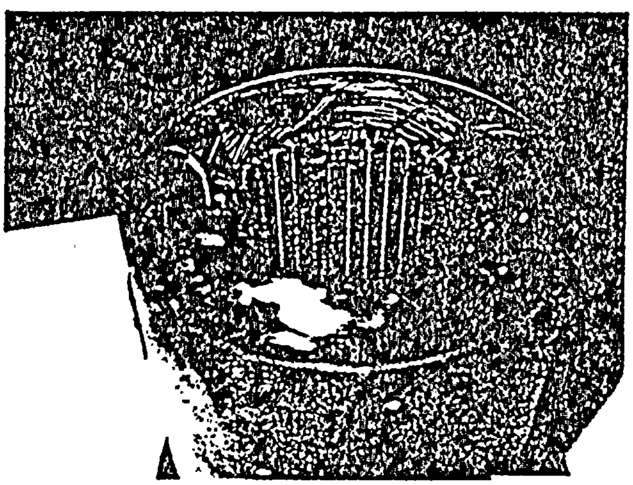
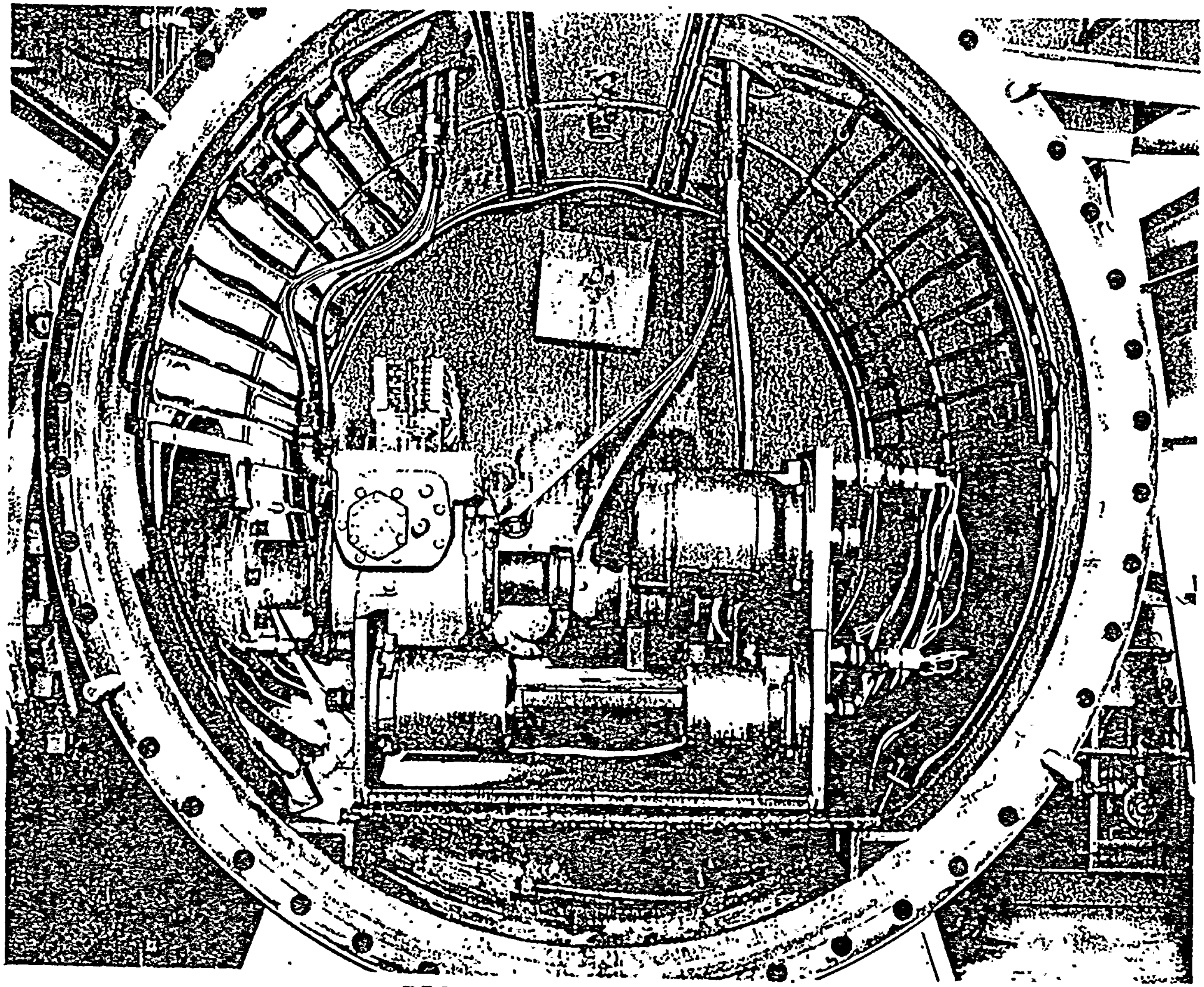


447014-JZ P66 FR.

TEST MOTOR #1
POST TEST INSPECTION



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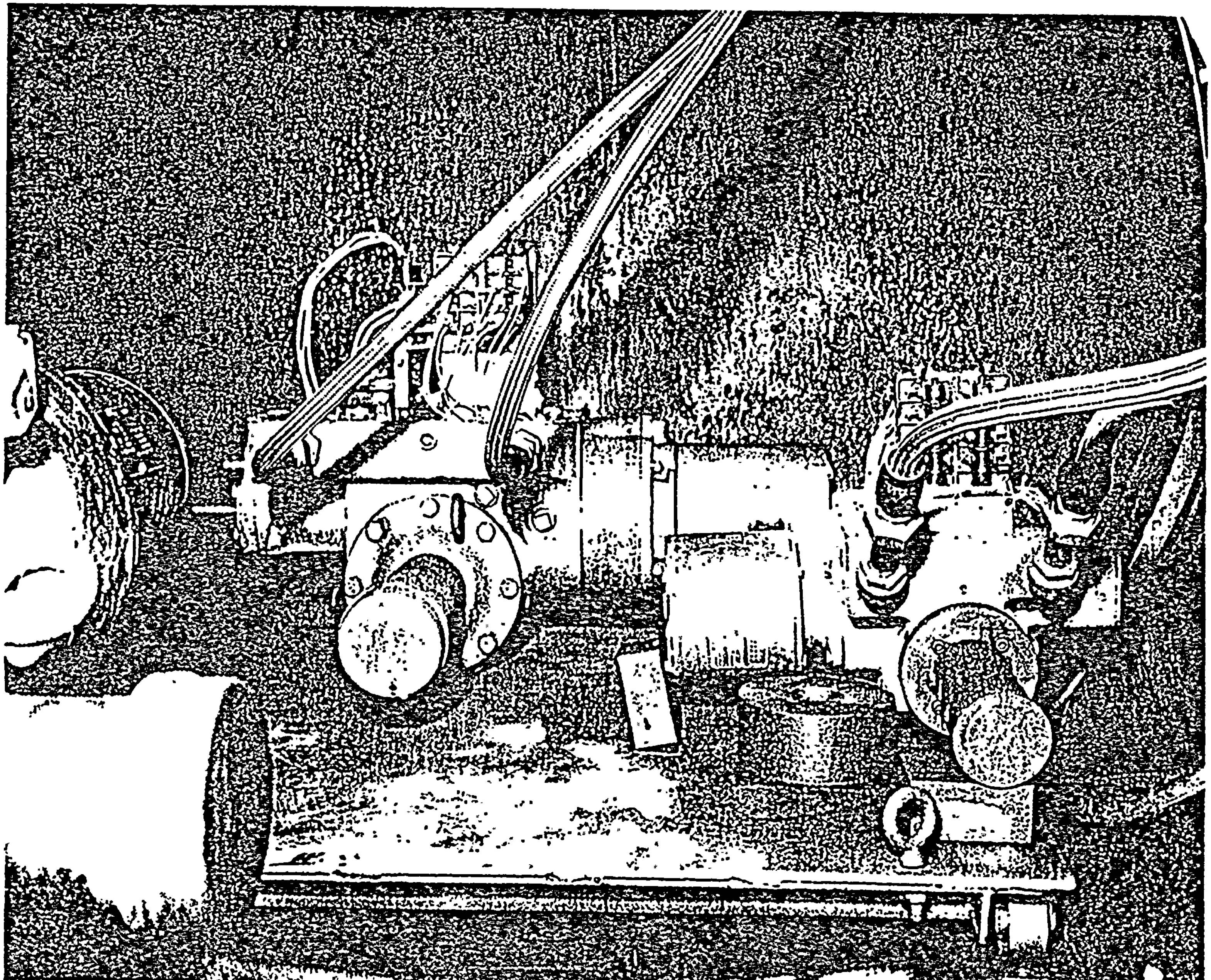
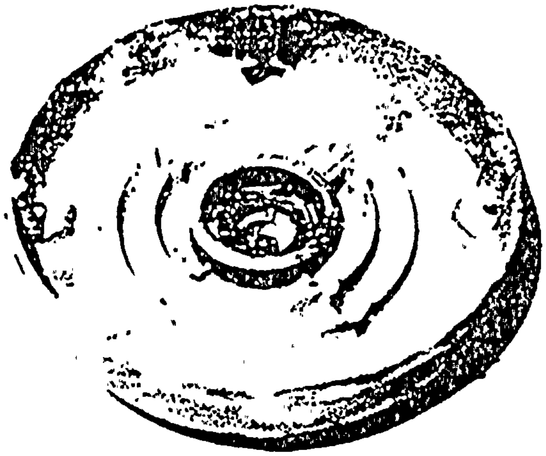
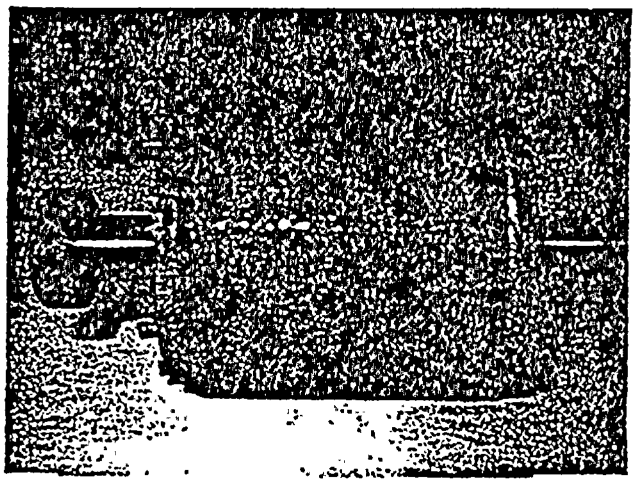


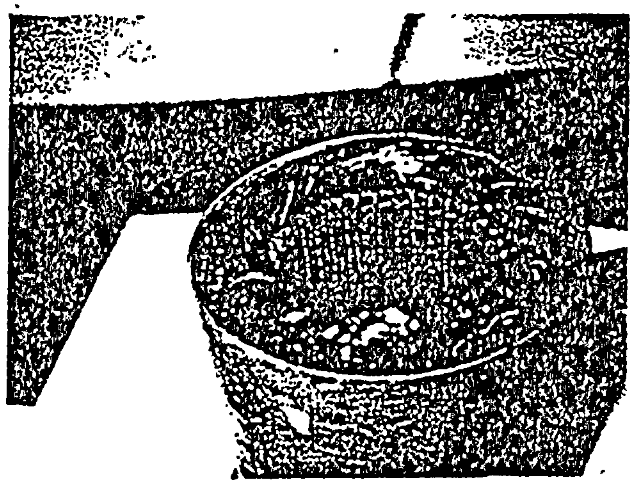
TEST UNIT #1 AFTER TEST



447014-BZ P56 FR.



447014-BZ FR P56



447014-BZ P56 FR.

MOTOR - VALVE ACTUATOR UNIT #1
POST TEST INSPECTION

APPENDIX E

DC Actuator Qualification

Report B0009

QUALIFICATION TYPE TEST REPORT

LIMITORQUE DC VALVE ACTUATORS FOR NUCLEAR POWER STATION SERVICE CONDITIONS

PER IEEE 382, 323 and 344

TEST PERFORMED SEPT. 2, 1975 to NOV. 3, 1975

PROJECT 600426

REPORT NO. B-0009

PREPARED BY

LIMITORQUE CORPORATION TEST LABORATORY

PREPARED BY: Thomas D. Hess Jr.
Tom Hess - Test Engineer

DATE: 4-30-76

APPROVED: W J Denkowski
W.J. Denkowski
Chief Engineer

DATE: 4/30/76

ACCEPTED C D Formica
C.D. Formica
Q.A. ADMINISTRATOR

DATE: 4/30/76

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PROFILE AND DATA SHEETS

APPENDICES

1.0 Purpose of Test

The purpose of this test was to determine the capabilities of a Limitorque Valve Operator (type SMB) equipped with a Porter-Peerless DC electric motor to satisfactorily operate during an environmental condition following unit aging. The Parameters stipulated in the test plan were as required by Bechtel-Philadelphia Electric for Limerick Station and simulates the most severe environment to which the Limitorque operator will be subjected in Boiling Water Reactor Nuclear Power Generating Station during a Post Loca Environment (Loss of Coolant Accident). The operator is considered acceptable on provision it proves capable of satisfactorily operating a valve in both opening and closing directions within a 25 hour period following the start of environmental exposure.

2.0 Test Plan

The test was conducted in Limitorque Corporations Environmental Test Facility at King of Prussia, Pa. One Limitorque Valve Operator equipped with a Peerless DC electric motor (radiation Class H insulation) was subjected to test conditions according to the following test plan.

2.1 Thermal Aging

2.1.1 Thermally age motor stator to 180°C for 100 hours. Refer to Appendix III for certificate of compliance. Regarding the Nuclear Valve Actuator switches and seals, the aging temperature would not exceed 200°F for 200 hours. The switch and seal materials are rated by the manufacturers for use at 300°F and 450°F respectively. Since Limitorque Corporation has successfully used Valve Actuators with these materials at continuous temperatures of 300°F, heat aging these components at lower temperatures was not considered necessary.

2.2 Mechanical Aging

2.2.1 Perform 2,000 operating cycles at rated load (20,000# thrust).

2.2.2 After completion of cycling, disassemble the test unit motor, permanently mark motor by commutation for rotational identification and take photographs of the brushes and commutator.

2.3 Radiation Exposure

2.3.1 Irradiate the test unit with motor to 1.0×10^7 Rads (gamma radiation).

2.3.2 After irradiation disassemble motor and take photographs as in 2.2.2.

2.4 Seismic Aging

2.4.1 Install three (3) accelerometers on the Limitorque Valve Control housing arranged to measure accelerations in each of these axes (one vertical and two horizontal).

2.4.2 Mount the Limitorque Valve Control with fixture to the shaker table with the axis of the stem nut mounted vertically.

2.4.3 Connect the limit switches and torque switches into the control. Connect a contact of the limit switch in series with the torque switch to detect switch chatter. Connect spare switch contacts to lights for further indication of chatter.

2.4.4 Scan in each of the 3 axes at a minimum of .1g from 5HZ to 33HZ, dwelling for 6 seconds at each frequency. Repeat scan from 33HZ to 5 HZ, dwelling at each integer frequency. Record the accelerometer readings at each scan dwell point of each of three axes - V (vertical) H_1 (horizontal parallel to motor axis) and H_2 (horizontal perpendicular to motor axis) for determination of cross coupling. Note resonance frequency in axis being scanned. (Resonance is defined as a minimum acceleration multiplication factor of 2).

2.4.5 Prepare to conduct dwell test in vertical axis V at resonant frequency determined in step 4 (Dwell at 33HZ, if resonant frequencies not evident)

A. On basis of 3.0g on V axis and 3.0g on both H_1 and H_2 axes, determine dwell g-level as follows:

1) At dwell frequency, note cross coupling on V axis determined during scan on H_1 and H_2 axes.

2) If any cross coupling noted, calculate acceleration adder to V axis.

a) H_1 axis

$$\text{Adder} = \frac{3.0g \times \text{cross couple g level at scan}}{\text{g-level of scan at dwell frequency}}$$

b) H_2 axis

$$\text{Adder} = \frac{3.0g \times \text{cross couple g level at scan}}{\text{g-level of scan at dwell frequency}}$$

c) Add resultant of a) and b) to 3.0g, establishing the G-level for the dwell test.

B. Conduct dwell test for 30 seconds on V axis using g-level determined from A.2.c. During the dwell, operate the unit in an open and close stroke. (Simulated thrust seat at same torque switch setting established during mechanical aging). Note results.

2.4.6 Prepare to conduct dwell test in horizontal axis H_1 at resonant frequency determined in step 2.4. (Dwell at 33HZ if resonant frequencies not evident).

A. On basis of 3.0g on H_1 axis and 3.0g on both H_2 and V axes, determine dwell g level as indicated in 2.3.5A except substitute V axis for H_1 axis.

B. Conduct dwell test as indicated in 2.4.5B.

2.4.7 Prepare to conduct dwell test in horizontal axis H_2 at resonant frequency determined in step 3. (Dwell at 33HZ if resonant frequencies not evident).

A. On basis of 3.0g on H_2 axis and 3.0g on both H_1 and V axes, determine dwell g level as indicated in 2.3.5A, except substitute V axis for H_2 axis.

B. Conduct dwell test as indicated in 2.4.5B

2.4.8 After seismic aging disassemble motor and take photographs as in 2.2.2.

2.5 Environmental Test

2.5.1 Install unit in test chamber.

2.5.2 Fill bottom of test chamber with water to assure saturation of the atmosphere in the chamber.

2.5.3 Heat test chamber to 120°F.

2.5.4 Conduct transient temperature rise (120°F to 340°F.)

2.5.5 Hold 340°F. for 1 hour.

2.5.6 Cool test chamber to 330°F. and hold to 4 hours after start of test.

2.5.7 Cool test chamber to 310°F. and hold to 7 hours after start of test.

2.5.8 Cool at 212°F. and hold to conclusion of test (25 hours).

2.5.9 Megger and cycle operator prior to start of test and the following nominal times after start of test.

1. 5 minutes
2. 1 hour - 5 minutes
3. 1 hour - 50 minutes
4. 3 hours - 50 minutes
5. 6 hours - 50 minutes
6. 24 hours - 50 minutes

2.5.10 Record thrust of test unit during each operating cycle.

2.5.11 Remove unit from test chamber, disassemble and inspect, noting condition of various parts. Take photographs.

3.0 Identification of Unit

3.1 Limitorque Operator

Model	SMB-O/25
Order Number	600426
Serial Number	189839
Overall Ratio	108 to 1

3.2 Motor Mounted to Limitorque Operator

Manufacturer - H. K. Porter Co.,Inc.
Serial No. - UC-02810
Full Load Torque - 25'#
Run Torque - 5'#
Volts - 125 Volts DC
Amps. - 14.5
RPM - 1900
HP - 1.805
Duty - 5 min.
Insulation - Class H
Winding - Compound
Commutator Bar - 48
Ambient - 40°C.
Temperature Rise - 115°C.

4.0 Test Procedure

4.1 Thermal Aging

4.1.1 The motor was heat aged by the motor manufacturer to 180°C for 100 hrs. A copy of the H.K. Porter certificate of compliance is in Appendix III.

4.2 Mechanical Aging

4.2.1 The Limitorque Operator with Porter-Peerless DC motor was installed on a test stand to establish a thrust load of 20,000# using the torque switch adjustment to attain the desired load. A thrust load of 19,794# (approx. 453'# torque) was measured. (An average of 37 readings).

4.2.2 The test unit was then aged for 2,004 operating cycles from September 2 to September 9, 1975. One aging cycle consisted of a 30 second closing stroke going into torque seat (approx. 20,000 lb. thrust per 4.2.1) and a 30 second opening stroke.

4.3 Radiation Exposure

4.3.1 The Limitorque Valve Operator with motor received a dose of 1.0×10^7 Rads gamma radiation at Isomedix, Inc. Parsippany, N.J. Irradiation was completed on Sept. 22, 1975. A copy of the Isomedix certificate of compliance is in Appendix I.

4.4 Seismic Aging

4.4.1 Seismic Aging was conducted at American Electronic Laboratories, Inc. Colmar, Pa. The test unit was qualified according to the procedure listed in Section 2.3.1. A copy of the AEL test report is in Appendix II. The seismic test was completed October 16. 1975.

4.5 Environmental Test

4.5.1 The environmental test was initiated on October 30, 1975 according to the test plan presented in Section 2.5. A chart of the test unit operating characteristics for the environmental test is presented in Fig. 2.

4.5.2 Event 0 9:40 A.M. 10/30/75

The test unit operated satisfactorily in the "close" direction, but in the "open" direction of the stroke, overran the "open" limit. During event 2 when this recurred, it was determined this was caused by a sluggish reversing contactor which was not part of the valve actuator. At the conclusion of event 2, the reversing contactor was disassembled, cleaned and reassembled which resolved the problem.

4.5.3 Event 1 9:58 A.M. (5 minutes after test start)

The test unit operated satisfactorily in both directions.

4.5.4 Event 2 10:57 A.M. - 1.1 hours after test start

Event 3 11:45 A.M. - 1.8 hours after test start

Event 4 1:40 P.M. - 3.9 hours after test start

Event 5 4:40 P.M. - 6.8 hours after test start

Event 6 10:35 A.M. - 24.8 hours after test start

Event 7 10:25 A.M. - 96.7 hours after test start

With the exception of Event 2 where the starter problem (event 0) recurred (refer explanation paragraph 4.5.2), the test unit operated satisfactorily in both directions, with the exception of the red indicator light remaining lit through the entire stroke.

4.5.5 Post-Test Inspection

The condition of the test unit after the Environmental Test was excellent, as is indicated in the photographs in Appendix IV. No mechanical damage or excessive wear was observed in the unit itself, however, a broken gear tooth was noted in the limit switch, which explained the malfunction of the red indicator light. The cause of this failure was indeterminable, however, it did not have any harmful effect on the ability of the unit to operate satisfactorily due to the torque switch back-up normally in the circuit.

5.0 Conclusions

Inasmuch as no detrimental effects due to aging were discernable, the unit is qualified for a 40 year life as described in the aging criteria. Furthermore, the unit operated satisfactorily throughout and after the Environmental LOCA Test, proving its capability of operating during and after the conditions imposed on the unit as previously outlined. Both the environmental test and post-test inspection were witnessed by representatives of Philadelphia Electric, who approved the unit as being acceptable for the service intended.

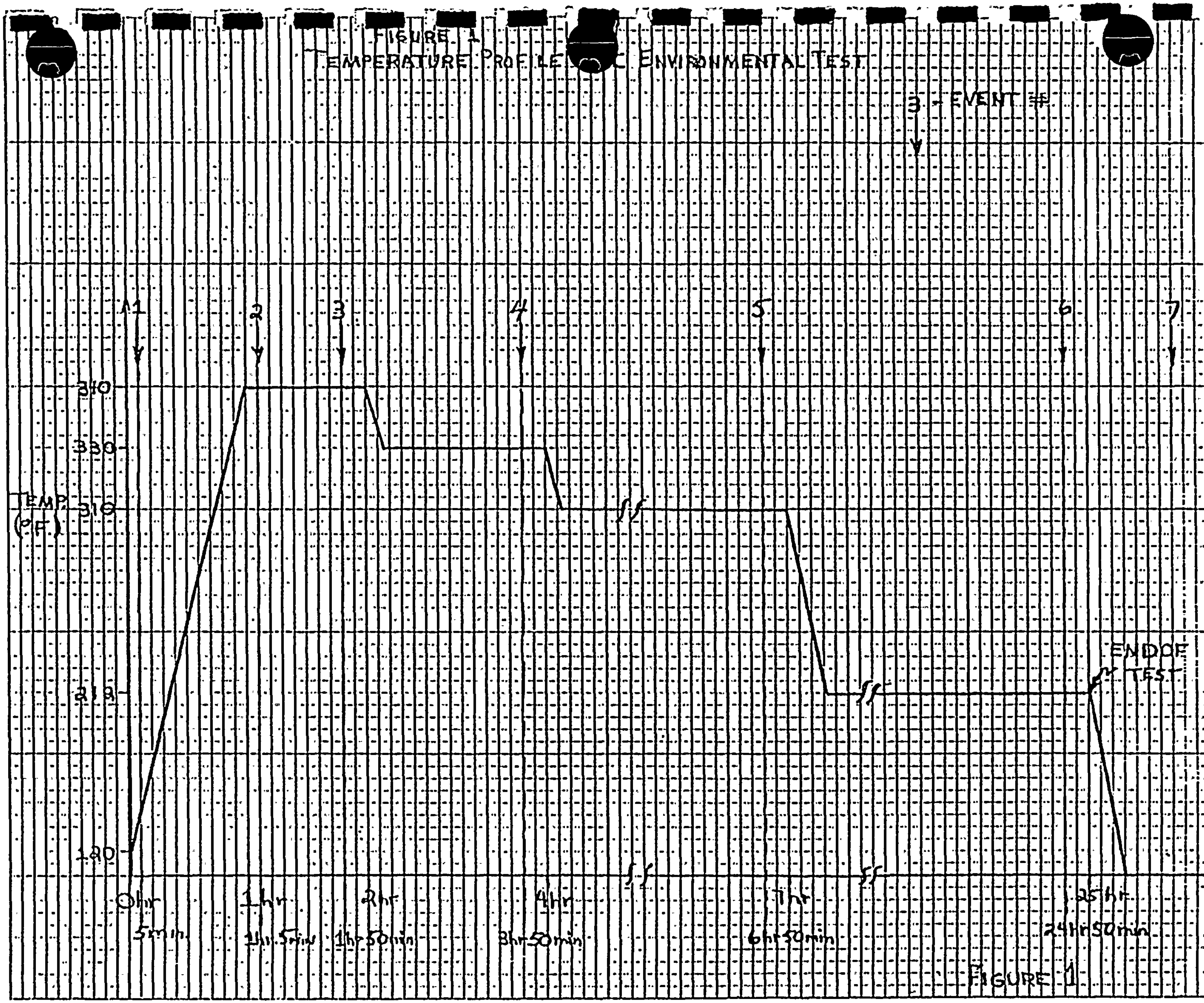


FIGURE 1
TEMPERATURE PROFILE C ENVIRONMENTAL TEST
3 - EVENT #
1
2
3
4
5
6
7
340
330
TEMP. (°F)
310
219
120
0hr
5min
1hr
1hr 5min
2hr
1hr 50min
4hr
3hr 50min
7hr
6hr 50min
25hr
24hr 50min
END OF TEST
FIGURE 1

FIGURE 2A

Ref. : IEEE 382-72
Rev. 1 (3/8/74)
Para 4.7.1

CATEGORY V INSULATION RESISTANCE

TEST NO. 389280

Sheet No. 1

Test Eng. ______

TEST UNIT CLASS H RADIATION INSULATION

VALVE OPERATOR S/N 189839 D.C. Motor S/N UCO2810 (Peerless)

TIME	EVENT NO.	RUN TIME	INSULATION RESISTANCE in ohms x 10^3 (unless otherwise specified)																				
			CONTROL LEADS															MOTOR LEADS					
		hr.	Cl_1	61	71	41	43A	43B	43C	45A	45B	51	53A	53B	53C	55A	55B	A_1	A_2	S_1	S_2	F_1	F_2
9:40AM	0	0	200M	200M	200M	200M	200M	200M	200M	200M	200M	200M	200M	200M	200M	200M	200M	200M	200M	150M	150M	150M	150M
	1	-	8M	4M	3M	500M	6M	6M	6M	5M	5M	4M	4M	4M	4M	4M	4M	1,5M	1,0M	,8M	,9M	1M	,8M
10:49AM	2	1.0	2.5K	2.5K	3K	1.5K	2.5K	2.5K	2.5K	2.5K	2.5K	2,5K	2,5K	2,5K	2,5K	2,5K	2,5K	1,5K	1,5K	2,5K	2,5K	3K	2,5K
11:50	3	1.8	1,5K	1.5K	1,5K	3,5K	1,5K	1,5K	1,5K	1,5K	1,5K	1,5K	1,5K	1,5K	1,5K	1,5K	1,5K	4K	4K	1,5K	1,5K	2K	1,5K
1:40	4	3,9	1,0K	,95K	,95K	3,0K	,85K	,85K	,85K	,85K	,85K	,85K	,85K	,85K	,85K	,85K	,85K	2K	2K	1,5K	1,5K	1,5K	1,5K
		5,8	,9K	,9K	,9K	2,5K	,75K	,75K	,75K	,75K	,75K	,75K	,75K	,75K	,75K	,75K	,75K	3K	3K	2,0K	2,0K	2,5K	2,5K
9:00AM	5	6,8	,8K	,8K	,8K	2,5K	,6K	,6K	,6K	,7K	,7K	,65K	,6K	,6K	,6K	,65K	,65K	2K	2K	1,5K	1,5K	2,0K	1,5K
10/31/75		23,3	160K	160K	160K	400K	160K	160K	160K	160K	160K	160K	160K	160K	160K	160K	160K	200K	200K	200K	200K	200K	200K
10:35AM	6	24.8	140K	140K	140K	400K	140K	140K	140K	140K	140K	140K	140K	140K	140K	140K	140K	200K	200K	180K	180K	180K	180K
10/31/75																							
11/3/75	7	-	1.5M	1.5M	1.5M	2.5M	1.5M	1.5M	1.5M	1.5M	1.5M	1.5M	1.5M	1,5M	1,5M	1.5M	1.5M	,5M	,5M	.4M	.4M	,4M	,4M
9:15AM																							

FIGURE 2B

Ref.: IEEE 382-72
Rev. 1 (3/8/74)
Para. 4.7.1

VALVE OPERATOR POWER & MECHANICAL CHARACTERISTICS

TEST NO. 389280

Sheet No. 1

Test Eng.

TEST UNIT CLASS H INSULATION

VALVE OPERATOR S/N 189839 Motor S/N UC 02810 (Peerless)

TIME	EVENT NO.	RUN TIME	CATEGORY II POWER & CYCLE TIME: POTENTIAL T_1-T_2	OPERATOR "OPENING": RUN CURRENT T_1	OPERATOR "OPENING": POWER	OPERATOR "OPENING": STROKE TIME	OPERATOR "CLOSING": RUN CURRENT T_1	OPERATOR "CLOSING": EST. PEAK T_1	OPERATOR "CLOSING": POWER RUN	OPERATOR "CLOSING": POWER PEAK	OPERATOR "CLOSING": STROKE TIME	CATEGORY VI MECH. CHAR. OPERATOR - IN SEAT: ZERO NULL	LOAD NULL	$\mu\epsilon$ OVER ZERO	CELL "K"	OUTPUT LOAD	REMARKS
		HR.	VOLT	AMP	WATT	SEC.	AMP	AMP	WATT	WATT	SEC.	$\mu\epsilon$	$\mu\epsilon$	$lb/\mu\epsilon$		LB.	
9:40	0	0	124	3.0	375	32.5	3.5	15.5	400	>2K	37.7*	11040	12360	1320	15	19,800	*Ran past. 10/30/75
	1	-	124	2.25	300	31.0	2.25	15.0	300	>2K	31.0	11030	12330	1300	15	19,500	10:00
10:57	2	1.0	123.5	3.25	350	32.0	2.50	15.0	300	>2K	32.1	11030	12660	1630	15	24,450	Ran past limit. See Note 1.
	3	1.8	122.0	3.25	350	32.0	2.5	16.5	300	>2K	32.0	11030	12540	1510	15	22,650	
	4	4.1	124	2.75	350	32.0	2.5	-	350	>2K	32.0	11030	12690	1660	15	24,900	
4:40PM	5	6.8	125.5	2.75	400	31.0	2.5	15.0	350	>2K	31.0	11025	12550	1525	15	22,875	
10:40AM	6	24.8	121.5	2.75	350	32.0	3.0	16.0	400	>2K	32.0	11025	12320	1295	15	19,425	
10/31/75																	
10:25	7	-	125/126	.425	450	33.0	4.25	15.5	550	>2K	33.0	11030	12230	1200	15	18,000	After completion of test.
11/3/75																	
	NOTE	1: Close rotor not working. Open and closed lite on. 6V open limit, 2.5V close circuit.															

FIGURE 3A

Ref. IEEE 382-72
Rev. 1 (3/8/74)
Para. 4.7.1

TEST LOG SHEET

TEST NO. 389280

Sheet No. 1

Test Eng.

Honeywell/TR-888

OPERATOR	DATE	RUN TIME	TIME OF-DAY	EVENT NO.	CATEGORY 1 - ENVIRONMENT: TEST CHAMBER AMBIENT: TEMPERATURE: T.C. #1	Thermometer top Bulb 1	Thermometer side Bulb2	PRESSURE: Gage #1	PRESSURE: Xducer #1	UNIT SWITCH COMPARTMENT AMBIENT: TEMPERATURE: Thermocouples 2	Thermocouples 3	Thermocouples 4	PRESSURE: Pressure Xducer 2	Pressure Xducer 3	Pressure Xducer 4	CAT. III FLUID CHAR. TEMP. CONDENS. T.C. #5	REMARKS
		HR.			°F	F	°F	psig	psig	°F	°F	°F	psig	psig	psig	°F	T.C.#3-in limit switch compartment. Xducer#3-attached to limit switch compt.
TDH	10·30	0	9:35	0	124/119	117	118	0	0	121/120	121/119	118/116	0	0	0	130	
		0	9:53		/226	217	225	7	8	/228	/142	/222	8	9	8	133	
			9:55		237/235	241	239	14	12	235/238	187/184	238/236	12	12	12	140	
			9:58	1	250/257	248	248	18	20	250/251	223/220	252/251	19	19	18	147	T.C.#3-187°F. Operate unit.
			10:03		263/269	264	263	24	30	265/272	245/248	267/269	28	28	27	156	
			10:06		272/279	269	269	30	33	271/281	258/261	273/276	32	32	31	164	
			10:09		281/283	275	274	33	37	281/287	271/269	283/283	35	35	34	168	
			10:13		284/288	280	280	37	42	286/292	279/279	288/288	39	39	39		
					/295	286	285	41	45	/298	/289	/292	43	43	42	181	Note: Multipoint Recorder was not monitor
					/302	292	291	45	51	/302	/295	/297	49	48	48		from this point due to time lag (recorder
					/305	296	296	50	56	/309	/301	/302	54	53	52	185	prints out every 4 min).
			10:24		/312	302	301	55	61	/316	/308	/309	59	57	57		
					/319	307	306	59	67	/323	/312	/316	65	63	63	196	
					/320	311	311	64	72	/324	/315	/319	69	67	67		
					/325	314	314	68	77	/327	/320	/320	73	72	72	201	
					/327	318	319	72	81	/331	/324	/324	78	75	75		
					/334	324	324	79	90	/336	/331	/331	86	82	81	214	
					/340	329	330	87	99	/342	/337	/337	95	91	92		
					/346	333	336	96	108	/348	/343	/343	105	101	102	220	
			10:50	2	/352	342	342	105	120	/355	/349	/349	117	111	114		Operate unit @ 10:57.
			11:30		341/358	343	344	104	112	342/360	341/355	343/357	129	123	126	254	Start cooling to 330°F @ 11:50.

Ref. IEEE 382-72
Rev. 1 (3/8/74)
Para. 4.7.1

TEST LOG SHEET

TEST NO. 389280

Sheet No. 2

Test Eng.

Honeywell/TR-888

OPERATOR	DATE	RUN TIME	TIME OF-DAY	EVENT NO.	CATEGORY 1 - ENVIRONMENT											CAT. III FLUID CHAR.	REMARKS
					TEST CHAMBER AMBIENT					UNIT SWITCH COMPARTMENT AMBIENT						TEMP.	
					TEMPERATURE			PRESSURE		TEMPERATURE			PRESSURE			CONDENS.	
					T.C.	Thermometer		Gage	Xducer	Thermocouples			Pressure Xducer			T.C.	T.C.#3-in limit switch compartment.
					#1	Top Bulb 1	Side Bulb2	#1	#1	2	3	4	2	3	4	#5	Xducer#3-attached to limit switch compt.
		HR.			°F	F	°F	psig	psig	°F	°F	°F	psig	psig	psig	°F	
TDH	10"30		11:48	3	341/357	345	343	105	119	342/361	342/351	343/357	116	109	111	258	
"	"		12:00Noon		331/344	333	332	86	109	332/346	331/346	336/345	94	92	93	259	
"	"		12:30PM		330/342	332	332	86	99	331/346	332/342	332/342	94	90	92	259	
"	"		1:30PM		331/342	332	332	86	99	331/346	332/342	333/342	96	91	93	262	Start cooling to 310°F @ 2:02PM.
"	"		2:25PM		311/324	312	312	64	72	313/327	316/327	314/323	68	64	64	258	
"	"		3:25PM		311/324	314	312	63	70	312/327	314/324	314/324	68	66	66	255	
"	"		4:25PM	5	312/322	313	313	63	70	313/327	313/324	314/324	68	66	66	255	Start cooling to 212°F, @ 4:50PM
"	"		5:20PM		198/203	210	180	0	0	213/224	255/262	211/217	0	0	0	185	turned off cooling coils @ 5:40Pm
"	"		5:50PM		174/187	195	170	0	0	196/203	242/246	199/201	0	0	0	125	Strip heaters controlling.
			6:50PM		205/205	186	184	0	0	198/203	224/225	199/197	0	0	0	170	
			7:50PM		205/205	186	192	0	0	199/203	203/203	197/196	0	0	0	195	
			8:50PM		206/207	189	197	0	0	199/203	199/200	198/198	0	0	0	200	
			9:50PM		207/210	190	198	0	0	200/204	195/197	199/200	0	0	0	201	
			10:50PM		209/210	193	200	0	0	202/207	198/200	202/203	0	0	0	205	
			11:50PM		210/210	194	200	0	0	203/208	198/200	203/204	0	0	0	207	
			12:50AM		212/213	196	202	0	0	205/210	200/203	205/206	0	0	0	208	
			1:50AM		212/215	197	204	0	0	206/212	201/204	206/206	0	0	0	210	
			2 :50AM		212/215	198	205	0	0	206/212	202/206	208/208	0	0	0	210	
			3:50AM		212/215	198	205	0	0	207/212	202/206	207/208	0	0	0	210	
			4:50AM		214/216	199	206	0	0	208/214	203/207	208/209	0	0	0	210	
			5:50AM		213/216	200	206	0	0	208/214	203/207	208/210	0	0	0	210	
			6:50AM		215/217	200	207	0	0	210/214	205/208	209/210	0	0	0	212	

FIGURE 3C

Ref. IEEE 382-72
Rev. 1 (3/8/74)
Para. 4.7.1

TEST LOG SHEET

TEST NO. 389280

Sheet No. 3

Test Eng.

Honeywell/TR-888

OPERATOR	DATE	RUN TIME	TIME OF-DAY	EVENT NO.	CATEGORY 1 - ENVIRONMENT												CAT. III FLUID CHAR.	REMARKS
					TEST CHAMBER AMBIENT					UNIT SWITCH COMPARTMENT AMBIENT							TEMP.	
					TEMPERATURE			PRESSURE		TEMPERATURE			PRESSURE				CONDENS.	
					T.C.	Thermometer		Gage	Xducer	Thermocouples			Pressure Xducer				T.C.	T.C.#3-in limit switch compartment.
					#1	Top Bulb 1	Side Bulb 2	#1	#1	2	3	4	2	3	4		#5	Xducer#3-attached to limit switch compt.
		HR.			°F	F	°F	psig	psig	°F	°F	°F	psig	psig	psig		°F	
TDH	10-31		8:50AM		216/219	202	208	0	0	211/217	207/210	211/212	0	0	0		213	
"	"		9:50AM		216/219	202	208	0	0	211/217	207/210	210/212	0	0	0		212	
"	"		10:50AM	(6)	215/219	202	208	0	0	210/217	207/210	210/212	0	0	0		213	End of test.

Appendix I

Certificate of Compliance - Radiation Exposure

ISOMEDIX

September 23, 1975

Mr. W. L. Sykes
Test Engineer
Philadelphia Gear Corporation
King of Prussia, Pa. 19406

Dear Mr. Sykes:

This will summarize the perimeters pertinent to the irradiation of one valve operator and motor assembly, one motor, and one set of brushes. Identification on the valve operator and motor assembly was:

SMB O Limitorque Operator
S/N 189839
Peerless DC Motor
S/N UC02810

The single motor was a Peerless D.C. motor, S/N BW 86029. The set of brushes was unmarked.

Units were placed in a cobalt-60 field of 0.2×10^6 rad per hour, at an air equivalent dose. They were rotated several times during the exposure to achieve a more uniform dose distribution. Total minimum dose received to the centerline of the operator and motors was 10.0 Mrad (air equivalent) with an overdose factor on the edges of the units of 1.2. The spare set of brushes received a real dose of 5.0 Mrad. Irradiation was in air at ambient temperature and a slight negative pressure. The temperature of the samples during irradiation did not exceed 90°F.

Dosimetry was performed using a Victoreen Model 555 Integrating Dose Rate Meter and Probe. The unit was calibrated on January 15, 1974 by the Victoreen Instrument Company, using Cobalt-60 and Cesium-137 sources whose calibrations are traceable to the U.S. National Bureau of Standards. A copy of the calibration certificate is available. Confirming dosimetry utilizing a Red Perspex system was also completed.

Irradiation was completed September 22, 1975, and the units returned to you under separate cover.

Very truly yours,

George R. Dietz

George R. Dietz
Manager, Radiation Services

RD:km

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

Isomedix Limited • Benoit Street, Mont St. Hilaire, Quebec, Canada Telephone (514) 467-1211
Mailing Address: Post Office Box 7, Beloeil, Quebec, Canada

Appendix II

Test Report - Seismic Qualification

TEST REPORT NO. 75-149 ET NO. OF PAGES 19

REPORT OF TEST
ON

VALVE OPERATOR

FOR

LIMITORQUE CORPORATION

AMERICAN ELECTRONIC LABORATORIES, INC.
ENVIRONMENTAL TESTING LABORATORY

Purchase Order 389280
Control No. 75-127-6100

	PERFORMED BY	REPORT BY	APPROVED BY	
Name	T. Mitchell	R.W. Hay	R.W. Hay	
Date	10/29/75	10/29/75	10/29/75	

FORM 313 (9-73)

ADMINISTRATIVE DATA

TYPE OF TEST: Seismic Vibration

MANUFACTURER: Limitorque Corporation
5114 Woodall Road
Lynchburg, VA 24502

UNIT OF TEST: Valve Operator

TYPE OR MODEL NO: SMB-0 S/N 189839

DRAWING, SPECIFICATION OR EXHIBIT: Limitorque O/N 389280

QUANTITY OF ITEMS TESTED: One Valve Operator with Motor (S/N UC 02810)
One Extra Motor (I.D.#BW86029)

SECURITY CLASSIFICATION OF ITEMS: Unclassified

DATE TESTS COMPLETED: October 16, 1975

TESTS CONDUCTED BY: American Electronic Laboratories, Inc.
Environmental Testing Laboratory
Richardson Road
Colmar, Pennsylvania

DISPOSITION OF ITEMS: Returned to the Manufacturer.

REPORT NO. 75-149 ET

1.0 INTRODUCTION

The SMB Type valve control shown in Figure 1 was submitted by Limitorque Corporation for Seismic Vibration Testing in accordance with Test Procedure O/N 389280, a copy of which is attached.

The testing was performed by the Environmental Testing Laboratory personnel of American Electronic Laboratories, Inc., Richardson Road, Colmar, Pa.

2.0 TEST PROCEDURE

The test procedure followed is included in Section 2.0. The basic test setup is shown in Figure 1 (horizontal) and Figure 2 (vertical). In all cases it was necessary to support the dead weight of the test item and fixture as evidenced by the ropes shown in Figure 2.

Accelerometers were located as noted in Figure 3 for cross axis and resonance determinations. Data was recorded on oscillograph traces.

3.0 DISCUSSION OF RESULTS

The test log is included in Section 6.0 of this report. The oscillograph recordings were not reproducible, but the originals remain on file with AEL in the Environmental Testing Laboratory. The resonance search data was taken from the oscillograph recordings and is included in the data section.

As noted in the test log, there were no resonances in any of the three axes. Crosstalk from 0.3g input in the vertical axis was H_1 = .04g and H_2 = .06g as taken from the oscillograph trace.

With the input in either horizontal direction, crosstalk in the vertical axis was extremely high. Because this was not expected, an analysis of the test set up was made. When driving in the horizontal directions, a slip plate was used. The entire assembly was mounted onto the slip plate which in turn is attached to the shaker head with a single line of five 3/8 inch bolts. The driving force through the slip plate is five inches from the system center of gravity. This creates a couple having a resultant vertical force. Because of the flexibility of the attach point at the shaker head and the fluidity of the oil film on which the slip plate is floating, the entire test setup acts as a spring mass system, giving about the bolt line with the driving force applied from the couple. The apparent

3.0 DISCUSSION OF RESULTS (continued)

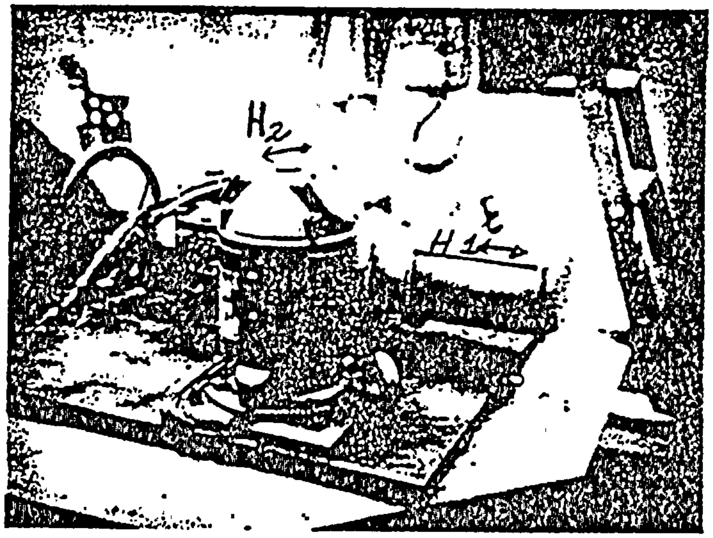
resonance of this spring mass system is near 33 Hz which would account for the vertical component when driving horizontally. Since the basic exciter crosstalk is less than 10 percent of the driven force and the crosstalk from vertical excitation was about 20 percent, a value of 4g's was set by Limitorque as the input force for the seismic dwells.

As a result of damage to the slip plate during the first horizontal dwell, it was necessary to make a modification of fixturing for the other horizontal direction. A bracket was made to attach the operator baseplate to the shaker head as noted in Figure 4. The effect of this setup is identical to that used with a slip plate. This setup was then used to complete the second horizontal axis.

The unit was operated from open to close, electrically, during each dwell by the Limitorque representative. There were no operational problems reported by Limitorque at any time throughout the test.

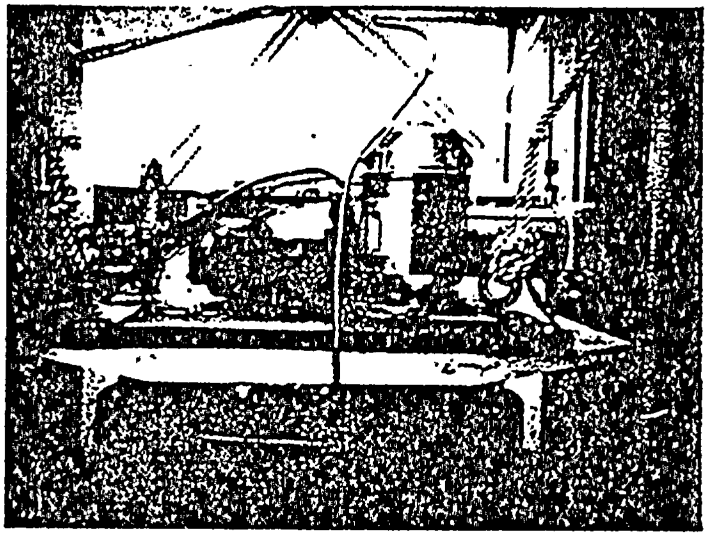
4.0 ILLUSTRATIONS

FIGURE 1



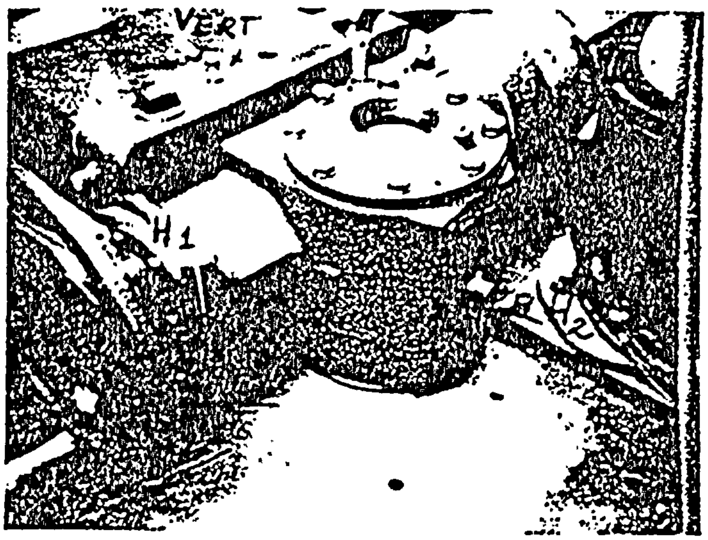
Valve Operator Set-Up in Horizontal (H1) Plane
Using Slip Plate

FIGURE 2



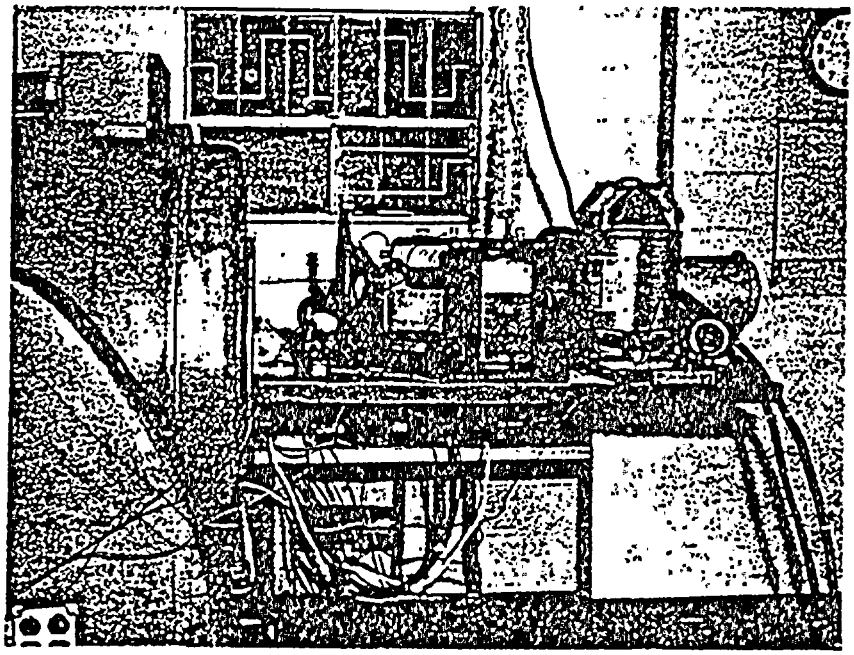
Valve Operator Set-Up in Vertical (V) Plane

FIGURE 3



ACCELEROMETER LOCATIONS

FIGURE 4



Valve Operator Set-Up in Horizontal (H1) Plane
Supported from Crane

5.0 APPARATUS LIST

EQUIPMENT	MANUFACTURER	MODEL NO.	AEL NO.	CALIBRATION DATE	CALIBRATION INTERVAL
Acoelerometer	Endevco	2215E	3214	27 June 75	6 mo.
Dial-A-Gain	Unholtz-Dickie	606	7685	20 July 75	3 mo.
Band Pass Filter	Krohn-Hite	330N	6209	21 Aug 75	6 mo.
Vibration System	M.B. Electronics	C150	8986	EACH USE	
Accelerometer	Endevco	2215E	7710	27 June. 75	6 mo.
Accelerometer	Endevco	2215E	8685	27 June 75	6 mo.
Charge Amplifier	Unholtz-Dickie	11MS	8723	18 Aug 75	6 mo.
Vibration Meter	Unholtz-Dickie	1610	8436	6 Aug 75	3 mo.
Servo Monitor	M.B. Electronics	N753	8751	EACH USE	
Sweep Oscillator	M.B. Electronics	N752-5	8654	EACH USE	
Counter Timer	Monsanto	101A	6186	18 Aug 75	6 mo.
Accelerometer	Endevco	2215E	8684	27 June 75	6 mo.
Accelerometer	Endevco	2215E	7929	21 Apr 75	6 mo
Accelerometer	Endevco	2215E	8078	20 Apr 75	6 mo.
Accelerometer	Endevco	2215E	8324	27 June 75	6 mo.
Vibration Meter	M.B. Electronics	M3	1518	1. July 75	6 mo.
Strobac	General Radio	1531-A	8190	2 July 75	6 mo.
Charge Amplifier	Unholtz-Dickie	D11	8723-A	18 Aug 75	6 mo.
Vibration Pick-Up	M.B. Electronics	115	0719	EACH USE	

5.0 APPARATUS LIST (Continued)

EQUIPMENT	MANUFACTURER	MODEL NO.	AEL NO.	CALIBRATION DATE	CALIBRATION INTERVAL
Charge Amplifier	Unholtz-Dickie	D11	8723-B	18 Aug 75	6 mo.
Charge Amplifier	Unholtz-Dickie	D11	8723-C	18 Aug 75	6 mo.
Charge Amplifier	Unholtz-Dickie	D11	8723-D	18 Aug 75	6 mo.
AC Voltmeter	Hewlett-Packard	400E	7028	28 Apr 75	6 mo.
Datagraph Recorder	CEC	5-126	9145	EACH USE	
Timer	Gra-Lab	171	7360	EACH USE	
DVM	Fluke	8000A	9254	29 May 75	6 mo.

The above equipment has been calibrated by standards which are regularly calibrated and whose accuracies are traceable to the NATIONAL BUREAU OF STANDARDS.

6.0 DATA

10/2/75 Limitorque Corporation - 17525- 6100

Vibration: Sine (Res. Search & Dwell)

1 - Valve Assembly & Extra Motor mounted to customer supplied fixture and vibrated IAW customer supplied Spec. TP O/N 389280. Set up for Res Search in Vertical Axis.

1000 Start Res Scan 5-33 Hz. recording on data'graph 3 accels (V, H1, H2) and control input .1g

1010 Complete scan tape 1
Resonances are noted on cross axes. The amplitude of H1, H2 are relative and are not absolute.

1045 Recalibrated for absolute trace outputs. Rerun vert.

1110 Start scan 5-33-5 Hz. 6 sec/cycle
Tape 2 .3g Input

1120 End scan. No resonances observed.
Change to Horizontal

1510 Start scan of H1 axis 5-33-5 Hz.

1520 End scan Tape 3 No Resonances
.3g input.

10/3 1010 Start scan H2 axis 5-33-5 Hz

1020 End scan Tape 4 No Resonances .3g Input

Check of cross talk readings shows that valves are higher than expected. Phonecon with Walt Sykes determined that vibration level will be 4 g peak for dwells. 1g base line data; checked with DVM will be used to verify existing tapes.

10/6/75 Limitorque Corporation - 17525- 6100

Sine Vibration

0900 H2 Axis vibrated at 1g in to Rv. tape of acels on valve

0905 H2 axis verified tape readings with DVM. All readings within .1g.

0910 Dwell at 2 g for 30 secs. On and 1 min. off 5 vibrations.

1st 2g dwell ok readings taken.

2nd dwell - shut down at 1g in due to noise from fixture.

Removed valve and tightened bolts on aluminum plate.

1010 2nd 2g dwell; Readings OK

3rd 2 g dwell; Readings OK

4th 2g dwell; Readings OK

5th 2g dwell; Readings OK

1020 1 dwell at 33 hz. 4 g's Pk for 30 seconds; shut down after 15 secs due to lost accel.

1035 Completed 4 g dwell. Valve oper. OK. Removed aluminum plate and noticed inserts on slip table loose.

1505 Set up in vertical axis.

Calibrated all accels at 1g.

1510 Start 33 Hz. scan. Base Line Data.

1st	dwell	33 Hz.	2g	In.	Readings	OK
2nd	"	"	"	"	"	"
3rd	"	"	"	"	"	"
4th	"	"	"	"	"	"
5th	"	"	"	"	"	"

1525 30 second dwell at 4g PK. Readings OK

Discontinued testing for now. Slip table to be repaired, or replaced.

10/15/75 Limitorque Corp. - 17525- 6100

Sine Vibration: Continued from Page 41-66

Accelerometers: H1, H2, Vert, Motor & Control.

All Calibrated at .4g In. 20 Hz Readouts as follows:

H2 & Vert Direct .4g = .4 VRHS

Control & Motor Directly on Meters.

H1 = .4g = .1M (volts X 4 = g)

1g Base Line Data H1 = .3V = 1.2g H2 = .11V = .11g

Vertical .27V = .27g

1110 1st dwell at 33 Hz. 30 secs. 2 g In.

Data Recorded by Limitorque Personnel

1111	2nd	dwell	33 Hz.	30 secs.	2g In.
1113	3rd	"	"	"	"
1115	4th	"	"	"	"
1117	5th	"	"	"	"

All Data Recorded by LC

1120 Dwell at 33 Hz. 30 secs. 4 g In.

Crosstalk Readings taken by Limitorque Corporation Personnel

TEST COMPLETED

10-2-75 Limitorque Corporation - 17525-6100

Vibration: Tape Data Recordings

Tape 2	Trace 1 H2 .5g = .46"	Vertical H2 2 V .5g = .42"	Cal. Data 3 H1 .5g = .44"	30 Hz. 4 control 5g = .50"
5 Hz	.04"	.24"	.03"	.33"
10 Hz.	.04	.26	.03	.34
14 Hz.	.07	.23	.03	.32
15 Hz.	.12	.26	.04	.32
16 Hz.	.12	.24	.04	.32
17 Hz.	.09	.28	.04	.34
20 Hz.	.06	.28	.06	.33
23 Hz.	.08	.30	.07	.34
24 Hz.	.09	.30	.08	.33
25 Hz.	.10	.30	.06	.33
27 Hz.	.06	.26	.04	.33
30 Hz.	.05	.26	.04	.35
33 Hz.	.06	.30	.04	.33

Tape 3 H1 Axis Same cal. as above. 30 Hz.

5 Hz.	.04"	.04"	.35"	.34"
10 Hz.	.04	.05	.33	.33
15 Hz.	.04	.04	.35	.34
20 Hz.	.04	.04	.33	.30
22 Hz.	.04	.05	.40	.32
24 Hz.	.04	.04	.44	.34
25 Hz.	.04	.04	.45	.33
27 Hz.	.06	.11	.53	.33
28 Hz.	.04	.10	.48	.36
29 Hz.	.06	.14	.44	.34
30 Hz.	.05	.08	.37	.35
33 Hz.	.03	.07	.36	.38

10/3/75 Tape 4 H2 Axis Same Cal. as above.

	Trace 1 (H2)	2 (V)	3 (H1)	4 (Control)
5 Hz.	.38"	.04"	.04"	.32"
10 Hz.	.38	.05	.06	.32
15 Hz.	.40	.06	.06	.32
20 Hz.	.40	.08	.08	.33
22 Hz.	.44	.08	.05	.33
24 Hz.	.44	.12	.07	.33
25 Hz.	.52	.12	.08	.33
26 Hz.	.51	.16	.08	.33
27 Hz.	.48	.16	.10	.32
28 Hz.	.46	.10	.10	.32
29 Hz.	.44	.08	.12	.34
30 Hz.	.42	.08	.12	.36
33 Hz.	.40	.05	.04	.38

7.0 TEST PROCEDURE

Test Procedure (O/N 389280)

Seismic Testing - Nuclear Power Generating Stations

Limitorque Valve Control - D.C. Operators

1. Install (3) accelerometers on the Limitorque Valve Control housing arranged to measure accelerations in each of these axis (one vertical and two horizontal).

2. Mount the Limitorque Valve Control with fixture to the shaker table with the axis of the stem nut mounted vertically.

3. Connect limit switches and torque switches into the control. Connect a contact of the limit switch in series with the torque switch to detect switch chatter. Connect spare switch contacts to lights for further indication of chatter.

4. Scan in each of the 3 axis at a min. .1 g from 5 Hz., to 33 Hz., dwelling for 6 seconds at each frequency. Repeat scan from 33 Hz. to 5 Hz. dwelling at each integer frequency. Record the accelerometer readings at each scan dwell point of each of three axis - - V (Vertical)., H1 (horizontal parallel to moto/ axis) and H2 (horizontal perpendicular to motor axis) for determination of cross coupling.

   Note resonance frequency in axis being scanned, (Resonance is defined as a minimum acceleration multiplication factor of 2)

5. Prepare to conduct dwell test in vertical axis V at resonant frequency determined in step 4. (Dwell at 33 Hz., if resonant frequencies not evident)

   A. On basis of 3.0 g on V axis and 3.0 g on both H1 and H2 axis, determine dwell-g level as follows:

      1) At dwell frequency, note cross coupling on V axis determined during scan on H1 and H2 axis.

      2) If any cross coupling noted, calculate acceleration adder to V axis.

         a) H1 axis

$$\text{Adder} = \frac{3.0g \times \text{cross couple g level at scan}}{\text{g level of scan at dwell frequency.}}$$

b) H2 axis

Adder - $\frac{\text{3.0 x crosscouple g level at scan}}{\text{g level of scan at dwell frequency}}$

c) Add sum of a) and b) to 3.0 g establishing the g level for the dwell test.

B. Conduct five dwell test for 30 seconds each on V axis, using one half g level determined from A.2.c) and one dwell test for 30 seconds using g level determined from A.2.c) above. During each dwell, operate the unit in a close and open stroke. Note results.

6. Prepare to conduct dwell test in horizontal axis H1 at resonant frequency determined in step 4. (dwell at 33 Hz if resonant frequency not evident).

A. On basis 3.0 g on H1 axis and 3.0 g on both H2 and V axis, determine dwelling level as indicated in 5A except substitute V axis for H1 axis.

B. Conduct dwell tests in H1 axis as indicated in 5B above.

7. Prepare to conduct dwell test in horizontal axis H2 at resonant frequency determined in step 3. (Dwell at 33 Hz. if resonant frequencies not evident).

A. On basis of 3.0 g on H2 axis and 3.0 g on both H1 and V axis, determine dwelling level as indicated in 5A except substitute V axis for H2 axis.

B. Conduct dwell tests in H2 axis as indicated in 5B above.

8. At completion of seismic test, run unit for one full close and open stroke.

SEISMIC AGING COMMENTS

Subsequent testing of a similar SMB-0-25 Valve Actuator with a D.C. Motor (AERO NAV Report 5772) conducted on a different type vibration machine disclosed negligible cross coupling existed in this Actuator.

The above confirms the analysis made in American Electronic Laboratories Report 75-149ET indicating the cross coupling that was measured was created by their vibration machine rather than the Valve Actuator.

The seismic aging levels used are therefore considered to meet the requirements of the specified levels.

Appendix III

Certificate of Compliance - Heat Aging of Motor

PORTER

H. K. PORTER COMPANY, INC.

ELECTRICAL DIVISION

1401 WEST MARKET STREET • WARREN, OHIO 44485

WARREN WORKS
AREA CODE 216
TEL. 399-3651

TELEX NO. 98-2440
"PEERLESS-WAR"

December 29, 1975

JAN 2 - 1976
PHILA. GEAR

Mr. Al Richards
Limitorque Corporation
181 S. Gulph Road
King of Prussia, PA 19406

Subject: P.O. # 600467-A, Our B-29376
Motor Model 176-18-0026-0
Motor Serial Numbers: XC-02809 and UC-02810

Al:

The two radiation test motors supplied against subject purchase order were aged at 180°C for a minimum of 100 hours to obtain an accelerated 40 year life. The motors were tested before and after aging and passed all tests satisfactorily.

The motors were manufactured to Class I radiation requirements for nuclear containment chamber service with material, construction, and insulation system specifications as shown on model 176-18-0026-0. Future motors supplied for Class I service will be of the same construction and materials even though electrical ratings may differ.

If further information is required, please advise.

Sincerely,

Dennis A. Weaver

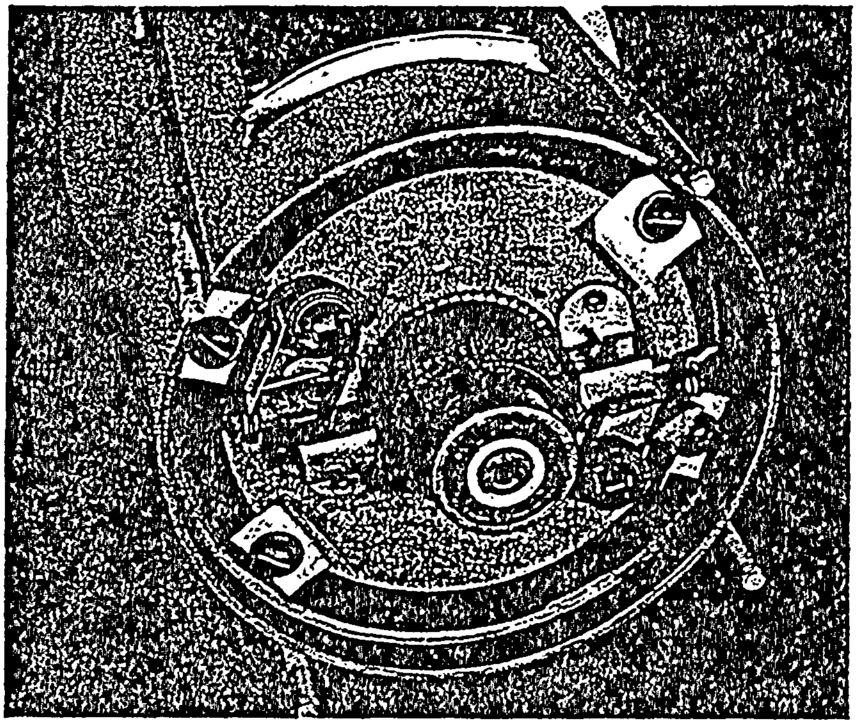
Dennis A. Weaver
Sales Engineer

lm

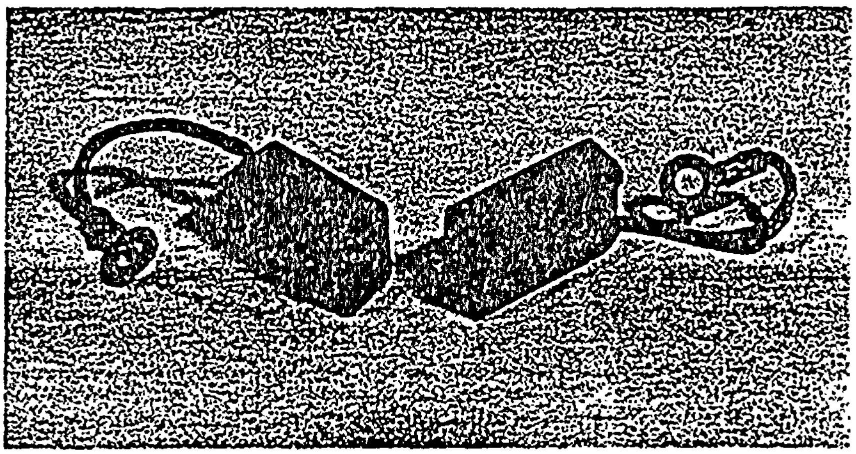
cc: R. Lambert
B-29367

Appendix IV

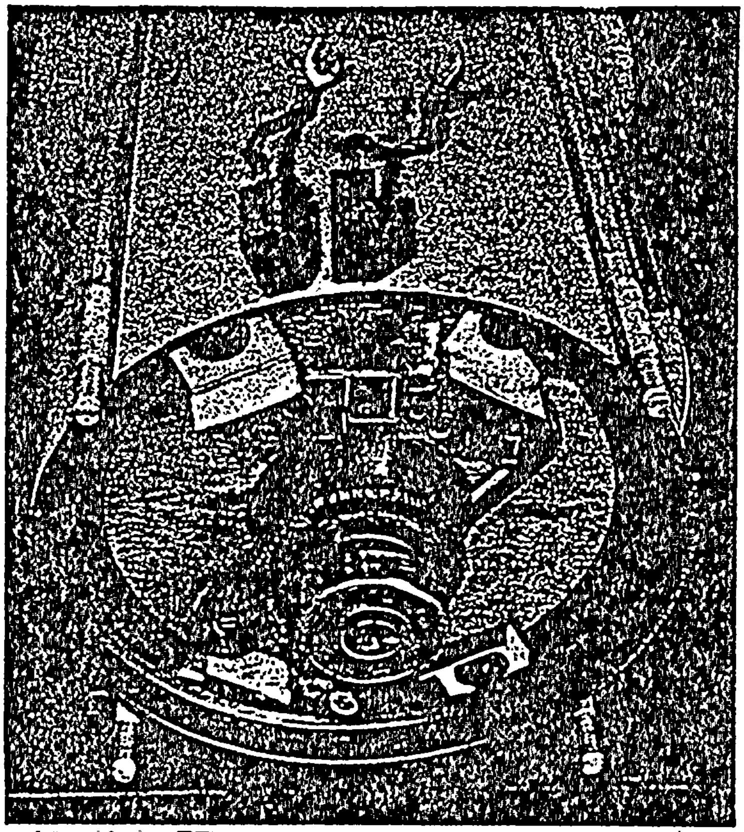
Progress Photographs



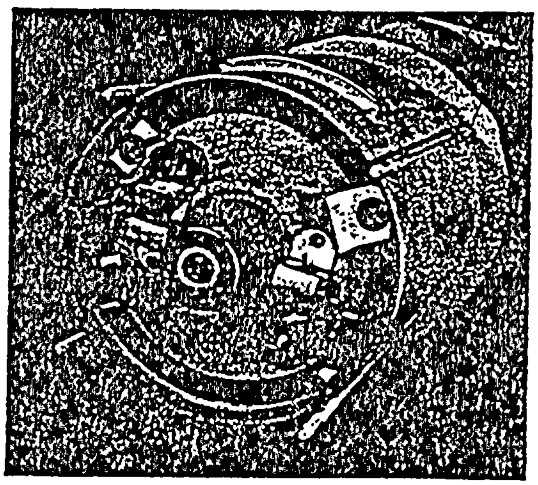
1 - Motor commutator area after 2,000 aging cycles.



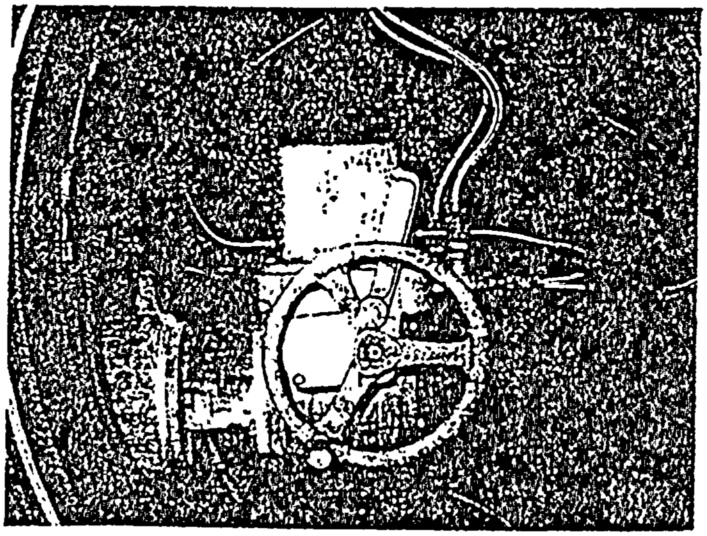
2 - Motor brushes after 2,000 aging cycles.



3 - Motor and brushes after 10 MRad radiation exposure.

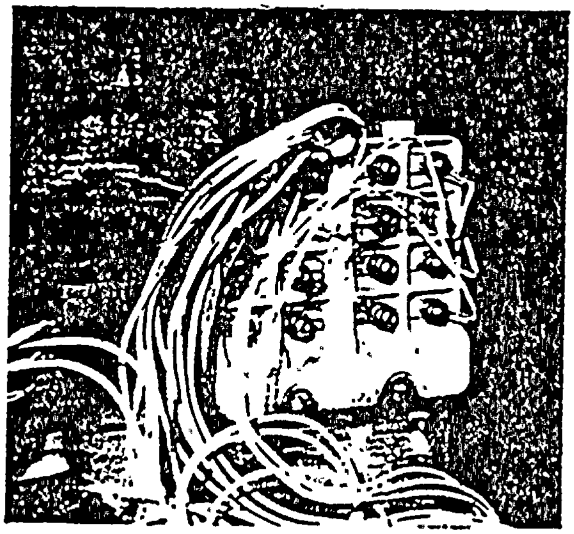


4 - Motor and brushes after seismic qualification.

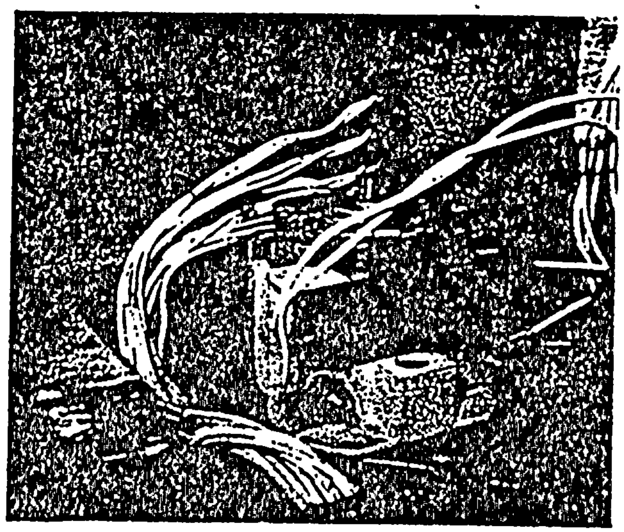


5 - Side view of test unit after environmental profile.

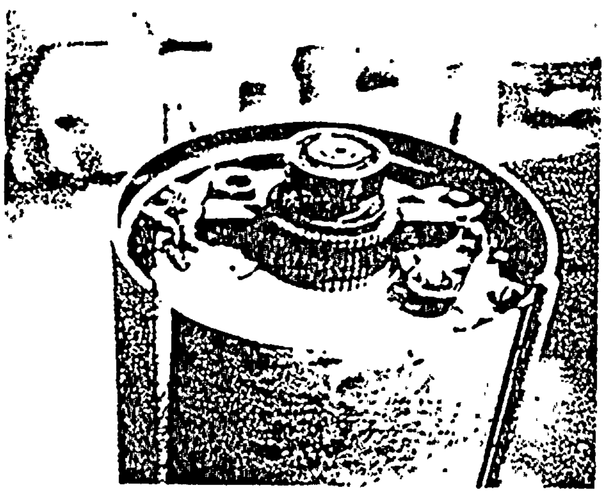
6 - Test unit limit switch compartment after environmental profile.



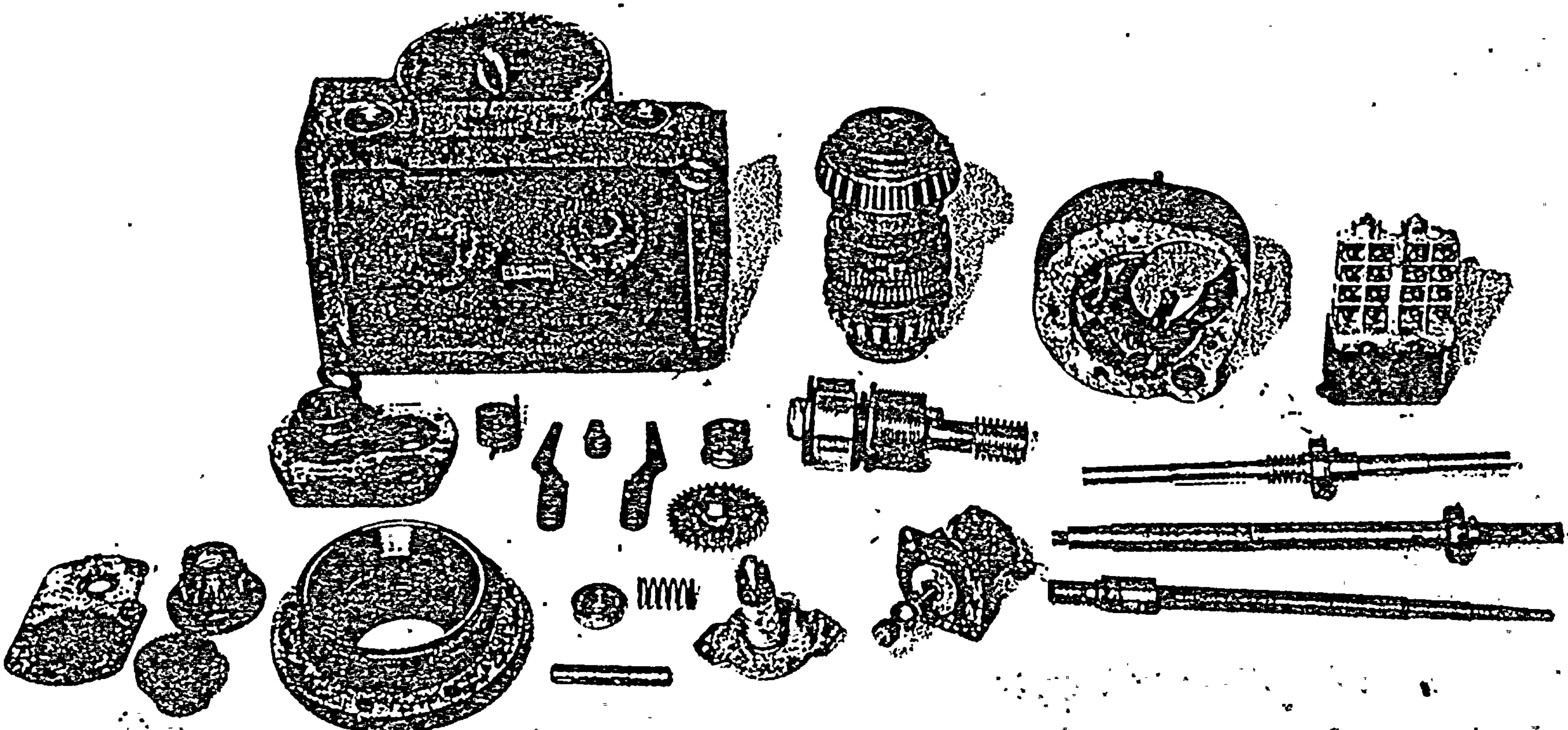
7 - Close-up of limit switch after environmental profile.



8 - Close-up of torque switch after environmental profile.



9 - Motor commutator area after environmental profile.



10 - Test unit after post-test disassembly.

APPENDIX F

Seismic Qualification Envelope

Report B0037

SEISMIC QUALIFICATION ENVELOPE

LIMITORQUE VALVE ACTUATORS

REPORT B0037

TESTS PER IEEE 344-75

PREPARED BY LIMITORQUE CORPORATION

PREPARED BY: J. B. Drab
J. B. Drab - Special Projects Eng.

DATE: 1-11-'80

APPROVED:
W. J. Denkowski - Vice President, Engineering

ACCEPTED: C. D. Formica
C. D. Formica - Q.A. Administrator

TABLE OF CONTENTS

APPENDIX

	REPORT NO.	UNIT SIZE	TEST DATE	
SMB-AC Units				
	Aero Nav Report 5771	SMB-000-5	4/30/75	Appendix 1
	Aero Nav Report 5773	SMB-3-100	7/22/75	Appendix 2
	Aero Nav Report 6-6246-1	SMC-04	3/18/76	Appendix 3
SB-AC Units				
	Aero Nav Report 5774	SB-0-25	7/23/75	Appendix 4
	Aero Nav Report 5770	SB-3-100	4/24/75	Appendix 5
SMB-DC Units				
	Aero Nav Report 5772	SMB-0-25	7/28/75	Appendix 6
	Acton Report 13732	SMB-000-5	12/1/77	Appendix 7
	Acton Report 13732-1	SMB-0-40	12/1/77	Appendix 8
SMB/HBC Assemblies				
	Aero Nav Report 5-6167-5	SMB-1-25/H4BC	11/18/75	Appendix 9
	Acton Report 14331-2&3	SMB-000-5/HOBC	9/11/78	Appendix 10
	Acton Report 14801-1	SMB-1-60/H3BC	5/10/79	Appendix 11
	Acton Report 14801	SMB-3-150/H5BC	5/11/79	Appendix 11
Modutronic				
	Wyle Report 43059-02	Modutronic (on SMB-5)	10/30/75	Appendix 12

SEISMIC QUALIFICATION ENVELOPE

1.0 INTRODUCTION

A group of Limitorque Valve Actuators, chosen to envelope the entire generic family of available actuators type SMB/SB/SBD sizes 000 to 5 and SMC-04 (refer Fig. 1) were subjected to a seismic qualification per IEEE 344-1975. Included were SMB,SB (which are mod SMB units), as well as SMC actuators. SMB and SMC valve actuators mounted on secondary reducers (type HBC) also were chosen to envelope the worst possible unit assembly combinations and were also subjected to seismic qualifications per IEEE 344-1975.

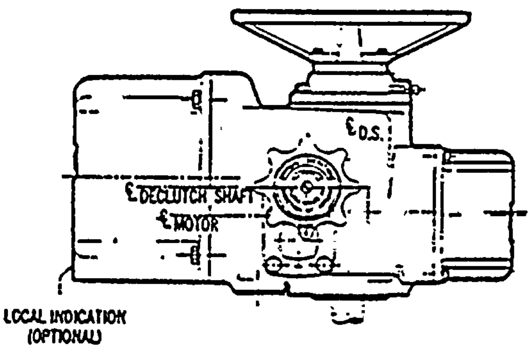
2.0 DISCUSSION

The "Seismic Qualification Envelope" establishes a generic test plan to envelope all standard Limitorque actuators as support for Limitorque's environmental qualifications. This report discusses shake table limitations and presents Limitorque's test philosophy to provide a better understanding of the test methods employed. Figure 1 is included showing representative actuators from the generic family.

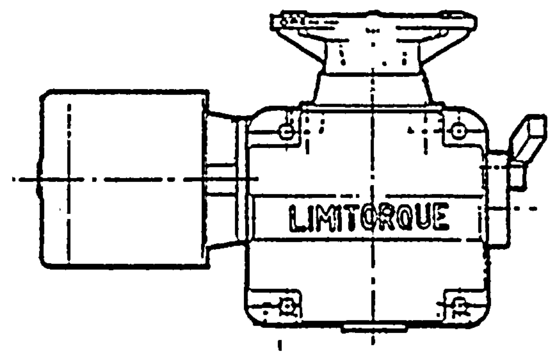
2.0.1 Generic Family

The entire line of Valve Actuators, including the electric motors types SMB/SB/SBD/SMC/HBC, is a generic family, all constructed of similar materials and designed to same concepts, tolerance and stress levels with physical size varying as a function of rating.

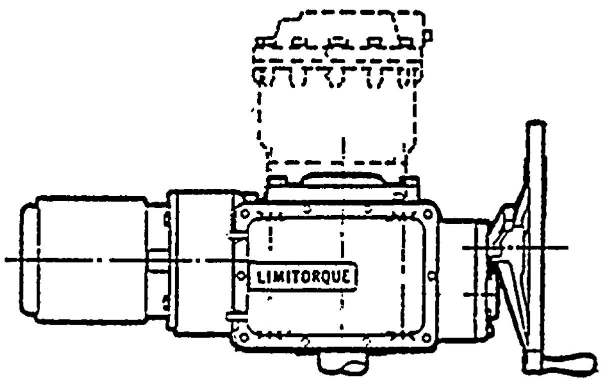
LIMITORQUE ACTUATOR GENERIC FAMILY



SMC-04

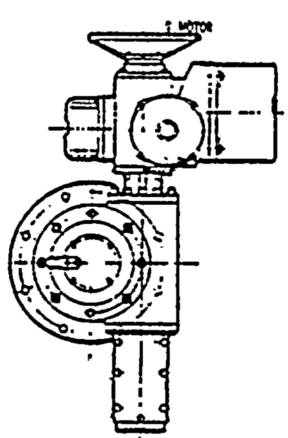


SMB-000 & SMB-00

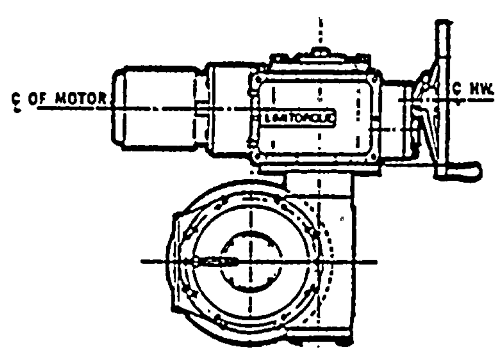


SMB-0 THRU 5

NOTE: VIEW WITH BROKEN LINES SHOW ADDITION OF SPRING PACK TO MAKE SB OR SBD ACTUATOR.



SMC-04/HBC



SMB/HBC

FIGURE 1

2.0.1 (Continued)

The same principle applies to the electric motors used with our actuators. Valve actuator weight is a mathematical function of torque and further the largest motor permissible on a specific actuator is nominally a fixed percentage of the overall actuator weight, further supporting the generic family concept (refer to Figures 3 and 4).

2.0.2 Seismic Qualification Envelope

This document "Seismic Qualification Envelope" - Report B0037, has been created to support our generic envelope used in our various environmental qualifications. Based on the generic family concept, the following applies to seismic qualification:

A. Since all Limitorque A.C. and D.C. equipment respond and are generically equivalent with regard to seismic excitation under 6g and under 35 hz, the A.C. and D.C. seismic test data would be mutually supportive of each other.

B. Seismic tests on SMB/HBC assemblies can be used to qualify the SMB actuator to the seismic level obtained from accelerometers on the SMB mounting flange as well as qualify the adaption between the SMB and HBC units to the seismic test levels.

2.0.3 Loading Simulation

During each of the seismic test dwells, the actuators are operated from a limit switch position to a torque seated position, back to the limit switch position to assure the actuator is performing

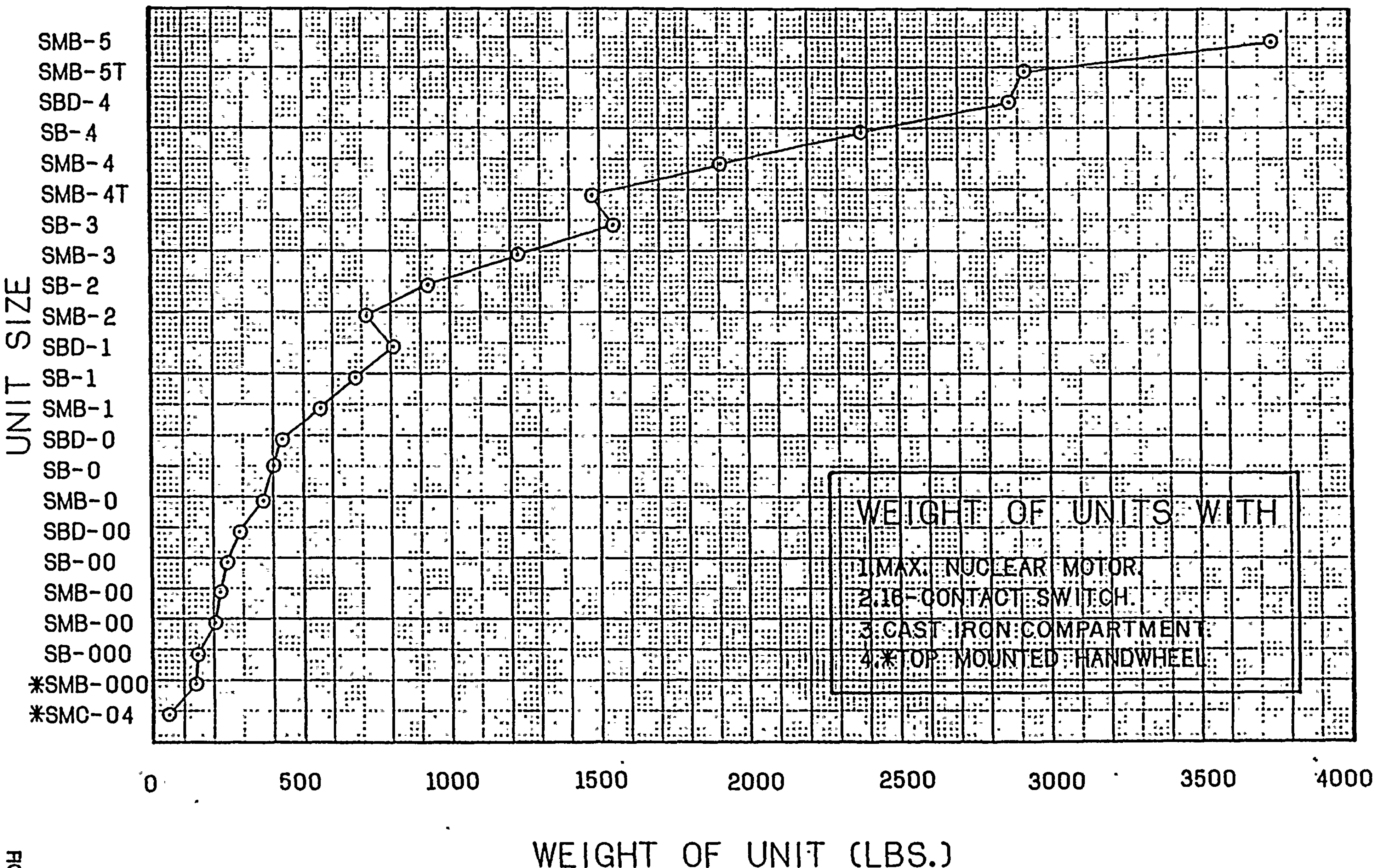
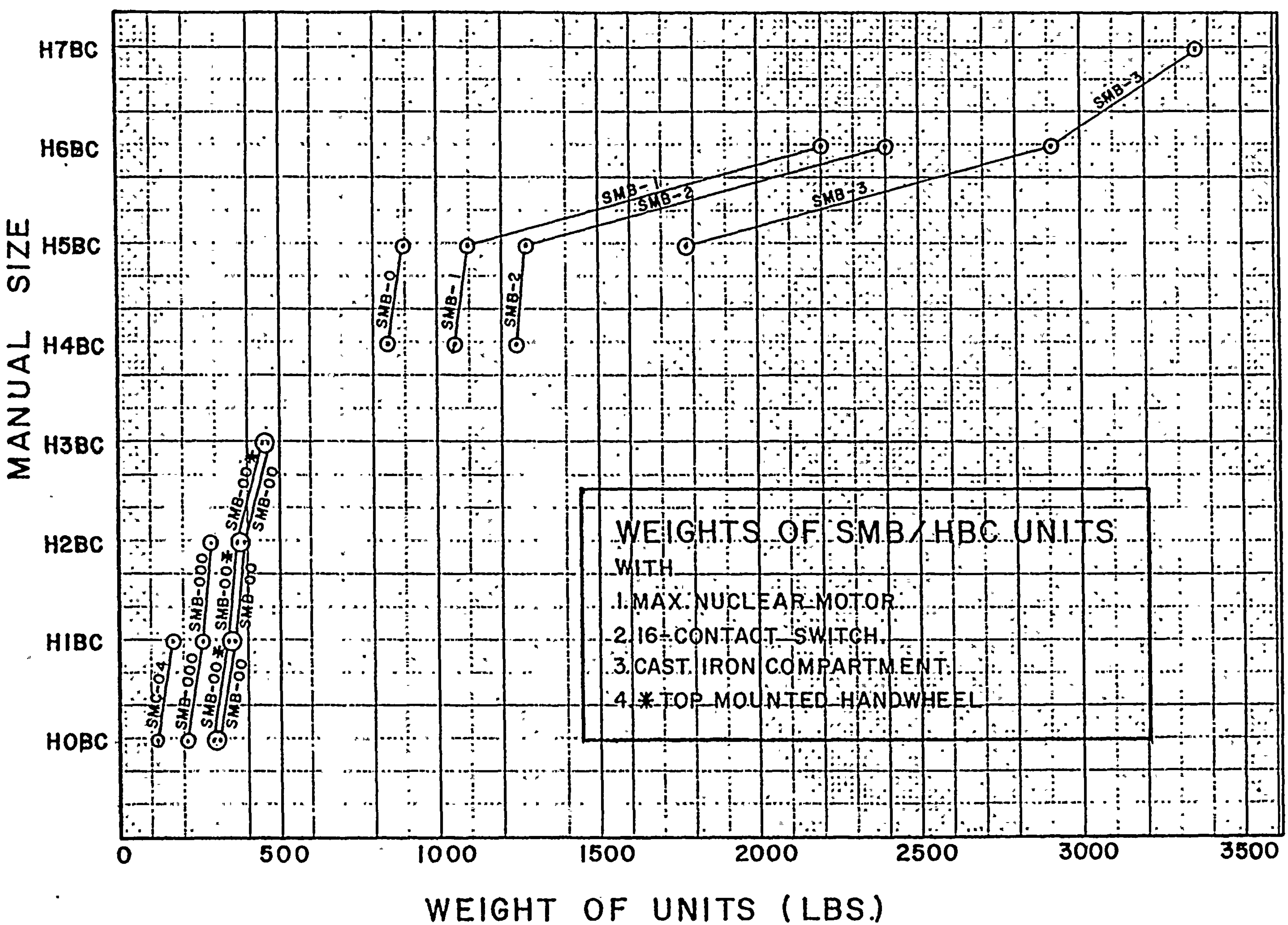

UNIT SIZE
SMB-5
SMB-5T
SBD-4
SB-4
SMB-4
SMB-4T
SB-3
SMB-3
SB-2
SMB-2
SBD-1
SB-1
SMB-1
SBD-0
SB-0
SMB-0
SBD-00
SB-00
SMB-00
SMB-00
SB-000
*SMB-000
*SMC-04
0
500
1000
1500
2000
2500
3000
3500
4000
WEIGHT OF UNIT (LBS.)
WEIGHT OF UNITS WITH
1.MAX. NUCLEAR MOTOR.
2.16-CONTACT SWITCH.
3.CAST IRON COMPARTMENT.
4.* TOP MOUNTED HANDWHEEL.

FIGURE 3



WEIGHTS OF SMB/HBC UNITS
WITH
1. MAX. NUCLEAR MOTOR
2. 16-CONTACT SWITCH.
3. CAST IRON COMPARTMENT.
4. ✱ TOP MOUNTED HANDWHEEL
MANUAL SIZE
H7BC
H6BC
H5BC
H4BC
H3BC
H2BC
H1BC
H0BC
WEIGHT OF UNITS (LBS.)
0
500
1000
1500
2000
2500
3000
3500
SMC-04
SMB-000
SMB-00✱
SMB-00
SMB-0
SMB-1
SMB-2
SMB-3

FIGURE 4

2.0.3 Continued

properly during the seismic excitation. The torque switch is calibrated prior to the seismic test to the units rating for both thrust and torque. The stroke time of the actuator during seismic testing is normally less than established for Environmental Qualifications due to restrictions established by seismic fixturing. However, the actual stroke time during a seismic test is unimportant since the intent is to subject the unit to seismic vibration with operation merely proving the Valve Actuator capable of operating and providing the required torque and thrust.

2.0.4 <u>Weight Distribution</u>

Primarily, seismic consideration directs itself to a weight distribution problem and resolves into the necessity of checking the adequacy of various connecting flanges. This document is a group of seismic tests conducted on units that are considered to contain either the typical or worst weight distribution that would provide the most severe loading on connecting flanges during seismic excitations, thereby providing a generic envelope for seismic qualification.

2.0.5 <u>Discussion - Test Method</u>

Most actuators are installed on valves mounted in pipe runs. It is the general contention in the industry that during an actual seismic event that, due to the pipe run, the valve and actuator would be

2.0.5 Continued

subject to excitation in one mode dominated by one frequency. This supports the sine dwell method of testing.

Furthermore, the sine dwell seismic test is, from our experience, the most severe test that can be performed on Limitorque actuators and thereby a more important reason for conducting this type of test.

2.0.6 Discussion - Resonance

Seismic tests conducted on a hydraulic shake table supported our engineering opinion that no resonances would be found below 5 hz and that no resonances or cross-coupling exist in the frequency range of 1 to 33 hz. Verification of this can be found in the tests conducted after Novmeber 1977 (included in the Appendix of this document). Accelerometer charts, that are light sensitive and not capable of being reproduced, are available for audit.

Currently, no seismic resonance checks have been made on all internal components. However, engineering evaluation of the internal components used in the construction of Limitorque Actuators shows that the elements used are rigid members with closely spaced supports with resonant frequencies much in excess of 33 hz.

2.0.7 Discussion - Cross Coupling

The great number of seismic tests we have conducted have shown no resonant frequencies below 33 hz and clearly provides verification that no cross coupling exists. Since the actuators respond independently

2.0.7 Continued

in each of the three orthogonal axis (no cross coupling), our seismic testing, even that performed prior to 1975, was in fact conducted per IEEE 344-1975 (refer to paragraph 6.6.6 of IEEE 344-1975).

In the seismic testing we have performed, we used several test facilities with these facilities having both mechanical and hydraulic shake tables. Some of the test data from the mechanical table illustrates slight indication of cross-coupling, however, shows no signs of resonance. During our progress of seismic testing, we evaluated the mechanical table and found that the slight signs of cross-coupling were in the table itself and not in the Limitorque Actuator.

2.0.8 Actuator Test Criteria

2.0.8.1 Description - Seismic Fixturing

Limitorque Actuators are required to produce their rated thrust and torque during seismic dwell tests to simulate an actual seismic event and provide assurance all of the actuator components are operating properly.

For linear actuators, such as SMB/SB/SBD/SMC, this is accomplished by use of an acme screw in the Actuator with anti-rotation device and shoulder to bear against the test stem in the seismic test fixture to cause torque switch tripping of the Actuator in the "close" position. This stimulates the seating of a gate or globe valve.

2.0.8.1 (Refer to Fig. 2)

When rotary actuators such as SMB/HBC or SMC/HBC are prepared for a seismic test, the fixture bolted to the secondary reducer (HBC) contains a stop with a key on the HBC output bearing against this stop in the "close" position. The torque switch on the SMB/SMC is calibrated to provide the rated output torque of the HBC. (Refer Fig. 2)

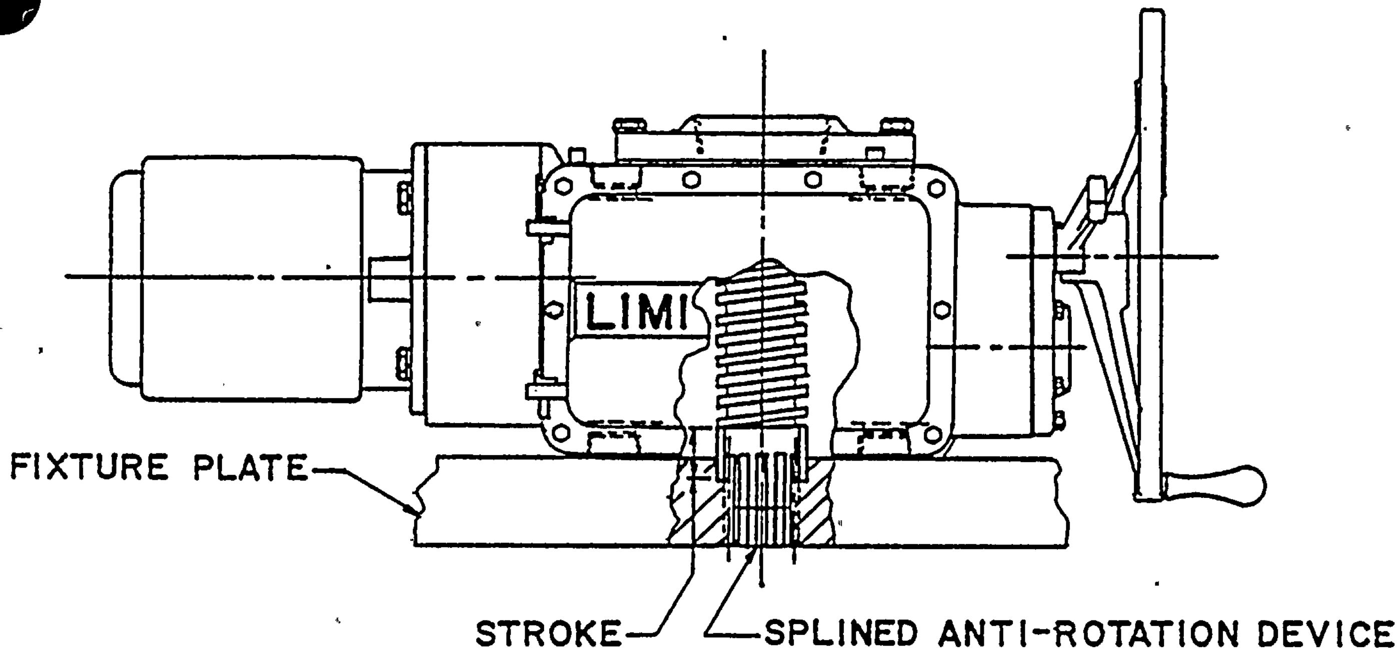
2.0.8.2 <u>Switch Calibration</u>

Prior to the start of the seismic test, the Actuator's torque switch is calibrated to the units output torque rating. Proper choice of the acme thread assures obtaining or slightly exceeding the units rated thrust for linear actuators.

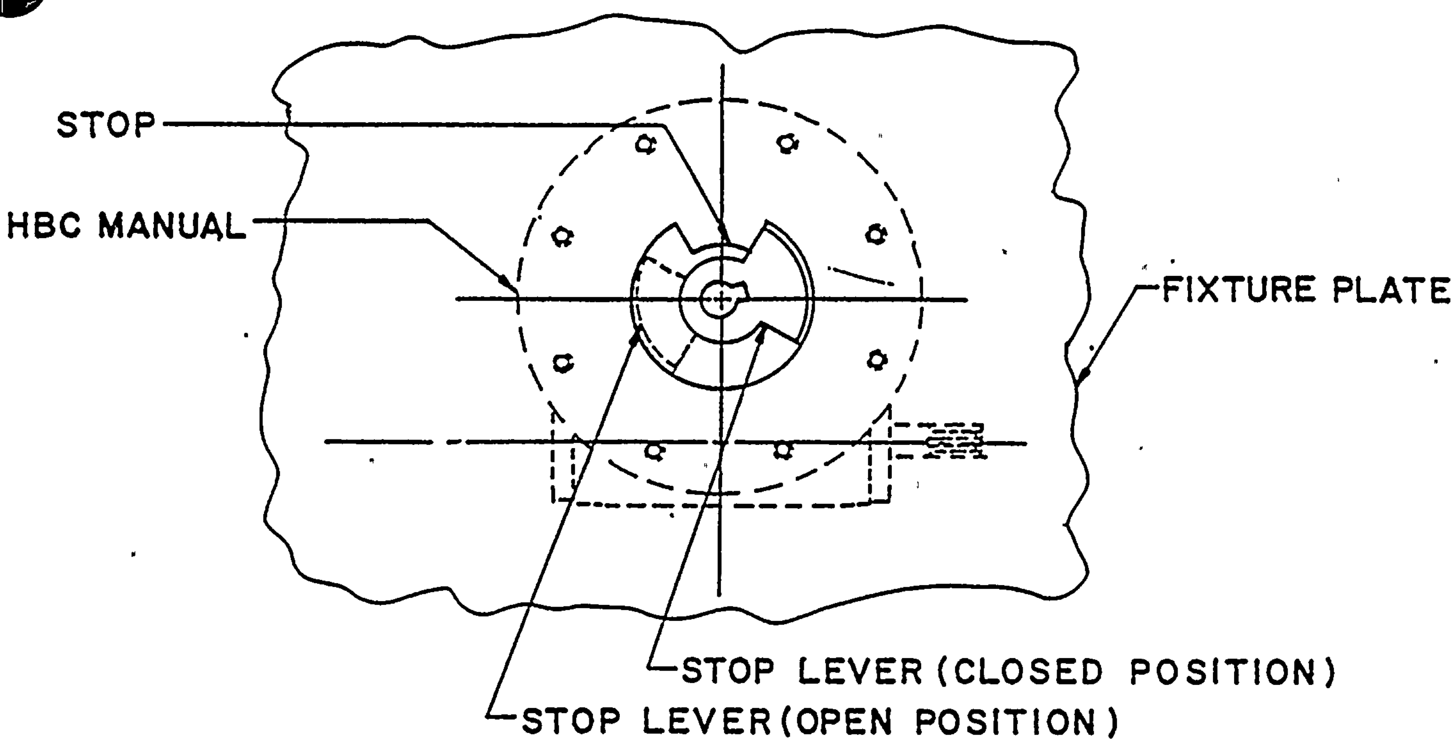
2.0.8.3 <u>Stroke Time</u>

To provide reasonable fixturing (low silhouette) to insure dynamic stability of the seismic testing machine, the stroke of the valve actuator is substantially reduced (for seismic test only) maintaining the torque seat feature and reducing stroke time. The actual stroke time during seismic testing/aging is unimportant since the intent is to age the unit by seismic vibration with operation merely proving the Valve Actuator capable of operating, providing the required torque and thrust, which has been demonstrated.

SEISMIC FIXTURING



LINEAR ACTUATORS-SMB/SB/SBD/SMC



ROTARY ACTUATORS- SMB/HBC & SMC-04/HBC

FIGURE-2