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PHILADELPHIA GEAR CORPORATION KING OF PRUSSIA, PENN. 19406

LIMITORQUE VALVE CONTROL

TEST OF LIMITORQUE VALVE OPERATOR
TO MEET GENERAL REQUIREMENTS
OF
AN ELECTRIC VALVE ACTUATOR
IN
NUCLEAR REACTOR CONTAINMENT ENVIRONMENT

TEST REPORT

600198 F-C ZZ3Z-01 JANUARY 2, 1969

NUCLEAR REGULATORY COMMISSION

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Contractor	DATE 1-2-69
Other	Witness

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- 1. Report Dated January 1969
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NUCLEAR ENVIRONMENTAL TESTS

1. Test report dated January 2, 1969

Addendum #1

35 Hz. - 5.3 G's (report #2539A-4723, Sept. 1970)

2. Test report #F-03441 dated September 1972

Appendix "A"
Test Data Log Sheets

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List of Instruments used in Obtaining

Test Data

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TEST REPORT - JANUARY 2, 1969 ENGINEERING ORDER NO. 600198

The Limitorque valve operator tested was Model SMB-0 with a 15 foot pound, 3 phase, 60 cycle, 440 volt motor, with special high temperature motor insulation and high temperature resistant nonmetallic components, to withstand the contemplated steam pressure, high temperature and chemical conditions expected in the event of a nuclear reactor failure within the containment vessel. The Limitorque operator was wired for a torque seating control for closing direction and position limiting control for open direction. A 2 3/8" diameter by 1/4" pitch, 1/4" lead, left hand stem was used to simulate the stem of a valve being opened and closed The speed of operation was approximately 6" per minute over a 12" travel. The designed seating thrust to be exerted on the stem by the Limitorque valve control was 16,500 pounds of thrust in the closed position of the valve stem. A slide wire electric position transmitter was also installed and connected to a remote position receiver outside the test chamber.

TESTS TO BE PERFORMED ON OPERATOR

- Preliminary heat tests on component parts.
- 2. Preliminary heat tests on actuator.
- Preliminary live steam test on actuator.
- 4. Heat aging test of electric motor and electric motor with brake.

- 5. Shock and vibration test of actuator to simulate seismic 030018 conditions.
- 150 life cycle test of actuator producing approximately 16,500 pounds of thrust.
- 7. Test of Limitorque valve operator and electric brake motor ____ under a simulated reactor containment post-accident steam and chemical environment.

The standard Limitorque operator geared limit switch and torque switch was subjected to a dry heat test for approximately 16 hours at a temperature of 375°F. Periodically during this test, the switches were removed from the oven and actuated by hand. The operation was satisfactory and no malfunctions occurred. All parts functioned freely and there was no binding, jamming, nor abnormal distortion of parts. The test was successful in all respects.

2. PRELIMINARY HEAT TESTS ON ACTUATOR

A completely assembled and operational Limitorque operator was placed in an oven where the temperature was maintained at approximately 325°F. for a duration of 12 hours. The unit was electrically operated every thirty minutes for a period of approximately two minutes per cycle and using the geared limit switches to stop the actuator at the full open and full closed position of travel. Indicating light circuits were also wired to the geared limit switches.

The test was successful in every respect. There were no malfunctions of the operator and upon inspection of the component parts used, there was no noticeable deterioration or wear.

The lubricant used in the geared limit switch did become hard and caked, however the lubricant used in the Limitorque

gear housing remained pliable and had its original consistency.

It was determined that the grease in the geared limit switch

gear housing should be changed to the same grease as in the

Limitorque operator gear housing.

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3. PRELIMINARY LIVE STEAM TEST ON ACTUATOR

A complete Limitorque actuator was set up for electrical operation and live steam was piped into the conduit taps on the top of the limit switch compartment. One of the bottom conduit taps was left open to drain off any condensate. The operator was set up on a timer basis for operation over a period of approximately nine hours and operating every thirty minutes for two minutes per cycle. During this test, the live steam in the switch compartment seemed to have no effect whatever on the function of the limit switches in their control of the operator at the full open and full closed position of travel. In addition, the limit switches were wired up to indicating lights which operated satisfactorily.

The test was successful and there was no noticeable effect on the function of any of the parts in the limit switch compartment.

4. HEAT AGING TEST OF ELECTRIC MOTOR AND ELECTRIC MOTOR WITH BRAKE

The electric motor for the Limitorque operator to be used in the environment test and another electric motor equipped with a disk type brake were subjected to a heat aging test.

Both electric motors were sent to Reliance Electric Co. for heat age testing. This test consisted of baking the motors at a temperature of 180°C. for a total of 100 hours to simulate aging the motor to a 40 year life expectancy. Motor insulation checks were made and found to be within normal limits. There were no adverse effects on the motors and motor insulation resistance measured infinity to ground.

5. SHOCK AND VIBRATION TEST OF ACTUATOR TO SIMULATE SEISMIC CONDITIONS

The Limitorque operator to be used in the environment test was shipped complete to the Lockheed Electronics Co., in Plainfield, New Jersey, for shock and vibration testing to simulate seismic conditions. A copy of this report is enclosed herewith. The test basically consisted of mounting the Limitorque operator on a shock and vibration table to test it at 20 cycles per second vibration at 1G load for a period of two minutes on - one minute off. This would constitute one cycle. The cycle was repeated five times in both the vertical and horizontal axis of the operator. The actual test report and photographs are included here.

The test was successful and there was no noticeable effect whatsoever on the Limitorque operator.

.6.

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The Limitorque operator was shipped to the Franklin
Institute Research Laboratories, Philadelphia, Pennsylvania.
The operator was mounted on a stand inside the test chamber and a 150 cycle load test was made on the unit. This test consisted of stroking the 2 3/8" diameter valve stem a total of approximately 12 inches in two minutes. The valve stem in the full closed position produced a thrust of 16,500 pounds on a rigid plate securely bolted to the test chamber. The thrust was measured by the same strain-gauge recording instrument used in the actual environmental test conducted by the Franklin Institute. The unit was wired up so that the closing direction and the open position geared limit switch stopped the unit in the full open position. The speed of travel was 6 inches per minute.

After the life cycle testing was completed, the unit was inspected and found to be in excellent condition. There was no noticeable wear on any of the parts. The same electric motor which had been heat age tested at Reliance Electric Co. was used for this life Cycle test. There was no noticeable adverse effect on the electric motor and it functioned properly.

7. TEST OF LIMITORQUE VALVE OPERA: UNDER SIMULATED REACTOR CONTAINMENT POST-ACCIDENT STEAM AND CHEMICAL ENVIRONMENT

The attached report of the Franklin Institute Research
Laboratories describes the actual testing under this environ-

mental condition.

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After the test was completed, the Limitorque operator was shipped back to Philadelphia Gear Corporation, King of Prussia, Pennsylvania where it was disassembled and all parts were inspected. Photographs are included showing the various parts of the operator. All parts, including the electric motor, slide were position transmitter, seals, bearings, gears, and shafts, were inspected and no noticeable wear was noted. However, the gear frame of the geared limit switch had corroded and caused a minor failure.

The geared limit switch frame had been attacked by the boric acid in the stan atmosphere. This caused the gear frame to corrode and resulted in binding up of the shafts of. the geared limit switch where they extend through the geared limit swirth housing. This caused the malfunction of the switch as described in the Franklin Institute Research Laboratories' Report. A material change has been instituted to correct this corrosive action of the material used in that particular switch. On all present orders being processed, and on all future units to be shipped to meet environmental conditions such as this, the gear frame housing of the geared limit switch will be a bronze material which is not subject to corrosion by boric acid solutions. The motor insulation . resistance after all testing was 1,000 megohms across all three motor terminals to ground at 500 volts.

Test Report No. 2120-4594

REPORT OF TEST

PHILADELPHIA GEAR CORPORATION

SMBO-15 LIMITORQUE

Report Writer:

B. F. Soltis

Test Engineer:

Mary Black

LOCHMEED ELECTRONICS COMPANY

MILITARY BYSTEMS DIVISION PLAINFIELD, NEW JERSEY

Date: July 31, 1968

Approved by: Mn.t.

N. Johnson, Supervis

N. Johnson, Supervisor Environmental Laboratory



PURPOSE OF TEST:

To subject the test specimen to the Vibration Test referenced in Philadelphia Gear Corporation Purchase Order No. 600198.

MANUFACIURER: Philadelphia Gear Corporation

King of Prussia, Pa.

030025

SPECIMENS TESTED:

SMBO-15 Limitorque (Reliance Motor S/N 435571-MS)

APPLICABLE DOCUMENTS :

Philadelphia Gear Corporation Purchase Order No. 600198

24-8041-0594

CASE NUMBER:

One (1)

QUANTITY OF SPECIMENS TESTED:

SECURITY CLASSIFICATION OF SPECIMENS TESTED:

DATE TEST COMPLE 'ED:

7/30/68

Unclassified

TEST CONDUCTED BY:

LOCKHEED ELECTRONICS COMFANY ENVIRONMENTAL LABORATORY

DISPOSITION OF SPECIMENS TESTED:

Returned to Franklin Institute, Applied Mechanics Laboratory per the request of Philadelphia Gear Corporation per Lockhaed Electronics Company Packing Slip No. 41775 dated 7/31/68.

TEST APPARATUS :

Reaction-Type Vibration Machine, LAB Company Model RVH-72-5000. S/N 51401

Vibration Meter, ME Company Model M-6. 3/N 539

Vibration Pickups, MB Company Type 120. S/N 14187 (vertical) and S/N 11263 (horizontal)

The test specimen was secured to the vibration machine, as shown in Figures 1 and 2, and subjected to five (5) cycles of vibration in both the vertical axis and the horizontal axis with the mounting flange in the horizontal plane.

TEST PROCEDURE:

TEST PROCEDURE: (Cont'd) .

TEST RESULTS :

RECOMMENDATIONS:

Test Re- rt No. 2120-4594

Each cycle consisted of two (2) minutes of vibration at a frequency of twenty (20) cps. and a acceleration level of one (1) "g", followed by one (1) minute of no vibration.

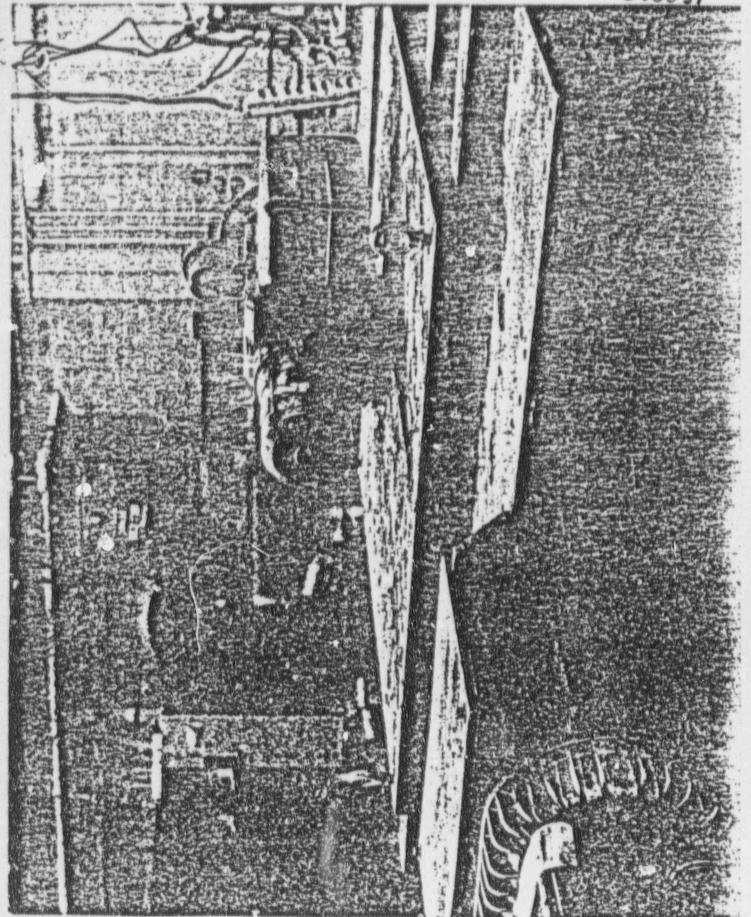
Visual inspections for evidence of any external physical damage were conducted throughout vibration testing.

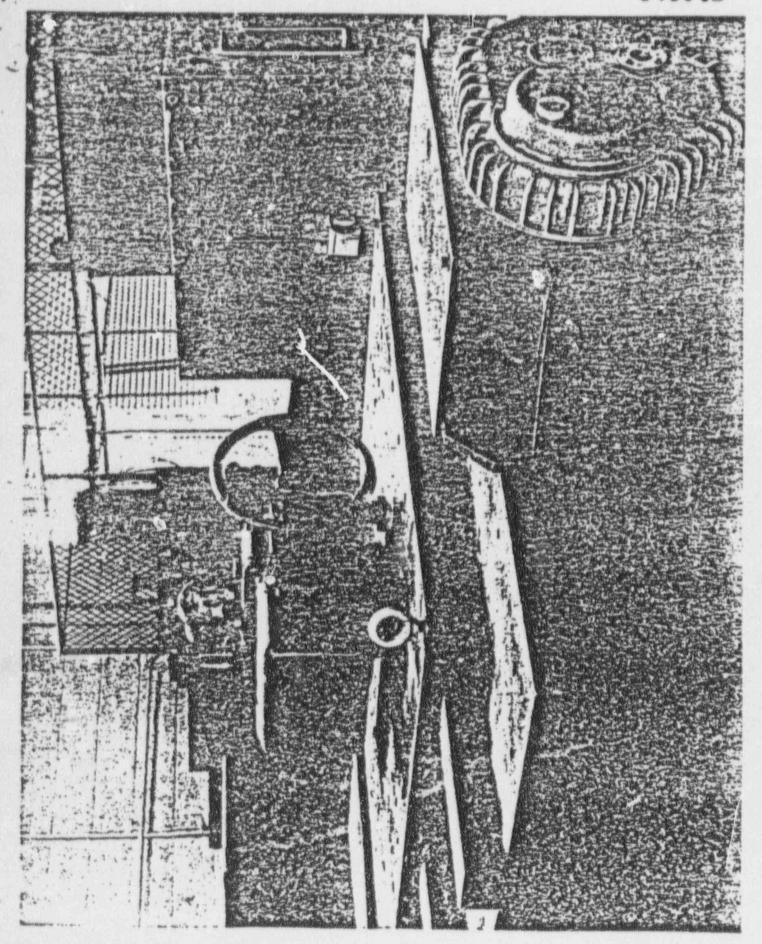
The Vibration Test was completed with no visible evidence of any external physical damage.

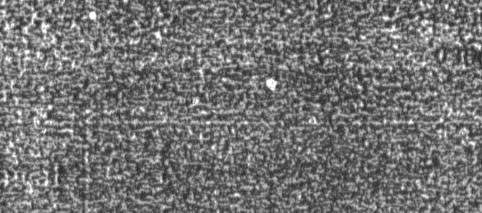
None. Data merely submitted.

Test Engineer: The Colon

W. A. Black











Report

TEST OF A LIMITORQUE VALVE OPERATOR

UNDER A SIMULATED REACTOR CONTAINMENT

POST-ACCIDENT STEAM AND CHEMICAL ENVIRONMENT

by

R. Cl. de Herrick LeRoy E. Witcher

Prepared for

The Philadelphia Gear Corporation King of Frussia, Fennsylvania

November, 1968

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(Performance Test Data of
Limitorque Valve Operator)

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SUMMARY

A Model SMM-O Limitorque Valve Operator manufactured by The Philadelphia Gear Corporation was tested by The Franklin Institute Research Laboratories for performance under steam and decontaminate environments existing in water-moderated reactor containments following some credible accident. The Limitorque operator plus an additional motor-brike assembly was tested in accordance with Level 4 of the Standard Draft, dated June 7, 1968, prepared by Sub-Committee 2 (Equipment Qualification Testing) of the IEEE/NSG/Technical Committee for Standards.

Actual tests were begun on October 31, 1968 and continued for seven full days.

The Limitorque Valve Operator continued to operate throughout and after the environmental test. It was not assery to sequence start the operator to unseat it from the full closed position after the 20 psi pressure level was reached. The geared limit switch bypass around the open torque switch was apparently set too close to the full closed position. This caused the torque switch to momentarily open and stop the operator before it had unseated the valve stem. It is our understanding that this could be corrected by setting the geared limit bypass switch to trip open after the valve stem is unseated.

The environment did effect the geared limit switch as was evidenced at the end of the first 24 hour period when the Limitorque operator went to the full open position and stopped by the open

limit torque switch rather than by the open position graved limit switch. Both indicating lights remained on even though the valve stem had been moved to the full open position.

At the end of the seven day environmental exposure, the Limitorque operator closed the valve stem normally, however due to the failure of the geared limit switch, a jumper wire had to be used to bypass the switch to allow the Limitorque operator to open the valve stem fully.

The motor brake assembly operated satisfactorily throughout the test.

I. INTRODUCTION

Following discussions between staff members of The Philadelphia Gear Corporation and The Franklin Institute Research Laboratories (FIRL), an agreement was signed under which FIRI would test a Limitorque valve operator and a separate motor-brake assembly under simulated reactor post-accident environments. This is the final report of that test progress.

The conditions simulated for the test were the pressuretemperature-humidity (saturated steam) environments and the chemical
environments that could be expected to exist in the containment
vessels of water-moderated power reactors following some credible
accident such as the rupture of a major reactor piping assembly. The
particular conditions simulated are those set forth in the IEEE
Standard Draft, dated June 7, 1968, of the IEEE/NSC/Technical Committee for Standards, Subcommittee 2 (Equipment Qualification Testing) as transmitted by Philadelphia Gear letter, Lawson to Witcher
(FIRL), on July 16, 1968. The test was made in accordance with the
applicable portion of this standard with one exception: the pressure
specified to be 5 psi between 24 and 168 hours after test initiation
as shown in Figure 3, page 9 of the IEEE standard was changed to be
15 psi. This change was requested by Philadelphia Gear in the letter
of July 16, 1968 previously cited.

It must be emphasized that this test program was for the emergency steam and chemical environmental conditions only. Preconditioning tests including radiation aging, heat aging, and a lock tests were not included in the program at FIRL. Neither were postest inspections or other acceptance criteria.

II. EQUIPMENT TESTED

The equipment ted was (a) a Limitorque volve operator and (b) a motor-brake accounty as identified and described below.

(a) Name Plate Information of Valve Operator (Test Unit 1)

NAME:

SMB-O Limitorque Valve Operator

Order No. 600198

MANUFACTURER: Philadelphia Gear Corporation

MOTOR:

Reliance Built Torque Motor

Identification No. 435571-JTR

START:

15 ft.-1b.

RUN:

3 ft.-1b.

TYPE:

FRAME:

M56

PHASE:

3

RPM:

1700

CYCLES:

VOLTS:

230/460

CODE:

AMPS:

5.6/2.8

Temp. Rise at Run Torque of 15 Minutes:

75°C

Type H Insulation

Gear Unit

(b) I we Motor with Brake (Test Unit 2)

MOTOR

MANUFACTUREP: Reliance Electric Company

3300 10th Street

Columbus, Indiana

IDENTIFICATION #: 442010-JTR

START: 15 ft.-1b. FRAME:

RUN: 3 ft.-1b. kPM: 1700

230/460

TYPE.

VCLTS:

PHASE: 3

AMPC .

5.6/2.8

CYCLE 60

CODE:

Rise at RJN Torque: 75°C (15 minutes)

DINGS MAGNETIC DISC BRAKE

MODEL: \$-61009-50 VOLTS: 230

SERIAL NO : 157010 Continuous Duty

TORQUE: 3 ft.-1b.

III. TEST DISCUSSION

The tests were conducted in an environmental test facility installed at FIRL. Figures 1 and 2 show the central part of the fitty including the test chamber with the Limitorque and motor—sembly mounted (Figure 1). Both figures show the chamber are recorder mounted on the upper right wall, the dual channel recorder mounted directly below and the Limitorque and sembly temperature recorder mounted under the right hand table.

_ back wall are mounted the Limitorque and motor-brake controls.

Power leads to the motor-brake and the Limitorque are brought from the panel board to a junction box mounted above the vessel. From the junction box, Teflon insulated #12 wire was brought through the vessel wall in Conar feed-through fittings and thence to the Limitorque and the motor-brake.

The Sanborn recorder shown in Figure 1 was used to measure the valve scating force as measured by strain gages on the valve stem guide protiuding to the left from the tank.

The facility was pressurized by a two inch steam line from the FIRL building steam mains. The fast pressure rise was achieved by quick-opening valves in the steam line. Subsequent regulation was performed by a Spence regulating valve. In order to achieve the fastest possible rise in steam pressure in the test chamber an additional 2 inch line was placed to the chamber by-passing the regulating valve. This allowed an empty vessel rise from zero gage pressure and 140°F ambient to 90 psig in 8 seconds. Pressure rise time with the Limitorque was somewhat greater as described in the actual test procedure.

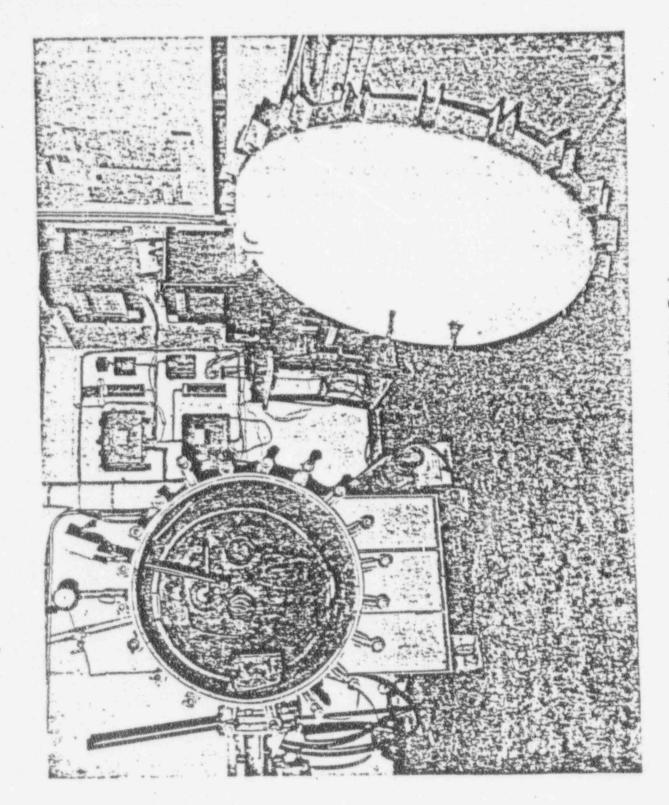
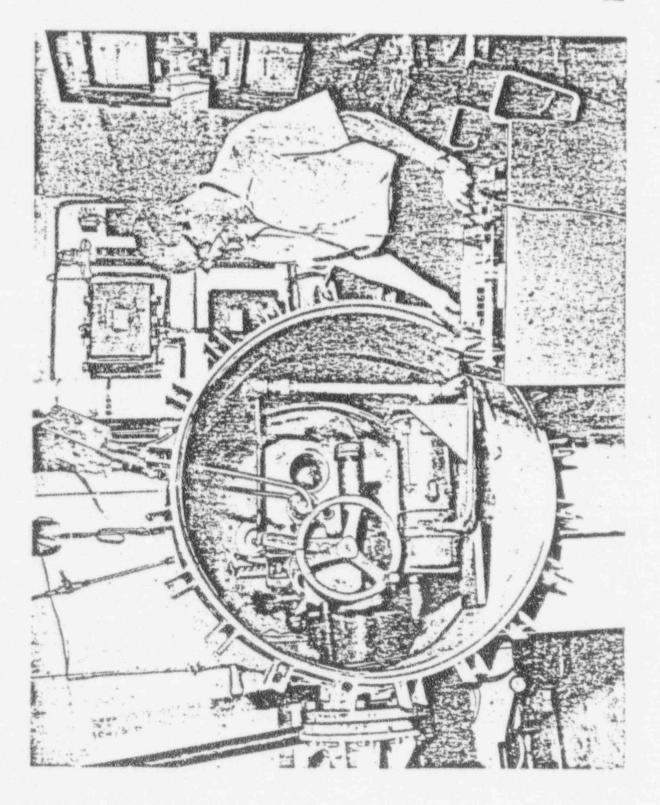


Fig. 2 - Test Facility After Test



A. MEASUREMENTS

(1) Temperature inside unit and limit-switch compartment

Limitorque Operator: Temperature was measured by means of four thermocouples installed in the Limitorque Operator. The valve operator was received by FIRL with three thermocouples already installed in the motor windings. One additional thermocouple was installed by FIRL in the limit-switch compartment.

Motor-Brake Assembly: Temperatures in the brake assembly were also monitored by three thermocouples installed prior to delivery to FIRL. Two were in the motor windings and one was in the brake assembly.

All temperatures in the Limitorque and the motor-brake assembly were recorded by a separate multi-point temperature recorder.

(2) Motor Voltage, Amps, and Watts

A polyphase recording watt mater was used to record the power input to the Limitorque test unit. In addition, three indicating voltmeters and two ammeters were read during each operation of the motors. These data are given in Tables 1 and 2.

No measurements or recordings were made for the motor-brake assembly.

(3) Temperature and Pressure Inside Environmental Chamber

The environment and test chamber temperatures were recorded throughout the seven day test with thermocouples at strategic locations. The temperatures recorded were the chamber steam temperature (1), temperature in the valve operator switching compartment (2), the tank wall temperature (3), and the inlet steam (4).

Pressure was monitored visually by means of a precision mechanical gage and by a pressure transducer for the analog recording of pressure by a two-pen potentiometer recorder. The other pen of the pressure recorder was used in conjunction with another transducer to measure and record pressure in the limit-switch compartment of the Limitorque valve operator.

(4) Boric Acid Concentration and pH of Condensate

In lieu of measuring the concentration and pH of the condensate, a solution of 1.5% (by weight) boric acid in water was prepared and stored in a cooler vat. This solution and only this solution was pumped into the environmental chamber. The condensate was not recirculated, but was drained from the tank overflow as the fresh solution was injected. The boric acid used to simulate the post-accident spray was prepared by dissolving seven pounds of technical grade boric acid (H3BO3) in 55 gallons (460 pounds) of demineralized water. The solution was prepared at 80°F to facilitate the solution of the boric acid crystals. A 50% solution of resgent grade sodium hydroxide (NaOH) was used to titrate the boric acid solution to obtain a stable pH of 7.67 as measured with a Beckman pH meter.

Preparation of the solution was made in a stainless steel chiller tank, equipped with a stirrer and cooling controls. The solution was cooled to 21.5°C (70.7°F) for the test. Eight gallons of solution was used to fill the test chamber auxilliary heaters for the pre-heat cycle and to provide a boric acid source for the initial test.

Boric acid flow rate was measured with a Brooks Flow Meter. The solution was then pumped into the spray manifold in the test chamber by a high head centrifugal pump.

- (5) Valve Operator Seating Force in Valve Closed Position

 The valve operator seating force was measured by a full strain gage bridge on the valve operator external stem drive, which was calibrated by a pre-calibrated load cell. During the test, this force was recorded on one channel of a two-channel Sanborn recorder.
- (6) Motor Insulation Resistance Before and After Test

 Motor insulation resistance was measured with a megohmeter at the motor terminals before and after the test. Since power was supplied to the motor with Conax gland power fittings with Teflon insulated wire, the insulation resistance of these leads were also measured with the megohmeter.
- (7) The Limitorque unit was tested with the limit-switch compartment as an integral unit. A transmitting potentiometer indicating the valve stem position was operated throughout the test in addition to the indicator switch for the external "open-close" light.

A check valve replaced a ball-check grease fitting on the gear housing, with the free flow into the test chamber.

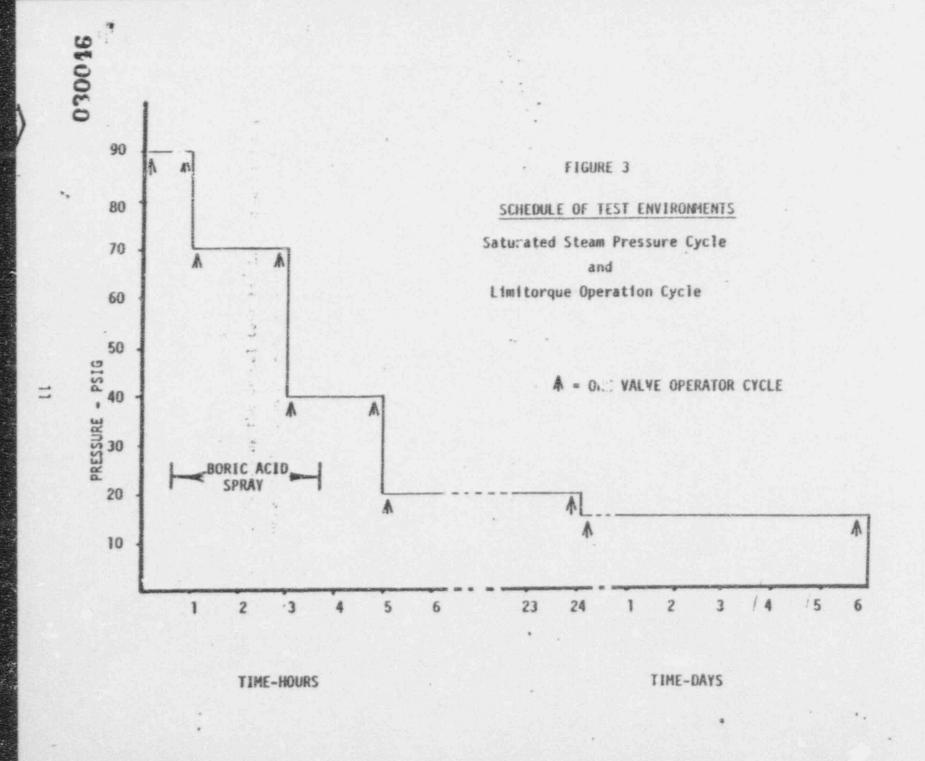
B. TEST SEQUENCE AND OBSERVATIONS

(1) Simulation of Long Term Ambient

Prior to beginning the actual test the Limitorque and motor brake were slowly brought up to a temperature of 140°F at atmospheric pressure, in order to simulate the long term ambient prior to an accident. This, in our test chamber, was accomplished by periodically introducing a small amount of steam from the mains in addition to heating the condensate in the bottom of the test chamber with the electric heaters.

(2) Start of Test

Upon reaching the 140°F ambient level, the actual test was begun at 3:15 p.m. on October 31, 1968 by suddenly admitting steam to the test chamber. The pressure was brought up to and held at 90 psig, in accordance with Figure 3. The rise time was 14 seconds as recorded by two observers using stop watches and precision gages as reference. A precision mechanical pressure gage was the primary instrument used at this time although pressure transducers were operating with a two-pen recorder for the purposes of recording chamber pressure and limit-switch compartment pressure. Figure 4 shows the pressure rise in both the test chamber and the limit switch compartment of the Limitorque. The recorded pressure variation in chamber pressure upon reaching the 90 psi level was caused by a leak in the pressure transducer at that time.



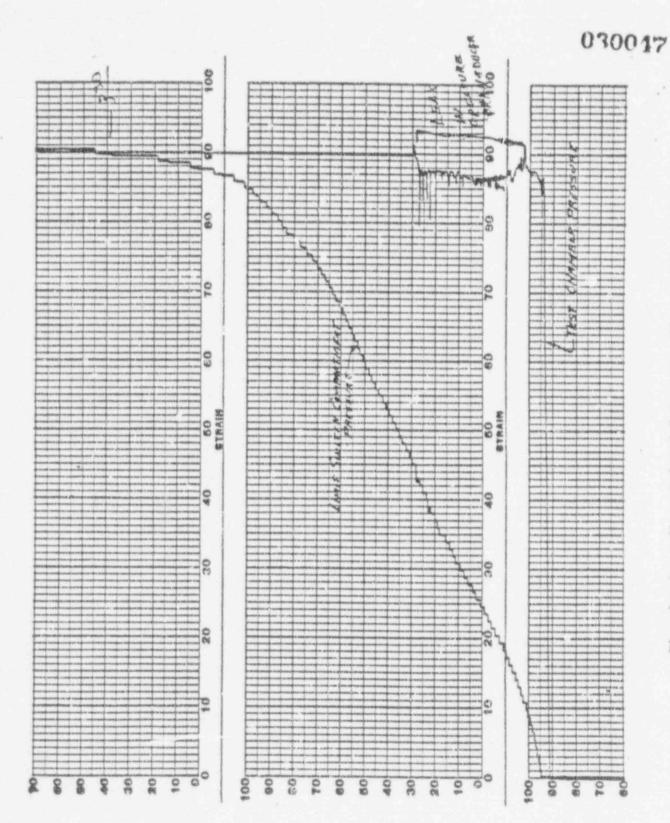


Fig. 4 - Recording of Initial Pressure Rise to 90 psig.

(3) Limitorque Operation

-- Six minutes after the beginning of the test the Limitorque and motor-brake assembly were each operated through one complete cycle. Operation was normal.

(4) Start Boric Acid Spray

Forty minutes after the start of the test the boric acid spray was started. 1.5% boric acid, buffered with sodium hydroxide to a pH of 7.67, was supplied at 10 gal. per hour in a downward spray pattern over the Limitorque casing and control compartment for the next four hours without interruption.

(5) Limitorque Operation

Fifty-five minutes after the start of the test the Limitorque and the motor-brake were each operated through one complete cycle. Operation was normal.

(6) Pressure Reduced to 70 psig

One hour after the start of the test the pressure was record to 70 psig in the test chamber within a period of three minutes.

(7) Limitorque Operation

Seven mirutes after reaching the 70 psig saturated steam conditions in the test chamber the Limitorque and motor-brake were again operated through one complete cycle. Operation was normal.

(8) Limitorque Operation

Five minutes before going to the 40 pai level the Limitorque and motor-brake were again operated. Operation was normal.

(9) Pressure Reduced to 40 paig

Three hours after the start of the test the pressure in the test chamber was reduced to 40 psig, by adjusting the regulator valve in the steam supply line and by running cold water through the condenser coils inside the test chamber head. The change from 70 psig to 40 psig was accomplished in five minutes.

(10) Limitorque Operacion

Five minutes after reaching the 40 psig sacurated steam conditions in the test chamber the Limitorque and the motor-brake were again operated through one cycle. Operation was normal.

(11) Boric Acid Spray Scopped

The boric acid spray which had been supplied continuously for four hours in a spray pattern over the Limitorque was stopped. No further chemical environment was simulated.

(12) Limitorque Operation

Five minutes before the end of the two hour 40 psig saturated steam condition the Limitorque and motor-brake were sgain operated. Operation was normal.

(13) Pressure Reduced to 20 paig

Five hours after the start of the test the p. seure regulator was adjusted from the 40 psig setting to the 2 psig setting. Cooling water was also supplied to the cooling coil in the chamber head. This accomplished the transition from 40 psig to 20 psig in four minutes.

(14) Limitorque Operation

Tive minutes after reaching the 20 psig level, the Limitorque and the motor-brake assembly were operated through one complete cycle. The water-brake assembly operated normally. The Limitorque operated, but its operating characteristics had changed. It closed normally, but to open the unit it was found to be necessary to joggle the open and close buttons in sequence to start up the unit. Once started, it operated satisfactorily, but the opening time was 112 seconds instead of the normal time of 110 seconds. The absence of a peak in motor torque at the end of the opening stroke signified that the opening stroke was atopped as usual by the limit switch.

(15) Limitorque Operation

Nineteen hours after the previous Limitorque operation and five minutes before the end of the 20 psig condition, the units were operated once more. The motor-brake operated normally. The Limitorque closed properly, but upon opening the controls needed to be sequenced rapidly between "open" and "close". As before, once started, the Limitorque operated satisfactorily but this time the recorded rise in torque at the end of the opening stroke signified that the full open limit stop was reached, thus indicating that the preset limit switch failed to stop the opening stroke.

(16) Pressure Reduction to 15 psig

Twenty-four hours after the start of the test the pressure was reduced from 20 to 15 paig. This was accomplished as before by adjusting the regulating valve and running cold water through the cooling coil. Pressure reduction time was

seven minutes. No further change in pressure was made before the end of the test.

(17) Limitorque Operation

The test units were operated five minutes after reaching the 15 psig condition. The motor-brake operated satisfactorily although it appeared to be noisy to a short period of time with the brake released. The Limitorque operated as in the immediately preceding operation (Sequence 15) except that the position limit switches were not operating. The Limitorque operated satisfactorily but it had to be sequenced rapidly between "open" and "close" to unseat the stem when in the closed position.

(18) Limitorque Operation

Six full days (144 hours) passed while the units remained in the 15 psig saturated steam environment before the units were operated once more. The motor-brake operated satisfactor-ily. The Limitorque closed satisfactorily but this time the unit would not reverse to un-seat the valve stem on the opening cycle. Rapid sequencing of the "open" and "close" buttons as done praviously was to no svail and so a jumper was added to the controls on the panel board to reverse the Limitorque. This was successful and the Limitorque opened satisfactorily.

(19) Pressure Reduction to Atmosphere

Following the Limitorque operation of sequence 18 the pressure was reduced to the atmospheric pressure of the lab. This was done by circulating water through the cooling coil in the chamber head and later by slowly pumping cold water into the condensate well of the chamber.

The cooling operation before venting required approximately thirty minutes.

(20) Condensate Sampling

Before pumping water into the condensate well to cool the test chamber a sample of condensate was drawn and tested for acidity. The condensate had a pH of 8.20 which was believed to represent the pH of the steam from the supply mains (Philadelphia Electric Company). By this time most of the boric soid should have been diluted and carried away by the steam condensate.

(21) Opening of Test Chamber

Approximately one hour after the end of the seven day test (168 hour) cycle the tank was opened to inspect the units under test.

(22) Visual Inspection of Test Units

Figures 5 and 6 show, respectively, the test units immediately before and after the test. It is obvious that the steam and chemical environments had a very corrosive effect upon the units, especially upon the paint. However, as described in this test sequence, the units operated, even to the bandwheel which was tested and found to be satisfactory.

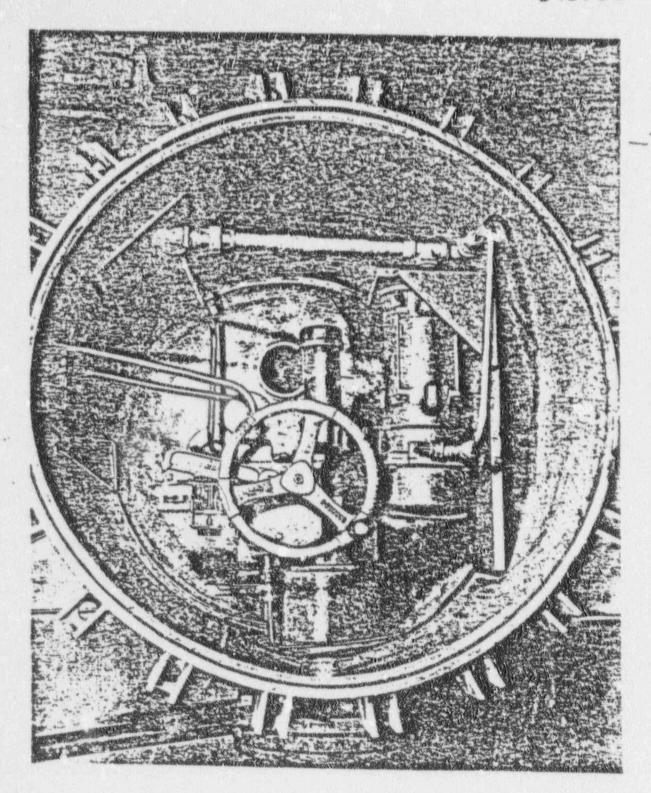
Figure 6 shows a certain amount of crud in the bottom of the tank. This was found to be (a) grease that had come out of the checkvalve, and (b) the remains of the visual position indicator which had been severly attacked by the environment. The plastic had melted and had apparently foamed.

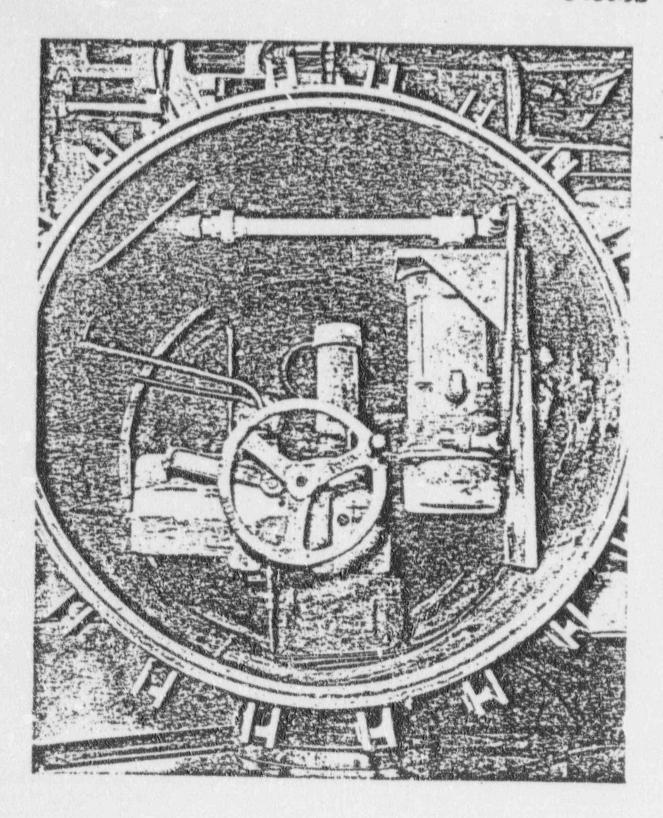
Figures 7 and 8 show the effect of the environment upon the limit switch compartment. The environment had penetrated the compartment and had lightly attacked certain components. This was evidenced by the previously discussed malfunction of the position limit switches as well as by the visual inspection.

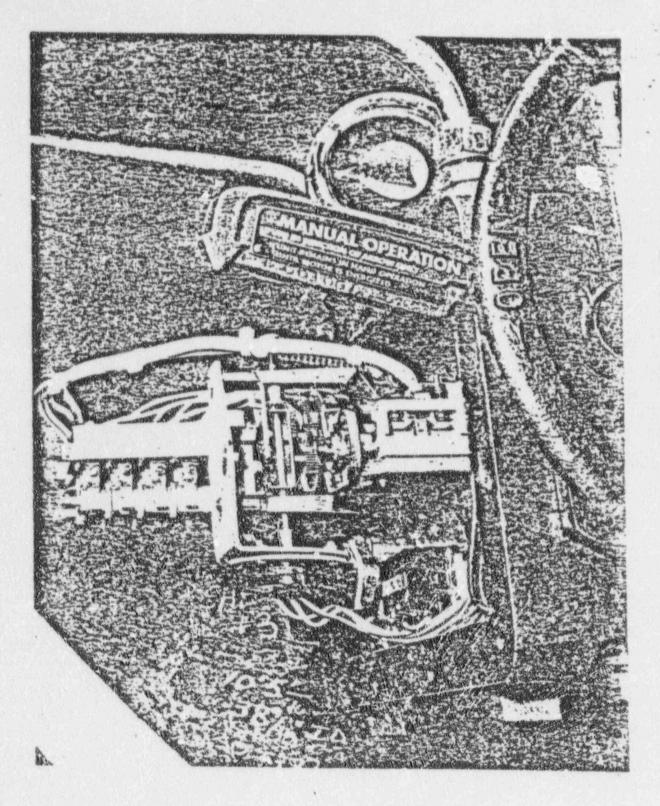
(23) Limitorque Operation

The Limitorque was operated once more before it was removed from the test chamber for return to the Philadelphia Gear Corporation. The operation was as described in sequence The jumper on the control panel was necessary for reversing the motor from "close" to "open".

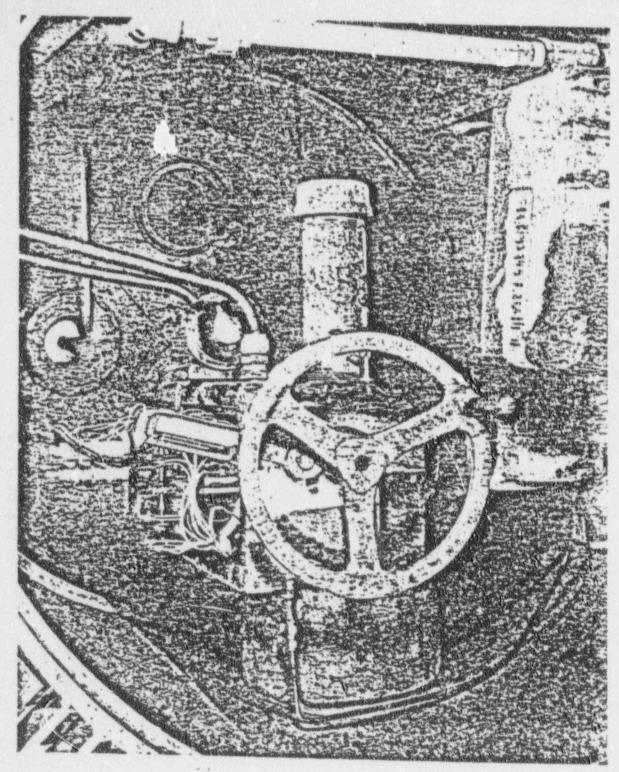












APPENDIX I

TEST DATA SHEETS

ENVIRONMENT TEST LYCLE

TEST LEVEL I	
Time at Start of Test: (cf 11 HILL Bour 15/5	030059
Initial Pressure 15 Paig Temp. 142 °F	
Pressure Rise Time: 14 Seconds	
Chamber: Press. 96 131 (- Temp. 329 *F	
Test Unit: Press. 9. Psig Temp. 328 *P	
First Test Cycle of Motor: /5 2 / Bours	
Start of Boric Acid Spray (40 minutes for Level I)	
Time: 15 5 5 Eous	Minuces
Boric Acid Flow Rate: 1555 aph	
Temp. 70.7 ph 21.	
Second Test Cycle of Motor at this Level: Time: 16/0 None	
End of Level I:	
Time: 1615 Eours	
Chamber Press. 91 psis Temp. 329 *P	

Temp. 329 .F

Unit Press. // psig

ENVIRONMENT TEST CYCLE
TEST LEVEL NO. TEMP. STEAM PRESS. 70 PSIG TEMP.
Time Level Reached: 1615 Hours
Time from Previous Level: 38 Minutes
Chamber Press: 70 psig Temp.: 312
Test Unit: Temp. 3/2 *F Press. 70 Psis
First Test Cycle of Motor at this Level: Time: 1625 Hours
Boric Acid Spray
· Flow Rate 10 9/4 Temp. 70.7 °F PH 7.67
Second Test Cycle of Motor at this Level: Time: 18 10 Hours
End of Level No. I
Time: it 15 Hour
Chomber Temp. 315 Press. 70 Psig.
Unit Temp. 315 *F

030051

SE. Witcher

ENVIRONMENT TEST CYCLE	
TEST LEYEL NO. IV DESIGNATED STEAM PRESS. 20	SATURATION 2 PSIG TEMP. 259
Time Level Reached: 2022 Hour	4
Time from Previous Level: 4 M	inutes
thamber Press: 20 paig	Temp.: 272 °F
Test Unit: Temp. 271 *F	Press. DO Psig
First Test Cycle of Motor at this Level: Time: 2035	Hours . 4170
Boric Acid Spray	
· Flow Rate now = Temp.	*F PH
	· ~ Mov. 1, 1968
Second Test Cycle of Motor at this Level: Time: 15/0 Hour	
End of Level No.	
Time: 1517 Hour	

26

Press. 20 Paig.

Press. 20 Psig

Chamber Temp. 256 °F

Unit Temp. - 256 .

1.8. Vitela

TEST LEVEL NO. III DESIGNATED STEAM PRESS. 40 PSIG TE Time Level Reached: 1520 Rours Time from Previous Level: 10 Minutes Chamber Press: 40 psig Temp.: 300 Test Unit: Temp. 287 F Press. 40	P. 28	?
Time from Previous Level: 10 Minutes Chamber Press: 40 psig Temp.: 500	i.	
Chamber Press: 40 psig Temp.: 500	1. 'Y	:
		•
Test Unit: Temp. 287 °F Press. 40		
	Psig	
First Test Cycle of Motor		0.
at this Level: Time: 1828 Hours		

, F	low Rate	10 904	Temp.	10	2 °y	PH 7.62
Acid	Spra;	Stropped "	2+ 1	955	hours	PH 7.62

Second Test Cycle of Motor at this Level: Time: 20/0 Hours

End of Level No.

Time: 20 18 Hour	
Chamber Temp. 287 °F	Press. 41.0 Psis
Unit Temp. 287 °F	Press. 40.5 Psig

PERFORMANCE TEST DATA OF LIMITORQUE VALVE OPERATOR COLLECTED DATA

Test Pr Psig	es. Time	Lin E 1-2	e Volt 3-1	. A-0		rrent	PWY	Stg. For-1bs	Stem Close	Travel e Open conds
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	1524	504	516	500	2.65				110	
	1610	500	512	500	2.80	2.97				110
	1613	500	514	500	2.68	2.83	.55	16,500	.110	
0	1625	500	514	496					1	110
	1628	504			2.68	2.97	.50	16,100	110	
	1810	506		500	3.05	2.89	.52			110
	1813	508		504	2.73	3.07	.50	16,500	110	
0 .				504	2,92	2.98	.56	16,500		110
•	1828	508	520	504	2.95	3.10	.50	16,500	110	
	1831	508	520	504	2.84	3.00	.52			108
	2010	508	520	504	2.98	3.10	.50	16,000	110	100
	2014	508	518	504	2.83	3.02	.51		1	107
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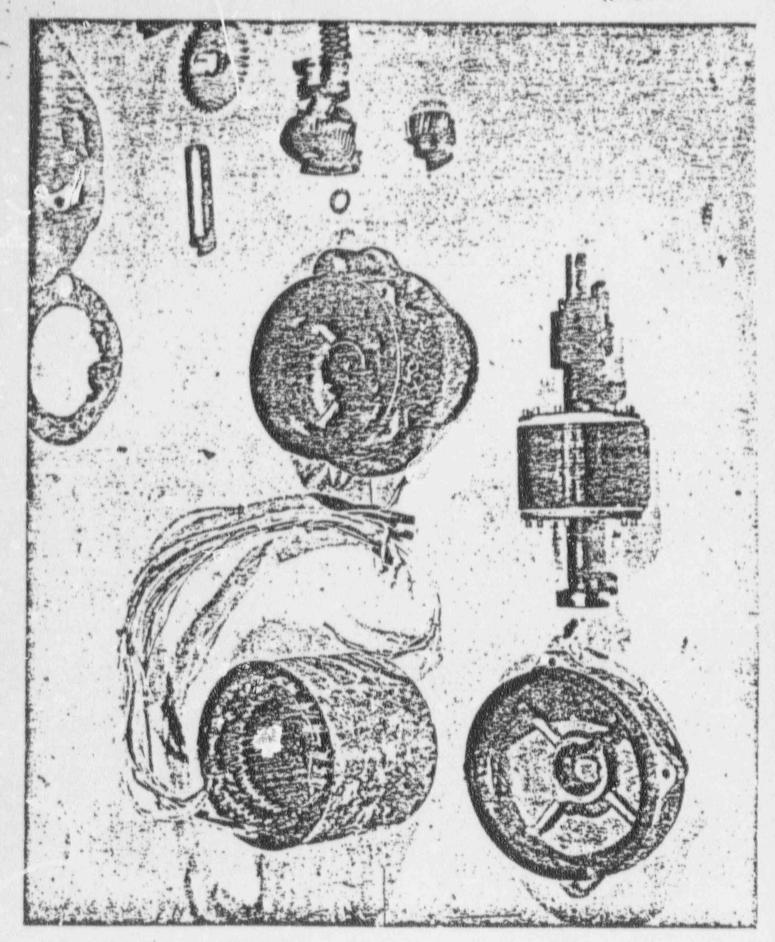
TABLE 2. Average and Peak Values

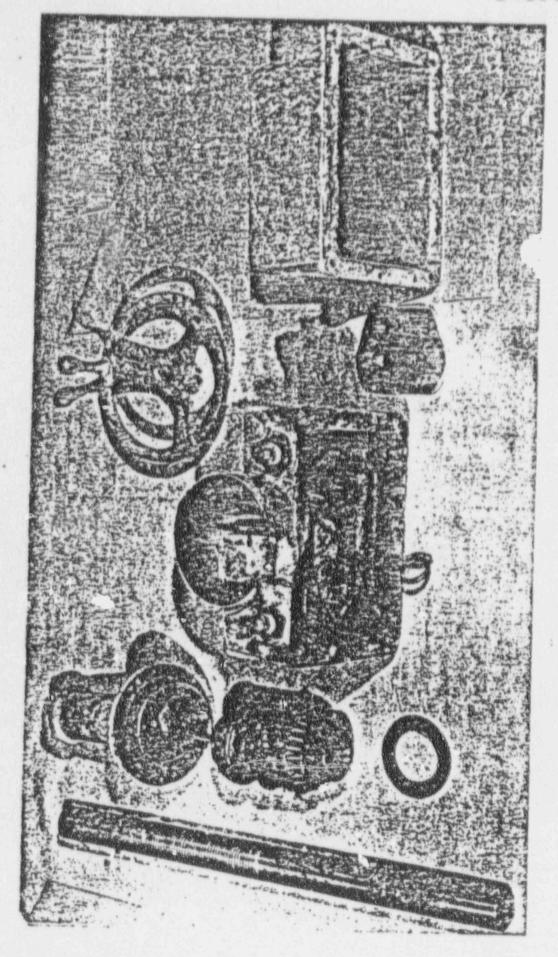
PERFORMANCE TEST OF LIMITORQUE VALVE OPERATOR

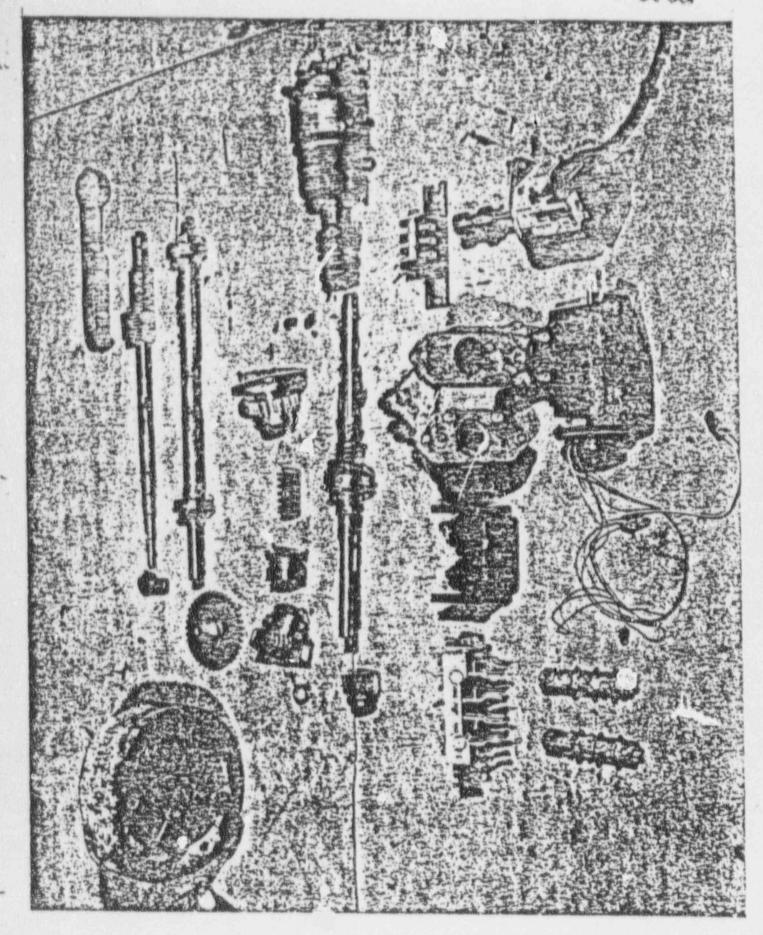
Oct. 31	Test Pressure Psig	Ave.Volt- age -3 ¢	Ave. Current	Peak Current	Power Peak
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		506.7	2.62		1.15
		504	2.88	Missed	1.54
		504.7	2.76		2.00
	70	503.3	3.01	3.30	1.50
		505.7	2.80		1.40
		509.3	3.00	3.40	1.45
		510	2.89		.85
	40	510.7	3,02	3.30	1.44
		510.7	2.92		.78
		510.7	3.04	3.30	1.39
		510	2.92		1.21
	20	510.7	3.03	3.40	1.45
		510.7	2.93		.76
		503.3	2.92	3.40	1.35
		503.3	2.78		1.09
	15	503.3	2.91		1.42
		503.3	2.80		1.48
		503.3	2.90		1.52
		503.7	2.80		.88
	Final	503.7			1.52
	Final	507.7			.95

PHOTOGRAPHS
OF
LIMITORQUE OPERATOR PARTS

DISASSEMBLED AFTER ENVIRONMENTAL TEST







ADDENDUM #1

**

PHILADELPHIA GEAR CORPORATION KING OF PRUSSIA, PENNA. 19406

LIMITORQUE VALVE CONTROL

ADDENDUM NUMBER #1
TEST OF LIMITORQUE VALVE OPERATOR
TO MEET GENERAL REQUIREMENTS

OF

AN ELECTRIC VALVE ACTUATOR

IN

NUCLEAR REACTOR CONTAINMENT ENVIRONMENT REPORT OF JANUARY 2, 1969

A. SHOCK & VIBRATION TEST

B. TEST OF LIMIT SWITCH WITH MATERIAL CHANGE

A. SHOCK AND VIBRATION TEST:

The Limitorque Operator size SMB-0 with a 15 foot pound, 3 phase, 60 cycle, 440 volt motor, nameplate order #338164 was shipped to Lockheed Electronics Company environmental labratory and tested on March 10, 1969.

Test Procedure

The test specimen was secured to a vibration machine and subjected to five cycles of vibration in both the vertical axis and the horizontal axis. Each cycle consisted of two minutes of vibration at a frequency of thirty-five (35) cps and an acceleration level of three (3) "G's", followed by one minute of no vibration.

Vibration scans were also conducted in both axis of vibration between five to thirty-five cps to determine the presence of any resonances.

Visual inspections for evidence of any external physical damage were conducted throughout the vibration testing. The vibration test was completed with no visual evidence of any external physical damage. No resonances were detected during the vibration scans.

The above is included in Lockheed Electronics Company Test Report #2268-4618.

Call Pro 7 2 1

030072

The previous shock and vibration test of a Limitorque Operator was extended to 1 G and 25 cps. The above test extended the level to 3 G's at 35 cps.

B. TEST OF GEARED LIMIT SWITCH WITH MATERIAL CHANGE:

On the previous test of a Limitorque Operator as submitted January 2, 1969, a failure occurred due to the action of the chemical spray on the material of the gear frame of the geared limit switch. This caused the premature failure of the geared limit switch. The gear frame material has been changed as previously recommended and an additional test of this revised geared limit switch has been conducted at The Franklin Institute Research Labratories in Philadelphia, Pannsylvania on April 9 through April 16, 1969. The geared limit switch was placed in the same environmental chamber as the previous test and was used in conjunction with starting 'nd stopping an electric motor also in the test chamber. The environment consisted of a seven day test wherein the geared limit switch was exposed to high steam pressure, temperature and chemical environment similar to the previous test.

The new geared limit switch successfully completed the test with no sign of wear or deterioration due to the steam pressure,

temperature or chemical environment. The test was completely satisfactory in every respect.

CONCLUSION:

The material change of the geared limit switch has been noted and will be included on all Limitorque Operators subjected to this environmental condition when specified.

This information is submitted as an addendum to our Test Report dated January 2, 1969.

Very truly yours,

Edward F. Lawson

Sales Manager

Limitorque Division

EFL/sls

5.3 G's, 35 Hz.

PHILADELPITIA GEAR CORPORATION

industrial gears · speed reducers · fluid mixers · limitorque valve controls · precision ground gearing

Main Office: Schuylkill Expressively, Suburban Phile. KING OF PRUSSIA, PA. 19406 TELEPHONE: 288-3000

030075

SUBJECT: REPORT OF TEST ON LIMITORQUE VALVE CONTROL

SHOCK & VIBRATION UP TO'S.3 G's, 35 Hz

Gentlemen:

On August 20, 1970 a seismic shock and vibration test was conducted on a Limitorque operator size SMB-0-25 suitable for nuclear containment vessel service at the Lockheed Electronics Company in Plainfield. New Jersey.

The Limitorque operator was mounted on a test stand and having a threaded valve stem being driven by the Limitorque operator simulating opening and closing a valve. The Limitorque operator was electrically connected so as to stop at the full close position by means of our torque switch and stop at the full open position by means of our geared limit switch. The Limitorque operator had used for motor control were wired to electric indicating lights at a remote panel.

The enclosed Lockheed Test Report shows that this unit successfully completed a 5.3 G shock level at 35 Hz with no discrepancies noted. An exploratory scan of 5 Hz to 35 Hz was made and no critical resonant frequencies were noted on the Limitorque operator. The unit was shocked and vibrated in such of three different axes a total of 2 minutes on, 1 minute off, three times per axis. The unit was operated electrically to both the full open and full close

position and all torque switches and limit switches functioned properly. None of the auxiliary limit switches wired to indicating lights ever flickered or indicated they were opening or flickering. All electrical and mechanical devices on the operator worked successfully.

An additional test level of 10 G's at a maximum of 49 Hz was conducted as noted in the test. The Limitorque operator had no defects during the first two minutes of operation at the 10 G level: however, switch loosened and we decided to discontinue the test. At that time the unit had been subjected to a total of 9 minutes of shock an vibration at 10 G's and 49 Hz.

The enclosed Test Report #2539A-4723 of lockheed Test Lab. is sub-

Very truly yours,

PHILADELPHIA GEAR CORPORATION

Edward F. Lawson, Sales Manager

Limitorque Division

enc.

Test Report No. 25394-4723 Issue 2

REPORT OF TEST on

LIMITORQUE CORPORATION 5M8-0-25 VALVE OPERATOR

. Report Writer: F. Soltis

Test Engineer: W. A. Black Charles

LOCKHEED ELECTRONICS COMPANY PLAINFIELD, NEW JERSEY

Date: September 23, 1970

Approved by: N. Johnson & Supervisor

Environmental Laboratory





Test Report No. 2538A-4723

Issue 2

PURPOSE OF TEST:

To subject the test specimen to the Seismic Test referenced in Limitorque Corporation Purchase Order Number ... 348572, dated 8/6/70.

MANUFACTURER:

Limitorque Corporation 5114 Woodall Road Lynchburg, Virginia 24502

SPECIMENS TESTED:

SM3-0-25 Valve Operator

APPLICABLE DOCUMENTS:

Limitorque Corporation Purchase Order Number 348572, datad 8/6/70.

CASE NUMBER:

34-8041-0723

QUANTITY OF SPECIMENS TESTED:

One (1)

SECURITY CLASSIFICATION OF SPECIMENS TESTED:

Unclassified

DATE TEST COMPLETED:

8/20/70

TEST CONDUCTED CY:

LOCKHEED ELECTRONICS COMPANY ENVIRONMENTAL LABORATORY

DISPOSITION OF SPECIMENS TESTED:

Returned to Limitorque Corporation per LEC Packing Slip Number 66227, dated 8/24/70.

ABSTRACT:

The test specimen was subjected to the Seismic Test referenced in Limitorque Corporation Purchase Order Number 348572, dated 8/6/70.

The 5.3G portion of testing was complet with no discrepancies noted.

The 10 G portion of testing was terminated during the second cycle due to noted fatiguing of the gear limit switch mounting hardware.

TEST APPARATUS:

Reaction-Type Vibration Machine, LAB Company Model RVH-72-5000, S/N 51401.

Vibration Meter, MB Company Model M-6, S/N 423.

Vibration Pickups, MB Company Type 120, S/N 11263 and Type 124, S/N 14074.



Test Report No. 2539A-4723

Issue 2

TEST PROCEDURE:

The test specimen was secured to the vibration machine, as shown in Figure 1. and subjected to an exploratory scan over the frequency range of 5 to 3 Hz in two (2) axes. The exploratory cans were followed by three (3) cycles of vibration in each exis. Each cycle consisted of two (2) minutes of vibration at a frequency of 35 Hz and an acceleration level of 5.30's followed by one (1) minute of no vibration.

The test specimen was then set up as shown in Figure 2 and subjected to the above mentioned test in the third axis. At completion of this test, an additions exploratory scan was performed over the frequency range of 5 to 49 Hz and two (2) cycles were performed at a frequency of 48 Hz and an acceleration level of 10 3's.

The test specimen was energized during testing and all electrical monitoring was performed by Limitorque Corporation personnel.

The 5.3 G portion of testing was complated with no evidence of any discrepancies noted during either exis of test.

During the exploratory scan of the 10 G portion of testing, the gear limit switch mounting hardware loosened. These screws were tightened prior to the start of the first cycle.

The first cycle at 10 G's was then completed with no discrepancies noted. After approximately one [1] minute of the second cycle, the test was terminated due to fatiguing of the gear limit switch mounting hardware.

For additional information, refer to the five (5) attached data sheets.

None. Date merely submitted.

Test Engineer: W. A. Black get

TEST RESULTS:

RECOMMENDATIONS:

Test Report No. 2539A-4723

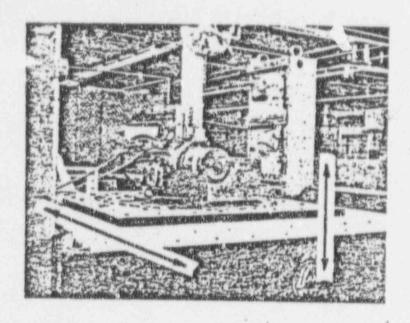


FIGURE 1

VIBHATION TEST SETUP [HORIZONTAL AND VERTICAL]

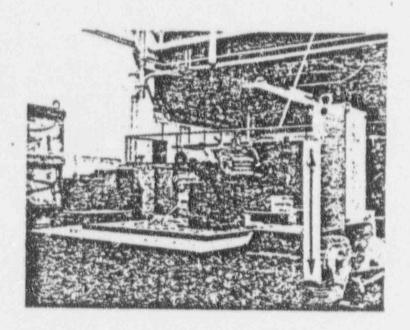


FIGURE 2

VIBRATION TEST SETUP (VERTICAL)

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